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DEEP LEARNING IN AGRICULTURE: A REVIEW OF COTTON LEAF DISEASE DETECTION AND FUTURE PERSPECTIVES

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ABSTRACT
The introduction of deep learning in agriculture has unlocked the potential for advanced monitoring systems that improve crop productivity and disease detection accuracy. Among key crops, cotton, a major global cash crop, is susceptible to various diseases that reduce yield and economic returns. This paper reviews the current deep learning methods used for cotton leaf disease detection, emphasizing the performance of Convolutional Neural Networks (CNNs) and transfer learning models. It explores the datasets available, technological challenges, and future prospects for the adoption of these techniques in precision farming systems. We also discuss integration opportunities with other cutting-edge technologies, including drones and explainable AI (XAI), while providing a comprehensive evaluation of existing literature. We provide recommendations to address challenges such as environmental variability and dataset scarcity[1][[3]. Future research directions are suggested to enhance deep learning applications in this domain.

Keywords: *Deep Learning, Cotton Leaf Disease, Convolutional Neural Networks, Agriculture, Precision Farming, Transfer Learning, Disease Detection*

1. INTRODUCTION
In recent years, agriculture, which forms the economic foundation for many countries globally, has experienced swift technological progress, with artificial intelligence (AI) at the forefront. Cotton (Gossypium hirsutum), a key industrial crop, faces numerous diseases that pose a threat to worldwide cotton production. These ailments, including bacterial blight, leaf curl virus, and fungal infections, substantially diminish crop yields and cotton fiber quality. Conventional detection techniques are labor-intensive, slow, and often subject to human error. As a result, technological innovations, such as deep learning models, have emerged to automate and improve the precision of disease identification[2]-[4].

Convolutional Neural Networks (CNNs), a subset of deep learning, have gained prominence in image-based plant disease detection. CNN models can accurately classify various diseases by examining leaf images. Additional methods like transfer learning further enhance this process by utilizing pre-trained models to address the common issue of limited datasets in agricultural applications. This review aims to provide an overview of the latest developments in deep learning techniques for detecting cotton leaf diseases, evaluate current datasets and models, and explore the future potential of integrating these technologies with precision farming practices[5].

2. OVERVIEW OF COTTON LEAF DISEASES
Cotton leaves are affected by a variety of diseases, which can be caused by bacteria, fungi, and viruses. These diseases can drastically impact cotton yield and quality if not detected and managed early[6].

- **Bacterial blight (Xanthomonas citri):** This disease causes water-soaked lesions on leaves, stems, and bolls. It spreads rapidly under high humidity, leading to reduced yields[7].
- **Cotton leaf curl virus (CLCuV):** This virus is transmitted by whiteflies and results in the curling of leaves, stunted plant growth, and boll malformation[8].
- **Alternaria leaf spot:** Caused by the Alternaria alternata fungus, this disease results in small circular spots that eventually coalesce, leading to leaf necrosis[9].
- **Verticillium wilt (Verticillium dahliae):** This soil-borne fungal disease causes leaf yellowing, wilting, and necrosis, severely damaging cotton plants[10].

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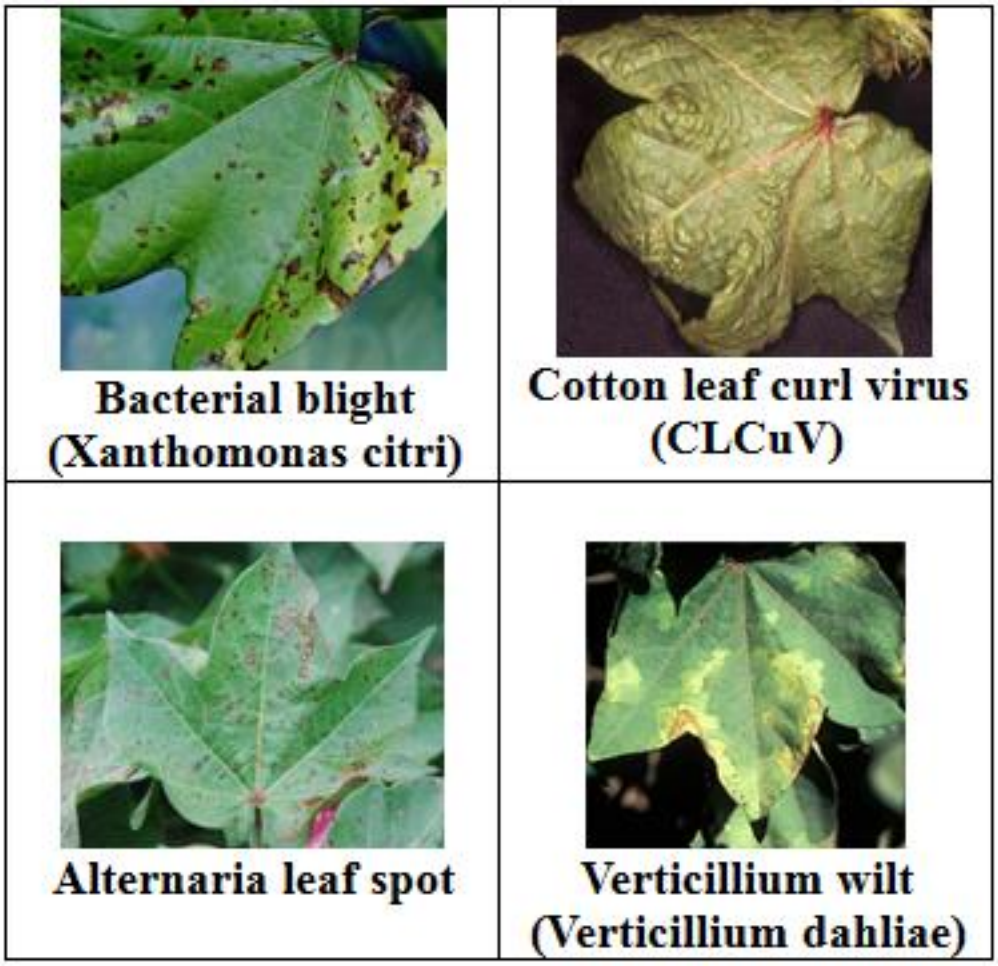

Figure: 1 shows Different types of cotton leaf disease.

Accurate detection of these diseases at an early stage can minimize losses and optimize pesticide application. However, the visual symptoms of different diseases often overlap, making manual inspection challenging. This necessitates the use of advanced detection techniques[11].

3. DEEP LEARNING APPROACHES FOR COTTON LEAF DISEASE DETECTION

Deep learning has emerged as a key technology for detecting cotton leaf diseases due to its ability to learn and generalize complex patterns in images. Here we explore the major deep learning approaches used in this domain.

3.1 Convolutional Neural Networks (CNNs)

Convolutional Neural Networks (CNNs) are widely adopted in image classification tasks, and they have shown great promise in detecting diseases in plants, including cotton. CNNs consist of convolutional layers that automatically learn to extract hierarchical features from input images. This makes them highly effective for detecting subtle variations in leaf appearance caused by diseases[12][13].

3.1.1 CNN Architecture

A typical Convolutional Neural Network (CNN) architecture for detecting cotton leaf diseases is composed of multiple layers, as shown in Figure 2. These layers include a series of convolutional and pooling layers, followed by fully connected layers. The convolutional layers play a crucial role in extracting important features from the input images, such as edges, textures, and shapes. The pooling layers function to reduce spatial dimensions, which helps minimize computational costs and mitigate overfitting issues. The fully connected layers, which form the final component of the network, are responsible for classifying the image into various disease categories[14]-[16].

Figure 2: Typical CNN Architecture for Cotton Leaf Disease Detection[15][16]

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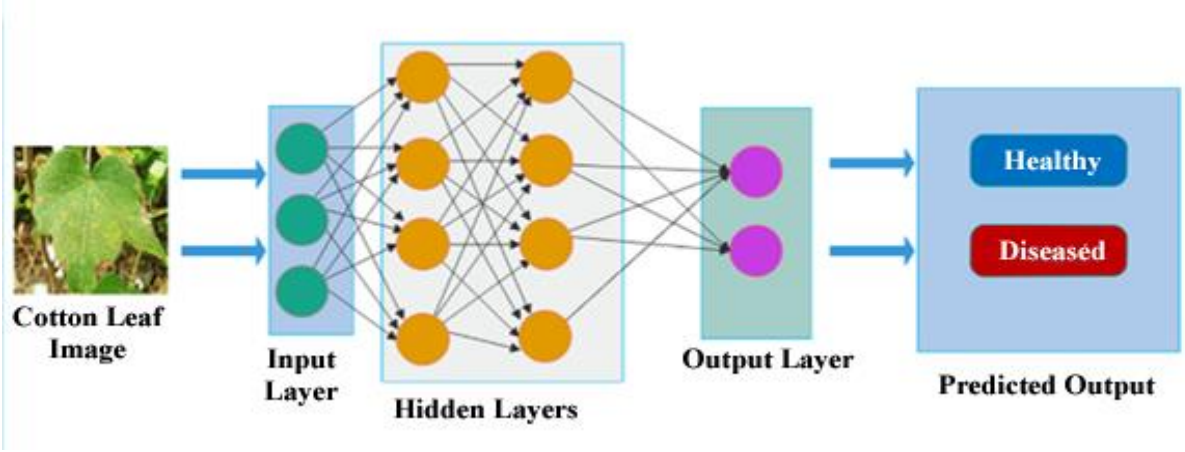

Figure 2: Typical CNN Architecture for Cotton Leaf Disease Detection[15][16]

Studies applying CNNs for cotton leaf disease detection have reported promising results:

- **Patil et al. (2020)** developed a CNN model to detect bacterial blight and Alternaria leaf spot, achieving an accuracy of 92.5%[2].
- **Wang et al. (2021)** used a CNN-based model to classify Verticillium wilt, bacterial blight, and leaf curl virus, achieving over 94% accuracy[7].

3.1.2 CNN Performance on Cotton Leaf Disease Datasets

Table 1 summarizes the performance of CNN-based models on different cotton disease detection tasks.

Table 1: CNN Performance on Cotton Leaf Disease Detection

Study	Dataset used	Disease Target	Accuracy (%)
Patil et al. (2020)	Custom Cottin Dataset	Bacterial Blight, Alternaria	92.5
Wang et al. (2021)	Plant Village	Leaf Curl Virus, Blight	94.0
Mandal et al. (2019	Custom Dataset	Verticillium Wilt	95.2

3.2 Transfer Learning

Transfer learning is an approach where a model pre-trained on a large dataset (e.g., ImageNet) is fine-tuned for a specific task using a smaller dataset. This approach is particularly useful in agriculture, where labeled datasets are often limited. Transfer learning has been successfully applied in cotton leaf disease detection, allowing models to leverage features learned from general images and adapt them to specific agricultural tasks[19][20].

- **Ravi et al. (2021)** applied transfer learning using VGG16 to detect cotton leaf curl virus, achieving an accuracy of 93%[20].
- **Xu et al. (2022)** fine-tuned a ResNet50 model for detecting Verticillium wilt and Alternaria leaf spot, reporting an accuracy of 90.8%[4].

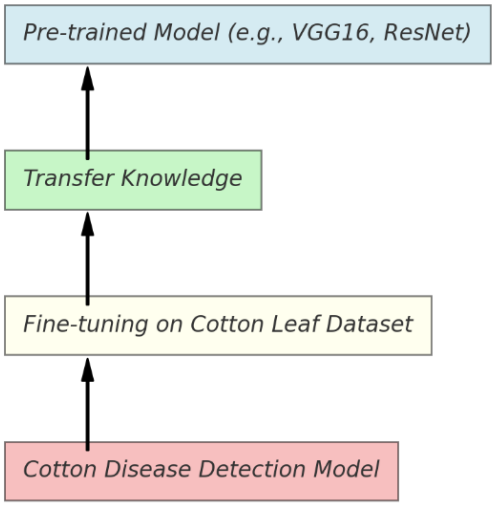

Figure: 3 shows the general process of transfer learning for cotton leaf disease detection.

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Table: 2 provides a comparison of various transfer learning models applied to cotton leaf disease detection.

Model	Dataset Used	Disease Targeted	Accuracy (%)
VGG16	Custom Dataset	Leaf Curl virus	93.0
ResNet50	plantVillage	Verticillium Wilt, Alternaria	90.8
InceptionV3	Cotton Disease Dataset	Bacterial Blight	91.5

Table 2 Performance of Transfer Learning Models in Cotton Disease Detection

3.3 Generative Adversarial Networks (GANs)

When there is insufficient labeled data to train deep learning models, Generative Adversarial Networks (GANs) offer a solution. These networks can create synthetic images to enhance existing datasets, thereby improving the robustness and effectiveness of models. For instance, GANs can produce realistic images of diseased leaves, helping to overcome the challenge of limited data availability.

Zhu et al. (2020) Synthetic images of cotton leaves affected by disease were created using GANs and subsequently employed to train a CNN model. This method, when combined with real-world data, resulted in a 5% improvement in the model's accuracy[22].

4. DATASETS FOR COTTON LEAF DISEASE DETECTION

The effectiveness of deep learning models heavily relies on the quantity and quality of datasets employed for training and validation purposes. In cotton leaf disease detection, researchers have made use of various datasets.

4.1 PlantVillage Dataset

The PlantVillage dataset is a publicly available collection of over 50,000 images of healthy and diseased leaves from various crops. It has been widely used for training deep learning models in plant disease detection, including cotton leaf diseases[23].

Advantages: Large number of images with annotations, making it a reliable dataset for training CNN models.

Disadvantages: Limited variability in real-world conditions such as lighting, occlusion, and background noise.

4.2 Custom Datasets

Several studies have collected custom datasets for cotton leaf disease detection. For example, Wang et al. (2021) created a dataset of 10,000 images of cotton leaves affected by bacterial blight, Alternaria leaf spot, and leaf curl virus. These datasets are often collected from farms and represent real-world conditions, making them more suitable for training models that generalize well to practical applications[24].

Table 3: Comparison of Cotton Leaf Disease Datasets[25]

Dataset	Number of Images	Diseases Covered	Publicly Available
Plant Village	50,000+	General (including cotton)	Yes
Custom (Wang et al.)	10,000	Blight, Alternaria, Leaf Curl	No
Custom (Zhao et al.)	8,000	Verticillium Wilt, Bacterial	NO

Table 3 compares key datasets used for cotton leaf disease detection.

5. CHALLENGES AND LIMITATIONS

Despite the promising results of deep learning models in cotton leaf disease detection, several challenges remain:

5.1 Dataset Scarcity and Class Imbalance

Cotton leaf disease datasets are often small and imbalanced, with some diseases being overrepresented while others are underrepresented. This can result in biased models that perform poorly on underrepresented disease classes. Transfer learning and data augmentation techniques like GANs can help mitigate this issue, but more diverse and comprehensive datasets are needed for robust model training[26].

5.2 Environmental Variability

Real-world conditions such as varying lighting, backgrounds, and leaf occlusion can impact the performance of deep learning models. While most datasets are collected under controlled conditions, models must be able to generalize to varying field environments for practical deployment[27].

Figure 4 shows the impact of different environmental conditions on cotton leaf disease detection accuracy[28].

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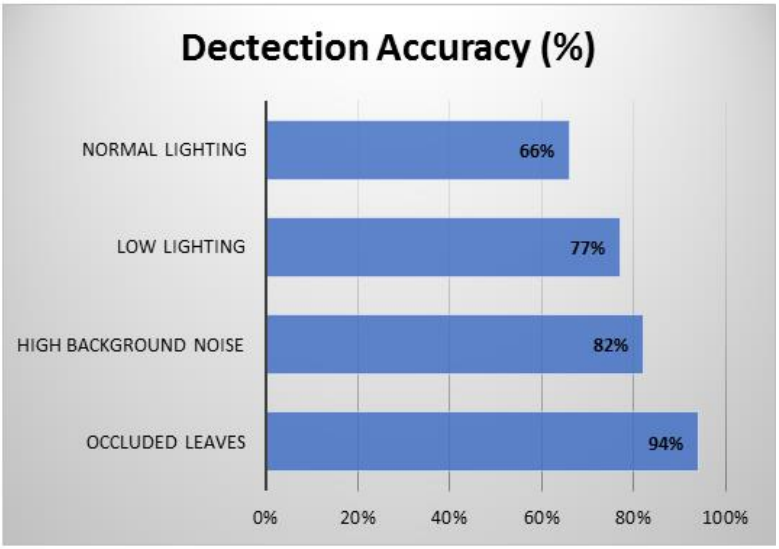

Figure 4: Impact of Environmental Conditions on Detection Accuracy

5.3 Lack of Explainability

Deep learning models, particularly CNNs, are often considered "black boxes" because they provide little insight into how they make decisions. This lack of interpretability can be problematic in agricultural applications, where farmers need to trust the model's predictions. Recent advances in Explainable AI (XAI) seek to address this issue by providing insights into model behavior and decision-making processes[29].

6. FUTURE PERSPECTIVES

Advancements in cotton leaf disease detection are expected to involve combining deep learning techniques with cutting-edge agricultural technologies.

Research in this field is likely to explore several promising avenues, including:

6.1 UAVs and Precision Agriculture

Unmanned Aerial Vehicles (UAVs), or drones, are increasingly used for monitoring large agricultural fields. UAVs equipped with high-resolution cameras can capture images of entire cotton fields, which can then be analyzed by deep learning models to detect disease outbreaks at scale. Integrating UAVs with AI systems offers a scalable solution for real-time disease detection and management[30].

6.2 Explainable AI (XAI)

As discussed, explainability is critical in building trust in AI systems. Future research should focus on developing interpretable models that allow farmers to understand the reasoning behind disease predictions[31]. This can be achieved through techniques such as attention mechanisms, feature visualization, and saliency maps.

Figure 5 shows a proposed framework for integrating XAI techniques in cotton leaf disease detection[32].

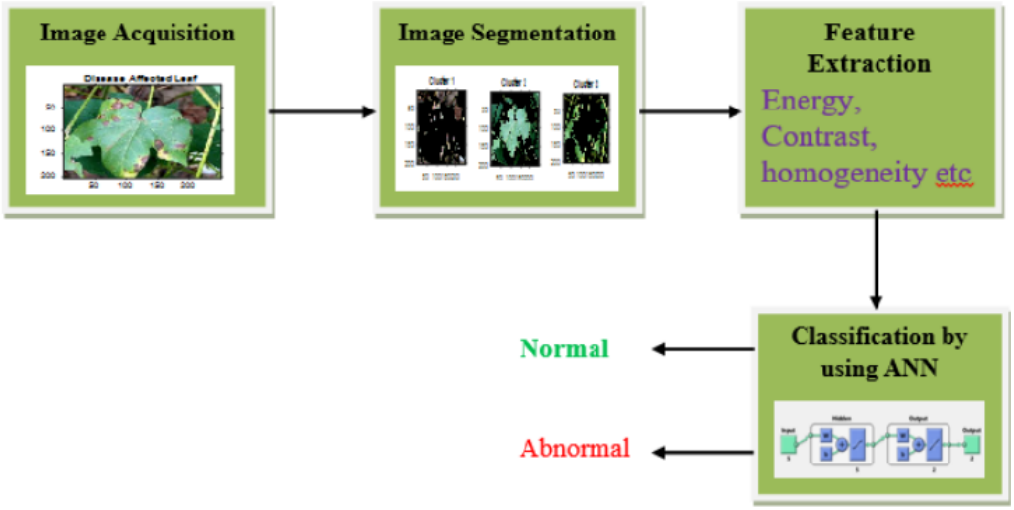

Figure 5: Framework for Explainable AI in Disease Detection

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7. CONCLUSION

Deep learning has shown tremendous potential in advancing the detection of cotton leaf diseases, with models such as CNNs and transfer learning demonstrating high accuracy in classification tasks. However, challenges such as dataset scarcity, environmental variability, and lack of interpretability remain. Future research should focus on developing more robust models by incorporating explainable AI techniques and integrating deep learning with precision agriculture tools like UAVs. By addressing these challenges, deep learning can play a key role in enhancing cotton disease management, ultimately improving crop yields and sustainability in agriculture[33].

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A STUDY ON QUALITY OF WORKLIFE AMONG WOMEN PROFESSORS IN MADURAI

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ABSTRACT
Quality of work-life (QWL) is a multidimensional and context-dependent concept shaped by temporal, cultural, and socio-personal factors (Sirgy et al., 2001). At its core, Quality of Worklife aims to foster a supportive work environment that upholds employee dignity, nurtures creativity, and promotes professional development (Walton, 1973). This research focuses on female faculty members in Madurai's arts and science colleges, investigating their work-life quality experiences. A central purpose of this study is to analyze the variables that contribute to quality of work life for female college professors. Thus many factors like Stress, worklife balance, job satisfaction and leadership like this are taken for the study. A mixed-methods approach was adopted, utilizing percentage analysis, descriptive statistics, correlation, and regression analysis to interpret the data. The study reveals that employers must pay greater attention to minimizing stress for women in the workplace. Findings highlight unique challenges faced by women in academia, such as societal expectations, dual caregiving roles, and workplace biases, which significantly impact their quality of worklife. It also suggested that the organizations may consider developing the leadership qualities of women working in organization as this factor has a direct positive impact on quality of worklife. Additionally the study suggests institutional interventions, such as mentorship programs, flexible work policies, and stress reduction initiatives, to enhance quality of worklife for women professors.

Keywords: *Stress, Worklife balance, job satisfaction, leadership and Quality of worklife.*

INTRODUCTION
One of the significant changes witnessed in the labor market in India has been the entry of women employees are rapidly growing in various sectors. Women who pursue professional careers while simultaneously fulfilling traditional homemaking responsibilities face significant challenges in maintaining work-life equilibrium. Thus, it may lead to cause stress. Stress is inevitable in today's complex life. From the moment of birth until the end of life, individuals constantly face a variety of stressful experiences Indian women have traditionally emphasized on home making and worked within the framework of the family system. However with the changing social dynamics, women are joining the workforce in big numbers. As such they have to maintain balance and the quality in two spheres, the family life and the professional life (Kalra & Rethinam , 2008).

The United States Department of Health, Education and Welfare commissioned research on this matter, resulting in the influential 'Work in America' report. Concurrently, rising inflation compelled government action on these workplace concerns. Accordingly, a Federal Productivity Commission was established. This commission actively supported numerous quality of work life initiatives through a unique collaboration between two institutions: the established University of Michigan Quality of Work Program and the newly formed National Quality of Work Center. Historical records show the term "Quality of Work Life" first entered American academic and public discourse in the 1970s, with Professor Louis Davis recognized as its originator. The movement gained international recognition when scholars convened the first global conference dedicated to this concept in Toronto (1972), establishing Quality of Worklife as a legitimate field of study. The international council for quality of work life was established in 1972(Elizur,1990). Post-1980, organizational strategies progressively shifted focus toward worker-centric productivity.

In the Indian context, quality of work life (QWL) serves as both a philosophical framework and a practical methodology for workplace transformation. This approach enhances operational efficiency at the micro-level by optimizing and developing human capital potential. The increasing global attention toward quality of work life was demonstrated by the substantial participation at the second International QWL Conference in Toronto (1981), which attracted 1,500 delegates. A notable demographic shift was observed, with practitioners (750 management professionals and 200 union representatives) outnumbering scholars, consultants, and policymakers. In contemporary organizational discourse, quality has evolved from a specialized term to a fundamental business necessity critical for long-term viability. In the mid 1990s till today faced with challenges of economize and corporate restructuring, quality of worklife is reemerging where employees are seeking out more meaning where rising educational levels and occupational aspirations in today's slow economic growth

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and reduced opportunities for advancement, naturally, there are rising concerns for quality of worklife and for career and personal life planning. (Havlovic,1991)

Thus the quality of worklife is multi- faced concepts which means having a work environment where an employee's activities become more important by implementing procedures or polices that make the work as a favorable activity and more rewarding . A high quality of worklife is essential for better performance at work and thus for successful and satisfied life. The quality of worklife is the quality of relationship between employees and total working environment. Those who enjoy their career are said to have a high quality of worklife, while those who are unhappy are said to have a low quality of worklife. The quality of worklife considers the people as an "asset" to the organizations rather than as "costs".(Saraji 2006)

Since there is a change in workforce more women employees are getting employed in all sectors. Thus study targets the women professors working in arts and science colleges in Madurai District and examines their quality of worklife experiences. The aim of the present research is under taken to identify the variables which cause impact over quality of worklife among women professors.

2 OBJECTIVES

1) To study the socio - demographic profile of women professors in arts and science colleges in Madurai district.
2) To study the influencing variables with regard to the quality of work life.
3) To develop a model for stress of women professors on quality of worklife variables.
4) To Study the overall level of quality of worklife.

3 STATEMENT OF THE PROBLEM

The role of working Women was changed throughout the world due to economic conditions and social demands. Thus the working women faced several though challenges in maintaining a balance between their Professional and Personal life. The people who enjoy to do the job is only having a high Quality of work life. The Quality of work life in an organization is essential for the smooth running and success of its employees (Delina,2007).The Work –Life Balance must be maintained effectively to ensure that all employees are running at their Peak Potential and free from stress and Strain. Quality of work life helps the employees to feel secure. The researcher has made an attempt in this regard and has undertaken the current study to analyze the Quality of Work life among Women Professors who are working in arts and science colleges in Madurai.

4 REVIEW OF LITERATURE

Castillo and Cano's (2004)[1] the study sought to investigate the suitability of one-item versus a multi-item measure of overall job satisfaction. The research findings indicated that teaching staff expressed overall contentment with their employment. A gender disparity emerged, however, with male faculty reporting higher satisfaction levels than their female counterparts. Among various job elements, the nature of the work itself served as the primary source of motivation, while physical working conditions proved least inspiring. Three key factors - acknowledgment from others, leadership quality, and interpersonal connections - accounted for differences in satisfaction levels among staff members. Interestingly, single-question assessments of job satisfaction yielded comparable results to more comprehensive multi-item evaluations.

Rajib Lochan Dhar (2008)[2] Has suggested that contending with stressful situations in the workplace is a common occurrence for the bus drivers leading to deterioration in their quality of work and life. These findings also extend the conceptual framework of quality of work life beyond the notions of stress, work load, and time pressure dealt with in previous research. The interpretive nature of his study allowed the exploration of the extent to which participants experience stress during their work and their perceptions of their quality of work life.

Ebrahim Kheradmand (2010)[3] study explore the relationship between Quality of Work Life and Job satisfaction of employees. The study operationalizes Walton's QWL framework to measure employee perceptions across eight critical domains: remuneration fairness, occupational health and safety provisions, career growth potential, workplace social dynamics, role balance between professional and personal life, organizational social integration, compliance with institutional norms, and human capital development opportunities. Collectively, these elements constitute the operational definition of enhanced work life quality in the current investigation

Mehdi Hosseini (2010)[4] emphasized that while career success, job satisfaction, and work-life balance are crucial for achieving optimal Quality of Work Life (QWL), an effective work system itself serves as a powerful motivational tool and a pathway to job enrichment. The study further highlighted that equitable compensation,

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professional development opportunities, and consistent career advancement significantly enhance employee performance, thereby contributing to improved QWL..

Kian-Sam Hong, Kok-Wah Tan & Suraini Bujang, (2010)[5] investigated the connections between quality of work life (QWL) and key occupational factors such as work commitment, stress, and job satisfaction. Their study found that while QWL significantly influenced these variables, no notable variations existed based on demographic factors (e.g., age, experience). However, when analyzing work commitment by gender, the researchers observed significant differences in engagement levels.Additionally, their findings indicated that work-related stress and job satisfaction remained consistent across demographic groups. Interestingly, the study reported no strong correlations between work commitment, stress, and satisfaction. The researchers emphasized that enhancing teachers' QWL not only improves their professional well-being but also positively impacts student learning outcomes.

Rochita Gangly, Mukherjee,(2010)[6] aimed at employees' perceptions of work-life quality, their job satisfaction levels, and the relationship between these two factors. The findings reveal that participants viewed certain aspects of their work environment as unsatisfactory, particularly regarding top management support and autonomy in their roles. However, they expressed ambivalence toward other dimensions, such as opportunities for personal growth and job complexity, which showed a mild tendency toward negative perceptions.

Alireza Bolhari (2011)[7] studied relationship of workers job satisfaction with their perception about existing organizational climate. Results revealed that perceived organizational climate effects workers job satisfaction significantly. Workers perceiving organizational climate as democratic had increase in job satisfaction as compared to those who perceived organizational climate as autocratic or undecided.

The aim of research of Sakthivel Rania and Selvarania (2011)[8] was to analyze the relationship between employee satisfaction and work/life balance. The research model examines multiple factors including professional advancement opportunities, recognition, assigned duties, salary, benefits, leadership-employee dynamics, workplace satisfaction, and personal-professional equilibrium. Findings suggest that high correlation exists between work task and employee satisfaction with a mediator variable namely work-life balance.

Sowmya and N. Panchanatham (2011)[9] has studied job satisfaction of employees in new private sector and select public sector banks specifically in the banking sector of the main metropolitan city Chennai. The study employed principal component analysis to identify key factors influencing job satisfaction among banking sector employees. Results revealed that workers exhibit a strong preference for supportive leadership and a positive work environment. Based on these findings, the research recommends that organizations prioritize employee well-being through targeted counseling and personalized care initiatives to enhance job satisfaction.

5 RESEARCH METHODOLOGY

5.1 Research Design
The researcher has adopted descriptive design, thus the population is the women professors working in arts and science colleges in Madurai. The study measures the quality of worklife among women professors. This is a descriptive research because it aims at describing the relationship of quality of worklife and its factors.

5.2 Data Collection Tools
This study includes both primary and secondary data for a thorough examination. Primary data was collected using standardized, objective questionnaires, while secondary data was obtained from published journals, research articles, and online sources

5.3 Sample Design
The sampling unit in this study is women professors who are working in different arts and science colleges in Madurai. Sample size is arbitrarily determined as 240.

5.4 Sampling Technique
The snowball sampling has been chosen for this study.

5.5 Statistical Tools Used
The collected data was classified and further analysis was done with the help of statistical tools like Percentage Analysis, Descriptive Statistics, correlation and multiple regression analysis.

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6 ANALYSIS AND FINDINGS

Table 4.1.1: Frequency Analysis of Age, Religion, Education, Designation and Marital Status of Respondents

Socio Economic Profile	Level	Frequency	Percentage %
Age (in years)	20-30	50	20.83
	31-40	69	28.75
	41-50	72	30.00
	Above 50	49	20.42
	Total	240	100.00
Religion	Hindu	125	52.08
	Muslim	95	39.58
	Christian	20	8.33
	Total	240	100.00
Education	Ph.D	130	54.17
	Ph.D with NET/SET	76	31.67
	PG with NET/SET	34	14.17
	Total	240	100.00
Designation	Assistant Professors	187	77.92
	Associate Professors	53	22.08
	Total	240	100.00
Marital status	Married	163	67.92
	Unmarried	55	22.92
	Widower	10	4.17
	Divoced	12	5.00
	Total	240	100.00

- It can be observed from the above table that the total sample of 240 respondents taken for study constitute 72 respondents belong to the age group of 41 – 50 (about 30 per cent), 125 respondents (52.08 per cent) belonging to Hindu religion, 130 respondents (about 54.17 per cent) were having Ph.D degree, 187 respondents (77.92 percent) working as assistant professors , 163 respondents (about 67.92 per cent) were Married.

Table 4.2 Descriptive Statistics of Study Variables

Variable	N	Minimum	Maximum	Mean	Standard Deviation
Stress	480	3.42	5.00	4.5765	.29781
Work Life Balance	480	2.50	5.00	4.1693	.63896
Leadership	480	1.40	5.00	4.1567	.25805
Job Satisfaction	480	2.83	5.00	4.2563	.49223

The above table shows that the respondents expressed highest mean level of agreement on the factor stress (4.57) with standard deviation 0.2978. This means that the majority of women professors in Madurai District strongly agree that stress is a significant factor affecting them. The small standard deviation suggests that there is little variation in their responses, meaning most respondents consistently expressed high agreement regarding the impact of stress. Also the respondents expressed their least level of agreement on the factor Leadership (4.15, 0.258) proceeded by worklife balance (4.16, 0.6389). This means that though women professors in Madurai agree that the low variation in Leadership scores suggests a shared perception that leadership support is adequate but not outstanding., their mean level of agreement on this factor is comparatively less than the other factors. It can also be noted that working women in Madurai have comparatively the higher variation in Work-Life Balance indicates mixed experiences, with some women professors managing well and others facing challenges. It may suggest that the colleges in Madurai district may need to enhance leadership qualities (e.g., mentorship, inclusivity) to better support women professors. Flexible work arrangements, childcare support, or workload adjustments could help reduce disparities in work-life satisfaction.

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Model Development for Stress

Multiple regression analysis is used to fit a model for the dependent variable Stress of working women in Madurai district on the independent variables Worklife balance, Leadership and Job Satisfaction.

H_0: There is no significant combined effect of Quality of worklife variables on the Stress of college professors in Madurai district.

H_1: There is a significant combined effect of Quality of worklife variables on the Stress of college professors in Madurai district.

The level of agreement of working women in Madurai district on different factors of quality of worklife of organizations in which they are working and also their stress level were measured on a 5-point scale with 1 being the lowest level and 5 being the highest level. The following table gives the correlations among the variables taken for study. It can be seen from the table that the dependent variable stress has significant moderate positive relationship with the variables Job Satisfaction (.413) and Leadership (.553) and low negative relationship with the variables Work life balance (-.114). It can also be observed that there is moderate positive relationship between the independent variables Job Satisfaction and Leadership As there is some relationship among the independent variables and in order to remove the multicollinearity, stepwise regression is used to build a model for stress on the quality of worklife variables.

Table 4.16 Correlations

	Stress	WLB	LEAD
WLB	-.114		
LEAD	.553	-.052	
JOB SAT	.413	-.358	.220

The SPSS software had performed iteration to include the variables one by one in the stepwise process and the following Table gives the model summary of the model fitted through SPSS software. It can be observed from this table the value of R-Square is .332, (adjusted R-square of .312) which means that about 33 per cent of the variation in the dependent variable stress was explained by the three independent variables Leadership, Job satisfaction and worklife balance.

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.576[a]	.332	.312	.329
a. Predictors:(Constant) Leadership, Job satisfaction and worklife balance				
b. Dependent Variable: Stress				

The high value of F (5,169) = 16.786 with low p-value <.001 verify that the model is statistically significant in explaining the variation in performance of working women professors in Madurai district.

ANOVA

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	335.596	3	67.119	16.786	.000[a]
	Residual	675.752	237	3.999		
	Total	1011.349	240	67.119		
a. Dependent Variable: Stress						
b. Predictors: (Constant) Leadership, Job satisfaction and worklife balance						

Table 4.3 (c) gives the coefficients of the independent variables included in the model. The fitted model for the dependent variable stress is expressed by the equation:

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Stress = 4.76 +.220 Job satisfaction –.053 worklife balance +.190 Leadership Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.76	.270		-.149	.000		
	Job Satisfaction	.220	.092	.269	3.480	.000	.619	1.737
	WLB	-.053	.059	-.048	-.732	.000	.559	1.848
	Leadership	.190	.090	.158	2.108	.000	.621	1.684
a. Dependent Variable: Stress								

The independent variables involved in the study are significantly explaining the variation in employee performance ($p < .01$). The Job Satisfaction and Leadership have a significant positive impact on Stress of the employees and the variable Worklife Balance have a significant negative impact on employee stress.

The beta (standardized coefficient) value signifies the order of impact of the independent variables. The high value of standardized beta coefficient for the variable Job Satisfaction (beta=.269) indicates that the dependent variable employee stress is highly influenced by the variable job satisfaction, followed by the other independent variable Leadership (beta = .158). The variable work life balance (beta = -.048) has the least negative effect on employee stress.

QUALITY OF WORK LIFE (QWL) INDEX

To study the Quality of Work Life of working women in Madurai district, a QWL Index was prepared. For this purpose, the working women in Madurai district were subjected to 20 questions under four categories of work-life viz., Job Satisfaction (comprising of five questions), Stress (comprising of five questions), Leadeship (comprising of five questions) and Work-life balance (comprising of five questions). The respondents were asked to express their level of agreement on these question on a 5-point Likert scale, 1 being the lowest level through 5 being the highest level of agreement. The responses were tested for reliability and few questions which were not contributing to the total variation for their corresponding factor were removed and the reliability was found to be good and already discussed under the sub-topic Test of normality. The grand average level of agreement of all the factors of QWL taken for study was considered for computation of QWL Index for working women in Madurai district.

The QWL Index was calculated for the entire sample size of 240 respondents and the same were classified under three categories such as High, Medium and Low based on the QWL index. The mean score and standard deviation of QWL index was found to be 4.368 and 0.148 respectively. The classification of respondents were made on statistical basis with respondents above Mean + One Standard Deviation of QWL index were classified as having "High" level of Quality of Work Life, the respondents below Mean – One Standard Deviation of QWL index were classified as having "Low" level of Quality of Work Life and the respondents having their QWL index between these two values were classified as having "Medium" level of Quality of Work Life. The criteria for classification of respondents are depicted in the following table.

Table 4.15: Criteria for Classification of respondents based on QWL Index

Category	**High**	**Medium**	**Low**
Criteria	**4.368 + 0.148** (Above 4.515)	(Between 4.220 and 4.515)	**4.368–0.148** (Below 4.220)

The classification of working women according to their QWL index is depicted in the following Table

Classification of respondents based on their QWL Index

QWL category	Frequency	Percent	Cumulative Percent
Low	22	9.2	9.2
Medium	173	72.08	81.25
High	45	18.72	100.0
Total	240	100.0	

It can be observed from the table that out of 240 working women, 22 (about 9 per cent) working women were classified as having "**Low**" level of QWL, 45 (about 19 per cent) working women were classified as having

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"**High**" level of QWL, and the remaining 173 (about 72 per cent) were classified as having "**Medium**" level of QWL.

FINDINGS

I Findings through demographic profile

- 30% of respondents belong to the age group of 41 – 50
- 125 respondents (52.08 per cent) belonging to Hindu religion
- about 54.17 per cent of women professors were qualified with Ph.D degree
- 187 respondents (77.92 percent) were assistant professors
- More than 65 % of respondents were Married.

II Findings on the factors of Quality of work life

- The low standard deviation indicates uniformity in responses, meaning nearly all respondents experience high stress levels.
- Moderate agreement that leadership support is present, but not highly satisfactory. The low standard deviation suggests consistent perceptions, most respondents feel leadership could be improved.
- Mixed experiences, with some managing well and others struggling while maintaining the worklife and their family life.

III Findings on the relationship between the factors of study

- The factor Employee stress of working women is highly positively influenced by the factor Job Satisfaction, followed by Leadership. The factor worklife balance has the highest negative effect on employee stress. This implies that Job Satisfaction is the strongest stress reliever because it fosters resilience and engagement. Also, more is the level of agreement on the factor Work-Life Balance is the top stress driver due to its direct impact on personal well-being.

IV Findings on Quality of Work Life Index

- The majority of working women (173 out of 240) perceive their QWL as moderate (neither high nor low). This suggests that while their work conditions are not severely problematic, there is significant room for improvement to elevate QWL to a "High" level.

CONCLUSION AND SUGGESTION

The organisations may conduct Workshops on mindfulness, time management, and coping strategies. Organise some skill enhancement programs to develop empathetic, inclusive, and supportive leadership styles. The study highlights stress as a critical issue, while leadership and work-life balance need targeted interventions. Implementing supportive policies, leadership development, and flexible work options can significantly improve job satisfaction and productivity among women professors in Madurai.

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ANALYTICAL REVIEW OF UNDERWATER IMAGE ENHANCEMENT BASED TECHNIQUES

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ABSTRACT
By investigating the underwater environment, new resources can be used in the fields of food, energy, medical science, object monitoring, etc., as well as military protection. Humans' reliance on the priceless resources found beneath the surface has led to an increase in underwater research. The blur, haze, noise, and colour cast coefficients deteriorate underwater images. The scattering and absorption of light beneath the water is what causes these factors. As a result, during the past few decades, study in the field of the underwater environment has increased. The underwater image-enhancing methods, datasets, and assessment metrics are thoroughly highlighted in this review study along with their applications and drawbacks.

Keywords: *Underwater Image, Enhancement, Deep Learning, Scattering*

INTRODUCTION
Underwater imaging is essential for applications including marine biological research, underwater archaeology, and deep-sea exploration. However, photographs taken underwater can decay due to the unique properties of the medium. Light absorption and scattering in water may produce images that are low contrast, fuzzy, and dominated by a single hue cast. These problems make it more difficult to discern features and reduce the effectiveness of subsequent image processing activities like object detection and recognition. In the past, a variety of technologies, such as color correction, filtering, and histogram equalization, have been used to enhance underwater images [1]. Histogram equalization distributes intensity values to improve contrast; however, it often suffers from color casting. While filtering methods like bilateral and median filters [2] reduce noise and improve image smoothness, they can also cause undue smoothing and information loss. Although they sometimes do not fully fix the colour cast, colour correction procedures evaluate and eliminate the water's hue from the image. Despite these tactics, the complex degradation effects shown in underwater photographs are often not sufficiently resolved by traditional techniques. The development of increasingly complex methods, like deep learning, is necessary to address these problems. Recent developments in underwater picture enhancement have been made possible by the advent of deep learning. Deep learning algorithms frequently outperform conventional techniques and can correct complex degradation effects brought on by big datasets.

RELATED WORK
In this section, we are presenting the literature review on underwater image enhancement approaches developed by various researchers or scientist in which some them are describing below:

Abin Det al. (2024) presented the experiment on various combinations of algorithms to determine the fusion method that produces consistent and intended results. Techniques explored include dehazing with boundary constraint and contextual regularization, integrated color models, gray world

adjustment, and histogram equalization, along with their combinations, to identify the fusion method that demonstrates the greatest improvement. The results indicate that, despite variations in the quality of input images, the proposed fusion procedure consistently delivers superior outcomes [3]. Yang C. et al. (2024) introduced a model named AquaAE for image restoration. This model adopts a simple autoencoder structure, utilizing skip connections to merge features from the encoder and decoder, and incorporates a red channel enhancement to improve image restoration quality. Their model demonstrates outstanding computational efficiency, with its FLOPs being only 2.6% of Twin-UIE's (1.32G) and its parameter count merely 2.8% of U-Transformer's (0.88M), highlighting the lightweight nature of the model [4]. Wang, J. [2023) suggested a method to restore these images utilising information solely from the captured image. The presented model conducts colour restoration and detail stretching on the input image post-preprocessing, and subsequently delivers the resulting image via a weight-assisted image fusion process. They conducted tests on over 11,270 images from EUVP, R165 and UIEBD datasets. The combined outcomes of the PSNR, SSIM, MSE and UCIQE metrics produced results of 20.9711, 0.8254, 74.3698 and 0.5643, respectively. It is worth noting that certain metrics outperformed comparable models, such as DHE, IBLA, and WB [5]. Lin, Y., et al. (2023) developed an underwater color restoration system based on two deep-learning network architectures. We enhanced the quality of underwater images and explored the use of generative adversarial networks (GANs) for automatic coloring. They compensated for the absorbed red light in underwater environments to improve the color representation of restored images. They combined the WaterNet and neural colorization networks and retrained them to achieve

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the goal of color restoration. We evaluated the results by observing color palettes and conducted corresponding analyses using k-means, CIE-2000, and percentage differences in color channels [6].Li, G., et al.(2023) employed multi-layered supervisory mechanisms for supervising the model, namely: a reconstruction loss is employed to supervise the J-Net network to emphasize the ability of the potential components to reconstruct the input image; a consistency requirement is applied to guide the A-Net network, ensuring that both the initial underwater photo and the reprocessed image maintain analogous structural tiers. Additionally, a color correction loss is employed to rectify any color deviations in the restored image. Test outcomes indicate that the UAUIR technique delivers commendable results in restoring underwater images, showcasing efficient recovery quality and processing speed [7]. Ning Wang et al. (2023) exclusively suppress un-useful underwater noise feature and effectively avoid over enhancement, simultaneously, an underwater attentional generative adversarial network (UAGAN) is innovatively established. Main contributions are as follows: combining dense concatenation with global maximum and average pooling techniques, a cascade dense-channel attention (CDCA) module is devised to adaptively distinguish noise feature and recalibrate channel weight, simultaneously, such that low-contribution feature map can be effectively suppressed; to sufficiently capture long-range dependence between any two nonlocal spatial patches, the position attention (PA) module is created such that the deviation among independent patches can be sufficiently eliminated, thereby avoiding over enhancement; and in conjunction with CDCA and PA modules, the entire UAGAN framework is eventually developed in an end-to-end manner. Comprehensive experiments conducted on underwater image enhancement benchmark (UIEB) and underwater robot professional contest (URPC) datasets demonstrate remarkable effectiveness and superiority of the proposed UAGAN scheme by comparing with typical underwater image enhancement approaches including unsupervised color correction method, image blurriness and light absorption, underwater dark channel prior, underwater generative adversarial network, underwater convolutional neural network, and WaterNet in terms of peak signal-to-noise ratio, underwater color image quality evaluation, underwater image quality measures, etc.[8]. Xinjie Li et al (2022) propose a novel scheme by constructing an adaptive color and contrast enhancement, and denoising (ACCED) framework for underwater image enhancement. In the proposed framework, Gaussian filter and Bilateral filter are respectively employed to decompose the high-frequency and low frequency components. Benefited from this separation, they utilize soft-thresholding operation to suppress the noise in the high frequency component. Accordingly, the low-frequency component is enhanced by using an adaptive color and contrast enhancement (ACCE) strategy. They derived a numerical solution for ACCE and adopt a pyramid-based strategy to accelerate the solving procedure. Experimental results demonstrated that our strategy is effective in color correction, visibility improvement, and detail revealing [9]. Martinho, L. A., [22] proposed an underwater image enhancement approach to improve the quality of underwater images through the fusion of image transformation methods. To validate the proposed methodology, experiments using real-world underwater images were carried out. From qualitative and quantitative analysis they demonstrated the accuracy and effectiveness of the proposed approach. For the Peak Signal-to-Noise Ratio (PSNR) metric the obtained result is 23.185. Meanwhile, for the Structural Similarity Index (SSIM) metric the obtained result is 0.859, outperforming state-of-the-art underwater image restoration techniques [10]. Sequeira, G., &Mekkalkiv, P. (2021) propound an innovative algorithm utilizing image restoration and image enhancement techniques, into a single algorithm for underwater image processing. Our image restoration algorithm is a modified approach based on automatic red channel algorithm for the blue channel, since the red color channel does not always have the least intensity underwater. To refine the contrast of the image, we use a modified Integrated Color Model for image enhancement. Results of the proposed algorithm show realistic, high contrast and clear underwater images as compared to other algorithms for the same set of images. To validate our enhanced results, we have used entropy and histogram analysis as a metric for quantitative analysis [11]. Li, X., et al.(2020) proposed a hybrid framework for underwater image enhancement, which unifies underwater white balance and variational contrast and saturation enhancement. In our framework, the improved underwater white balance (UWB) algorithm is integrated with histogram stretching, aiming to better compensate the attenuation difference along the propagation path and remove undesired color castings. In addition, a variational contrast and saturation enhancement (VCSE) model is developed based on the enhanced result obtained from UWB. The advantages of VCSE model lie in the improvements of contrast and saturation as well as the elimination of hazy appearance induced by scattering. Moreover, we design a fast Gaussian pyramid-based algorithm to speed up the solving of VCSE model. The improvements achieved by our method include the more effective in color correction, haze removal and detail clarification. Extensive qualitative and quantitative assessments demonstrate that the proposed approach obtains high quality outcomes, which outperforms several state-of-the-art methods [12].

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Table 1: Summary of The Above Literature Review

Author Name	Technology	Results	Advantages	Disadvantages
Abin, D. et al. (2024)	Fusion of dehazing, histogram equalization, gray world adjustment, etc.	Consistent superior image enhancement	Enhanced visibility and improved image quality across variations	Dataset information missing; computational cost not discussed
Yang, C. et al. (2024)	AquaAE (Autoencoder with skip connections and red channel enhancement)	High efficiency, only 2.6% FLOPs of Twin-UIE and 2.8% parameters of U-Transformer	Lightweight model, fast processing	Dataset not specified; effectiveness on different underwater conditions unclear
Wang, J. et al. (2023)	Weight-assisted image fusion, color restoration, detail stretching	PSNR: 20.9711, SSIM: 0.8254, MSE: 74.3698, UCIQE: 0.5643	Outperforms DHE, IBLA, WB models in various metrics	May not generalize well to all underwater conditions
Lin, Y. et al. (2023)	GAN-based automatic coloring and color restoration	Improved color representation and image enhancement	Effective in restoring absorbed red light in underwater images	Dataset not mentioned; potential overfitting due to GAN training
Li, N. et al. (2023)	Attention-driven unsupervised underwater image enhancement	High-quality restoration with efficient processing	No labeled data required; effective enhancement	Dataset missing; validation across multiple conditions not shown
Wang, N. et al. (2023)	Underwater Attentional GAN (UAGAN) with CDCA and PA modules	Superior enhancement performance on UIEB & URPC datasets	Suppresses noise, avoids over-enhancement, improves quality	Computational complexity may be high
Li, X. et al. (2022)	Adaptive color & contrast enhancement with denoising (ACCED)	Effective color correction, improved visibility & detail	Reduces noise, enhances contrast adaptively	Dataset missing; processing speed details not provided
Martinho, L. et al. (2022)	Fusion of intensity transformation techniques	PSNR: 23.185, SSIM: 0.859	Outperforms state-of-the-art techniques	Requires qualitative & quantitative validation across diverse conditions
Sequeira, G. et al. (2021)	Hybrid image restoration & enhancement, red channel modification	High-contrast and clear underwater images	Realistic image restoration, effective contrast refinement	Dataset not specified; method effectiveness in extreme conditions not assessed
Li, X. et al. (2020)	Hybrid framework (UWB + VCSE for contrast & saturation enhancement)	High-quality image enhancement	Effective haze removal, color correction, & detail enhancement	Processing speed improvements required

Underwater Image Enhancement techniques

Image enhancement is the process of modifying an input image to make it more suitable and visible for its intended use. The image's enhancement modifies its visual impression on the viewer and enhances its information content. Enhancement of images improves their qualities. Draw attention to the image's features, such as its edges, the contrast to create a display of the best photos for analysis and research. Because of the nature of light, underwater photos are of poor quality. The amount of light decreases when it enters the air and disperses in various directions because water is a denser medium than air. Light is refracted, absorbed, and scattered when it enters the water. The dispersion lessens the color contrast and blurs the light. These water-related impacts on underwater photos are caused by the water's characteristics as well as the organisms and other elements. There are various image enhancements techniques available for enhancing the quality of

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underwater image such as Histogram based technique, colour correction-based techniques, Filtering techniques, model-based techniques and deep learning and machine learning techniques.

a. Histogram Based Techniques

There are various histogram-based techniques are available which can improve the quality of image namely, Histogram Equalization (HE)[1], Adaptive Histogram Equalization (AHE)[2] and Contrast Limited Adaptive Histogram Equalization(CLAHE)[3]. Detail description of histogram techniques is given below:

Histogram Equalization(HE)

Histogram compensation is a method of contrast adjustment using image histograms [13]. This method usually increases the global contrast of many images. Particularly when the available data in the image is indicated by a close contrast value. This adjustment allows for better distribution of the histogram intensity. This allows areas with lower local contrast to obtain higher contrast. Histogram equalization leads to this by effectively spreading the most common intensity values. This method is useful for images with backgrounds and foregrounds. Both of these are bright and dark. In particular, this method may lead to better views of bone structure in the x-ray image and better details of the above or underexposed photographs. The main advantage of this method is that it is a rather simple technology and an invertible operator. Therefore, if you know the histogram compensation function, you can restore the original histogram. The calculations are not mathematically intense. The drawback of this method is that it is indiscriminate. Increases background noise contrast and reduces the available signals at the same time.

Adaptive Histogram Equalization (AHE)

Adaptive histogram equalization is a method of enhancing the contrast of an image by dividing it into processing blocks and independently enhancing the contrast of each block, regardless of the dominant image information. This approach is found to be more effective than nonadaptive histogram equalization in improving image quality by adjusting the contrast level.[14]

Contrast Limited Adaptive Histogram Equalization (CLAHE)

It the variant of adaptive histogram equalization, which prevents noise effect by limiting the amplification. The CLAHE algorithm has three major parts: tile generation, histogram equalization, and bilinear interpolation. The input image is first divided into sections [15]. Each section is called a tile. The input image shown in the figure is divided into four tiles. Histogram equalization is then performed on each tile using a pre-defined clip limit. Histogram equalization consists of five steps: calculation of histogram, over calculation, over distribution, over redistribution, and scaling and assignment using the cumulative distribution function (CDF). The histogram is calculated as many containers for each tile. Histogram bin levels higher than the clip limit are accumulated and distributed in other containers. The CDF is then calculated for the histogram value. The CDF value for each tile is scaled and displayed using the pixel value of the input imaging pixel. The resulting tiles are sewn together using bilinear interpolation to create a starting image with improved contrast.

Table 2: Comparison Betweek Various Histogram Based Techniques

Histogram Equalization	Adaptive Histogram Equalization	Contrast Limited Adaptive Histogram Equalization
This approach enhances the contract by redistributing intensity value across complete image.	This approach split the large image into small image and then apply the histogram locally	It is similar to adaptive histogram equalization but it limits the amplification of noise
This approach can be applied in whole image(globally)	This approach can be applied in partial image(locally)	It is similar toAHE but it limits the contrasting
The noise sensitivity generated in this approach is uniform for whole image	The noise sensitivity generated in this approach is not uniform for whole image. It may vary from region to region	Best for Medical Imaging, low-light images and images with noise
This approach can produces the unnatural brightness and excessive contrast	It amplify noise and creates artifacts	This approach helps in limiting or reducing the over brightness and noise artefacts.
It is low in processing	Its processing is higher than HE	Its processing in also high but it optimized the noise control

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b. Color correction-based method

Gray-World Correction

The gray world approach assumes the average color of an image is some predefined value of "gray," for example, half the value of the maximum intensity for each color component, i.e., (128,128,128) [16]. Based on this assumption, image colors are corrected through the following normalization:

$$R_n = R_o * 128/\bar{R}$$
$$G_n = G_o * 128/\bar{G}$$
$$B_n = B_o * 128/\bar{B} \quad (1)$$

where, (Ro, Go, Bo) is the original color, (R, $\bar{G}$, $\bar{B}$) is the average color, and (Rn, Gn, Bn) is the corrected color. One might also consider the use of the average color components (R, $\bar{G}$, $\bar{B}$) from an arbitrary reference camera, and use these, rather than the fixed value (e.g. 128) as the normalizing term. However, this may suffer problems if the reference camera's color distribution is not well balanced.

White Patch

The white patch approach is similar to the gray world method but assumes that the maximum value of each channel should correspond to full white, i.e. (255, 255, 255) [4]. Image colors are corrected through the following normalization:

$$R_n = R_o * 255/R_m$$
$$G_n = G_o * 255/G_m$$
$$B_n = B_o * 255/B_m \quad (2)$$

where, (Ro, Go, Bo) is the original color, (Rn, Gn, Bn) is the corrected color, and Rm, Gm, and Bm are the maximum observed color components in the three channels, respectively. Again, we may consider using one camera as a reference, with the same caveats as earlier.

Retinex-Based Methods

Retinex theory states an image as a multiplication of the illumination and the reflectance of the object. The characteristics of the illumination depend on the source of illumination[17]. The characteristics of the reflectance depend on the nature of the object. On the basis ofRetinex theory, mathematically we can say, illumination can be estimated by dividing the image with the reflectance. But as we know that, it is impractical to have the information about either illumination or reflectance. It is impossible to estimate the illumination from the image without any prior knowledge about the reflectance. Subsequently, different presumptions and rearrangements about illumination or reflectance or both are proposed to take care of this issue. A typical assumption is that the edges are same for both scene and reflectance, and also assumed that illumination spatially changes gradually in the scene. Due to this, in Retinex based methods mostly, the reflectance is computed as the proportion of the image and smooth version of the image which is treated as the estimation of the illumination. In Retinex based method for image enhancement, we mostly make up for the effect of illumination on the image. On the basis of image formation model of Retinex method:

$$I(m,n)=R(m,n).L(m.n) \quad (3)$$

Where I(m, n) is the image the range of I is in between 0 to 255, R(m, n) is the reflectance of the object the range of reflectance is in between 0 and 1 and L(m, n) is the illumination the range of illumination is also in between the value 0 and 255.

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Table 3: Difference between various color correction basedmethod

White Patch Algorithm	Gray-World Assumption	Retinex-Based Methods
Assumes the brightest area (white patch) in an image should be pure white and adjusts colors accordingly.	Assumes that the average color in an image should be gray, and adjusts the colors to balance them.	Inspired by human vision, enhances contrast and corrects lighting variations in an image.
Identifies the brightest pixels (white regions) and normalizes the image based on them.	Adjusts image colors so that the average intensity across all channels becomes neutral gray.	Decomposes an image into reflectance and illumination components and enhances the reflectance while suppressing illumination effects.
Removes color casts by assuming the brightest object is white.	Assumes overall color should be gray and adjusts all colors proportionally.	Enhances local contrast and adjusts colors based on lighting variations.
Works well when a true white object is present in the scene.	Effective in evenly illuminated images but struggles with strong color dominance.	Good for handling non-uniform illumination and enhancing details.
Fails if no white reference exists in the image.	Struggles with strong color biases (e.g., an underwater image dominated by blue).	Computationally complex and may introduce artifacts in some cases.
Color correction in images where white objects exist.	General color balancing in natural images.	Low-light image enhancement, underwater image enhancement, and shadow correction.

C. Filtering Techniques

Image filtering is a technique used in image processing to improve or modify the visual appearance of an image. For each pixel in a single image, image filtering includes a filter/kernel, allowing you to record a new pixel value based on the value of an existing pixel. Here, filters help define the weights applied to adjacent pixels at the time of the filter method. B. Various image filtering technologies are available, such as anisotrope and two-sided filtering.

Anisotropic Filtering

Anisotropic filtering is an image enhancement technique that improves the appearance of textures, particularly when viewed at oblique angles, by applying different levels of filtering in different directions, effectively preserving details while smoothing out unwanted noise, especially useful in applications like 3D graphics where distant surfaces can appear blurry without it [18].

Bilateral Filtering

Bilateral filtering is an image processing technique used for image enhancement by smoothing out noise in an image while simultaneously preserving sharp edges, making it particularly useful for tasks like denoising images while maintaining important details like object boundaries [19].

Table 4: Comparison between filtering techniques

Anisotropic Filtering (Perona-Malik Filter)	Bilateral Filtering
An edge-preserving diffusion-based smoothing technique that selectively reduces noise while preserving edges.	A nonlinear, edge-preserving smoothing filter that considers both spatial distance and intensity differences.
Uses partial differential equations (PDEs) to iteratively diffuse an image while preserving high-gradient regions (edges).	Uses a combination of spatial Gaussian filtering (for proximity) and range Gaussian filtering (for intensity similarity).
It=∇·(c(x,y,t)∇I)I_t = \nabla \cdot (c(x,y,t) \nablaI)It =∇·(c(x,y,t)∇I), where c(x,y,t)c(x,y,t)c(x,y,t) controls diffusion based on edge gradients.	(I_{filtered}(p) = \frac{1}{W_p} \sum_{q \in \Omega} I(q) \cdot G_s(
Strong edge preservation by controlling diffusion in regions with high gradients.	Preserves edges using a range filter that prevents averaging across intensity discontinuities.
Excellent at removing Gaussian noise while preserving structural details.	Reduces noise while maintaining fine textures and edges.
Higher (iterative process with PDE solving).	Lower than anisotropic filtering (single-pass convolution).

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Can introduce staircase (blocky) artifacts if parameters are not well-tuned.	May introduce slight blurring if parameters are not well chosen.
Medical imaging, texture-preserving denoising, edge-aware smoothing.	Image denoising, cartoon-like effects, HDR tone mapping, and video processing.

D. Machine Learning and Deep Learning Based Method

Convolutional Neural Network (CNN)

CNNs are used for image categorization and recognition because of their high accuracy. The Convolutional Neural Network is a hierarchical model that builds a network in the shape of a funnel, after that produces a fully connected layer. Which is of all interconnected neurons which are connected to one another, and the output is obtained. CNN outperform traditional neural networks using visual, speech, or audio signal inputs [20]. There are three different sorts of layers:

- Convolution layer
- Pooling layer
- Fully connected (FC) layer

The Convolution layers the initial layer of the Convolution network. According to the Convolution layer, you can add more layers of folding or pool layers, but the fully connected layer is the last layer. With each layer, CNN grows more severely and identifies larger portions of the image. The first layer focuses on the most basic aspects, such as color and limitations. When visual data passes through the CNN level, it recognizes larger parts or characteristics of the element and ultimately identifies the target object [21].

Generative Adversarial Network (GAN)

A Generative Adversarial Network (GAN) can be used for image enhancement by leveraging its ability to generate realistic images, allowing it to "improve" the quality of a low-quality or noisy image by creating a new, enhanced version that closely resembles a high-quality image, effectively removing noise, sharpening details, and correcting color imbalances while maintaining the original image content [22].

Table 5: Comparison between CNN and GAN approach for image enhancement

Convolution Neural Networks (CNNs)	Generative Adversarial Networks (GANs)
CNNs use convolution layers to learn and apply enhancement filters to underwater images.	GANs generate high-quality, realistic underwater images by competing between a generator and a discriminator.
Extracts features (edges, textures, colors) and applies transformations to enhance image quality.	The Generator creates enhanced images, and the Discriminator ensures they look realistic.
Improves color correction but may struggle with severe underwater color distortions.	More effective in color restoration, particularly for extreme underwater distortions.
Works well for removing underwater haze and improving contrast, but may lose fine details.	Produces sharper, more natural-looking images with improved contrast.
Removes noise effectively but may introduce over-smoothing.	Better at preserving textures while reducing noise.
Requires a large dataset with labeled ground truth images.	Can be trained in an unsupervised manner using unpaired images.
Less computationally expensive and easier to train.	More computationally demanding due to adversarial training.
Can enhance images but may struggle with extreme distortions and artifacts.	Generates realistic, high-quality underwater images with fine details.
U-Net, ResNet-based CNNs, Underwater Image Enhancement CNNs (UIECNN).	WaterGAN, UGAN, CycleGAN, FUnIE-GAN (Fast Underwater Image Enhancement GAN).
Struggles with extreme distortions and may over-smooth details.	Can suffer from mode collapse (generating similar images) and requires careful tuning.

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E. Fusion Based Method

This image enhancement technique refers to the process of improving an image by combining information from multiple sources (like different wavelengths or perspectives) into a single image, leveraging techniques like wavelet transforms, Laplacian pyramids, or the Intensity-Hue-Saturation (IHS) model to extract the most relevant details from each source, resulting in a more comprehensive and enhanced final image.

Multi-Scale fusion based enhancement

"Multi-scale fusion" in image enhancement refers to a technique where an image is decomposed into different scales (levels of detail), with each scale processed separately, and then the results are combined to create a final enhanced image, effectively capturing and preserving both fine details and overall structure of the original image, often used for tasks like improving low-light or underwater images where contrast and visibility are poor. [23]

F. Dehazing-Based Method

Dehazing-based image enhancement methods utilize algorithms designed to remove haze from an image, effectively improving visibility and contrast by mitigating the effects of atmospheric scattering, making them particularly useful for enhancing images captured in foggy or hazy conditions, thereby revealing more details in the scene. [24]

Dark Channel Prior (DCP)

The Dark Channel Prior (DCP) method is a technique used in computer vision, particularly for image dehazing, which leverages the observation that in most outdoor images, even when hazy, there will always be some pixels with very low intensity values in at least one color channel within a local patch, allowing for the estimation of the haze's transmission map and ultimately removing the haze from the image; essentially, it relies on the fact that "dark channels" exist in non-sky areas of an image, even when hazy, due to the presence of dark objects like shadows or edges [25].

Underwater Dark Channel Prior" (UDCP)

This method refers to a technique used in image processing specifically designed for enhancing underwater images by leveraging the principle that the darkest pixels in an underwater image, typically found in the blue and green color channels, can be used to estimate the transmission map and thereby remove the haze or color cast caused by light scattering in water, effectively improving image quality [26].

Red Channel Prior (RCP)

This method in the context of underwater dark channel refers to a technique used to enhance underwater images by leveraging the fact that the red channel of light attenuates significantly faster underwater, meaning that the darkest pixels in an underwater image are often found in the red channel; this information is then used to estimate the transmission map and recover the original color balance of the scene [27].

Table 6: Comparison between the various Dehazing based method

DCP (Dark Channel Prior)	UDCP (Underwater Dark Channel Prior)	RCP (Red Channel Prior)
Assumes that non-sky regions in natural images have at least one color channel with very low intensity (dark channel).	An extension of DCP, modified for underwater images by considering the differences in light absorption and scattering.	Assumes that underwater images have a strong red attenuation and enhances images by boosting the red channel.
Estimates the transmission map and removes haze by restoring contrast and colors.	Uses dark channel prior but adjusts for blue-green dominant underwater scenes.	Corrects the loss of red light by amplifying the red channel and balancing colors.
Works well in removing atmospheric haze but struggles with underwater images due to different scattering properties.	More effective than DCP for underwater images, as it considers light absorption differences in water.	Good for color restoration, especially for correcting the bluish/greenish tint in underwater images.
Weak underwater color correction; images may appear overly dark or have a greenish tone.	Improves color balance by considering underwater scattering, but may still struggle in very deep water conditions.	Works well for restoring red hues, which are lost in deeper water.

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May lose fine details due to incorrect transmission estimation.	Better at preserving details compared to DCP.	Retains edges well but may cause color distortion in some cases.
Moderate to high (requires transmission estimation).	High (adjusts transmission and applies underwater-specific constraints).	Low (simpler computation focused on red color correction).
Fails in underwater environments due to incorrect assumptions about light behavior.	Works well for shallow underwater scenes but struggles in low-light deep water conditions.	Can cause over-saturation or unnatural colors if not carefully tuned.
General haze removal in aerial/natural scene images.	Underwater image dehazing and contrast enhancement.	Restoring red color in underwater images, particularly in deep-sea photography.

Because of issues like light absorption, scattering, colour distortion, and low contrast, underwater image enhancement is essential. Numerous methods have been developed and can be broadly divided into three categories: standard image processing methods, deep learning-based methods, and physics-based methods.

Physics-based techniques account for light attenuation and scattering when modeling underwater environments. The Dark Channel Prior (DCP), originally created to eliminate haze on land, does not work well underwater due to erroneous assumptions. The discovery led to the development of the Underwater Dark Channel Prior (UDCP), which is more effective at dehazing underwater images by better accounting for blue-green water absorption. Furthermore, the Red Channel Prior (RCP) improves colour restoration by enhancing the missing red component in deepwater photos, although it can occasionally result in oversaturation. The Multi-Scale Retinex (MSR) method raises local contrast but might create unwanted halo artefacts. Other methods, like Histogram Equalisation (HE, AHE, and CLAHE), raise contrast but might make noise too much.

For further improvement, deep learning-based techniques make use of Generative Adversarial Networks (GANs) and Convolution Neural Networks (CNNs). CNN-based models that improve denoising, deploring, and contrast correction, such as UIECNN, ResNet, and U-Net, learn to improve images. For efficient training, they need sizable labeled datasets, though. GAN-based techniques, such as WaterGAN, FUnIE-GAN, and CycleGAN, compete between a generator and discriminator to produce realistic, high-quality underwater images. Although these models are quite good at removing noise and restoring colour, they can have mode collapse and are computationally costly. Transformer-based models, which use self-attention mechanisms to interpret complicated underwater distortions and provide high-quality outputs, have been investigated more recently, but at a large computational expense.

Conventional image processing methods emphasize enhancements based on transformation and filtering. Although wavelet-based augmentation requires a lot of work, it preserves edges and textures by breaking down images into frequency components. Although anisotropic filtering is computationally demanding, it successfully eliminates noise while maintaining details. A less complicated option that smoothes images without sacrificing edge clarity is bilateral filtering, which is helpful for real-time applications.

In general, physics-based techniques perform poorly on deep-sea photos but well on shallow-water sceneries. Deep learning-based methods require large datasets and significant processing capacity to achieve optimal augmentation quality. Conventional image processing methods are useful for real-time applications, but they are not very effective in handling intricate underwater aberrations. Whether the application calls for robust deep-sea image restoration, high-fidelity augmentation, or real-time processing, the technique selected will rely on its particular needs.

Table 7: Overall pros and cons of various Underwater Image enhancement techniques

Technique	Pros	Cons
Histogram-Based (HE, AHE, CLAHE)	Fast, real-time contrast enhancement. Simple to implement.	Over-enhances noise. Does not correct colors.
Color Correction (RCP, Gray-World, Retinex)	Restores natural colors. Low computational cost.	Poor contrast improvement. May introduce color artifacts.

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Filtering (Bilateral, Anisotropic, Wavelet)	Denoising while preserving edges. Works well in low-light conditions.	No color correction. Can introduce blurring.
ML & DL (CNNs, GANs, Transformers)	Best enhancement in contrast, dehazing, and color correction. Learns from data, adaptable to different conditions.	Requires large datasets and high computation. May generate unrealistic results if training is insufficient.
Fusion-Based (MSF, FUIE)	Produces balanced, high-quality results. Works well across different underwater conditions.	Complex implementation. Requires multiple processing steps.
Dehazing-Based (DCP, UDCP, Depth-Based)	Removes haze and improves contrast. Works well in deep-sea conditions.	May cause over-darkening. Computationally expensive.

Table 8: PSNR comparison of Underwater Image Enhancement Techniques

Technique	PSNR (dB) ↑
Histogram-Based	18
Color Correction	22
Filtering	23
ML & DL	31
Fusion-Based	28
Dehazing-Based	26

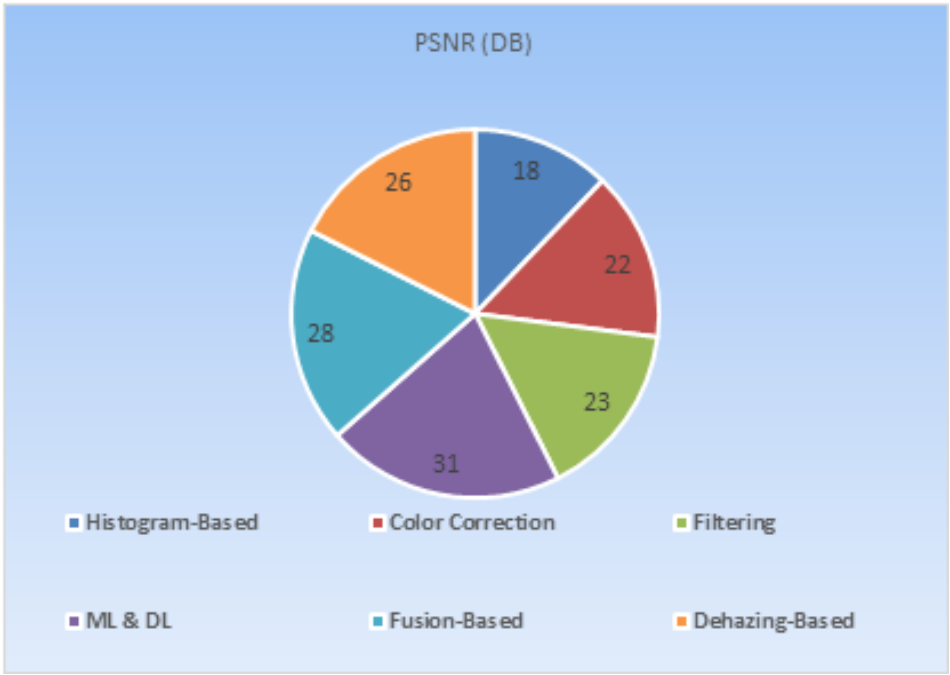

Figure 1: PSNR comparison

Table 9: SSIM comparison of Underwater Image Enhancement Techniques

Technique	**SSIM ↑**
Histogram-Based	0.55
Color Correction	0.57
Filtering	0.63
ML & DL	**0.87**
Fusion-Based	0.82
Dehazing-Based	0.73

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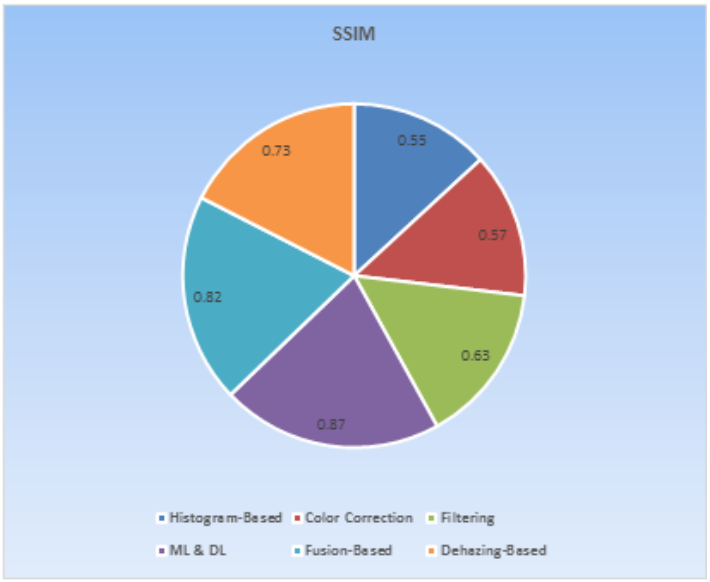

Figure 2: SSIM comparison

Table 10: UIQM comparison of Underwater Image Enhancement Techniques

Technique	UIQM ↑
Histogram-Based	2.21
Color Correction	2.5
Filtering	3
ML & DL	4.7
Fusion-Based	4.2
Dehazing-Based	3.6

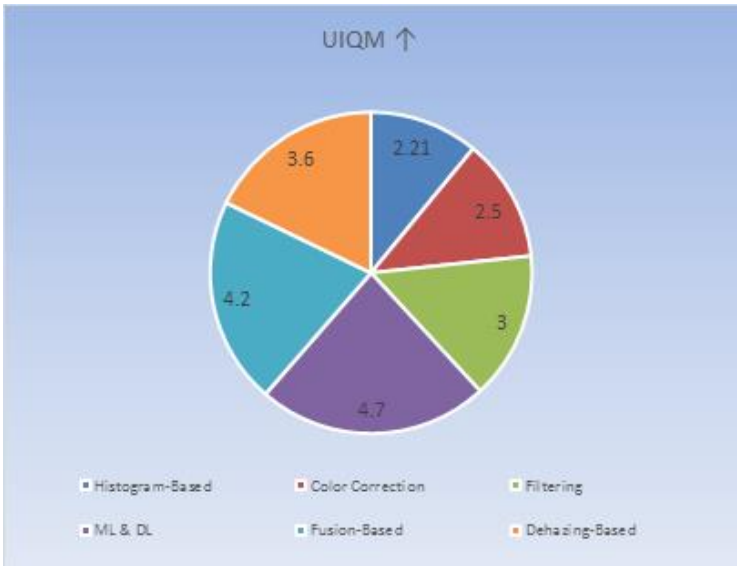

Figure 3: UIQM comparison

Table 12: Computational Cost of Underwater Image

Technique	Computational Cost ↓
Histogram-Based	Low
Color Correction	Low
Filtering	Medium
ML & DL	High
Fusion-Based	High
Dehazing-Based	Medium

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Availability of Dataset for Underwater Image Enhancement

In this section we are discussing the dataset available for underwater image enhancement which are shown below in table 13. It plays significant roles in the performance improvement of various underwater images.

Table 13: Datasets

Dataset Name	Year	Images	Resolution	Annotation
UIEB (Underwater Image Enhancement Benchmark)	2019	890	Various (High & Low)	No
EUVP (Enhanced Underwater Visual Perception)	2020	15,000+ (Raw & Enhanced)	256×256 to 720×1280	No
UFO-120 (Underwater Object Detection & Enhancement)	2021	150,000+	480p to 1080p	Yes (Object Bounding Boxes)
UIQS (Underwater Image Quality Set)	2021	1,350	Various	Yes (Quality Scores)
SQUID (Sea Quality Underwater Image Dataset)	2020	3,000	Various	No
OceanDark Dataset	2021	5,000+ (Low-light images)	720×1280	No
Fish4Knowledge (F4K) Dataset	2012	700,000+ video frames	320×240 to 640×480	Yes (Fish Species & Tracking)
HICRD (Hybrid Image and Color Restoration Dataset)	2022	10,000+	720p+	Yes (Ground Truth Pairs)
Underwater Super-Resolution Dataset	2023	2,000+	High-Resolution	Yes (Paired Low & High-Res)
Seathru Dataset	2020	1,500+	1080×1920	Yes (Paired Images for Dehazing)

CONCLUSION

Enhancing underwater images is crucial for enhancing visual quality in scientific study, underwater robotics, and marine exploration. To solve issues like colour distortion, low contrast, blurriness, and haze brought on by light absorption and scattering in water, a number of methods have been put forth. Conventional techniques, such those based on histograms, increase contrast but run the risk of over-enhancement and noise amplification. While they help restore color balance, color correction techniques such as White-Patch, Gray-World, and Retinex-based solutions have trouble with severe distortions. Although they are computationally costly, filtering-based techniques like bilateral and anisotropic filtering successfully reduce noise while maintaining features. By estimating and eliminating haze, dehazing-based techniques like Red Channel Prior (RCP), Underwater DCP (UDCP), and Dark Channel Prior (DCP) improve image clarity, although they frequently call for depth information. Fusion-based methods, on the other hand, rely on the quality of the input photos and combine several enhancing tactics to improve results. Significant advancements in underwater picture augmentation have been made in recent years by machine learning and deep learning techniques, especially Convolution Neural Networks (CNNs) and Generative Adversarial Networks (GANs). Although these techniques yield state-of-the-art results, their real-time application is difficult due to their high computational power and training dataset requirements.

Future studies should concentrate on hybrid strategies that combine deep learning with conventional enhancement methods to balance computational effectiveness and quality in order to improve underwater picture enhancement. To lessen reliance on labeled datasets, self-supervised and unsupervised learning approaches can be investigated, as acquiring high-quality ground truth photos is challenging. Furthermore, the accuracy of improvement techniques can be raised by incorporating underwater imaging concepts into deep learning models influenced by physics. Another important area of research is creating lightweight deep learning models that are optimized for real-time applications, such surveillance and underwater robotics. Additionally, improving model generalization across various undersea situations will be facilitated by the development of more standardized and diverse datasets. To guarantee reliable and impartial improvement, deep learning models' interpretability and explain ability should also be given top priority. Finally, to make enhancement models more resilient to different underwater settings, such as shallow, deep-sea, and murky water conditions, cross-domain adaption algorithms can be devised. Future developments in underwater picture improvement will greatly aid autonomous underwater vehicle operations, marine exploration, underwater navigation, and environmental monitoring by tackling these issues.

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COMBATING INDIA'S HOSPITAL-ASSOCIATED INFECTIONS: GENOMIC SURVEILLANCE, CRISPR DIAGNOSTICS, AND IOT-DRIVEN STRATEGIES

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ABSTRACT
Hospital-associated infections (HAIs) in India, including those found in intensive care units (ICUs), exceed worldwide average rates because they occur at frequencies between 10% and 30%. The hospital-associated infections that develop from multidrug-resistant (MDR) pathogens because of environmental interactions and horizontal gene transfer (HGT) while facing inadequate healthcare infrastructure. The mixing of hospital-based pathogens with community-based pathogens in the environment triggers the development of "superbugs," which spread via plasmids and transposons to carry resistance genes. The formation of biofilms on medical devices corresponding to ventilators and catheters creates an additional layer of protection that defends pathogens from antibiotics as well as immune system responses. The HAI burden in India worsens through diagnosis delays combined with inadequate genomic surveillance and the economic stress faced by healthcare patients and economic projections showing reduced GDP growth. The review presents innovative diagnostic and therapeutic approaches to fight HAIs through next-generation sequencing (NGS) technology for AMR gene identification in addition to CRISPR-Cas systems for fast pathogen detection and engineered biosensors for continuous pathogen surveillance. IoT-connected wearable gadgets merged with predictive analytics systems help in preemptively controlling outbreaks, while CRISPR technology enables plasmid elimination. Numerous issues remain in IoT systems because infrastructure shortages exist, coupled with high deployment expenses and security vulnerabilities that affect IoT devices. Equitable expansion of genomic and IoT technologies requires government policies in addition to public-private initiatives and India's Ayushman Bharat Digital Mission. A complete strategy for combating HAIs demands antimicrobial stewardship together with advanced diagnostics and ecological decoupling that targets pathogen-environment interactions. Through the integration of precision medicine with genomic surveillance and resilient healthcare policies, India can become a global example of containing antimicrobial resistance by reducing healthcare-associated infections.

Keywords: *Hospital-associated infections, Antimicrobial resistance, Genomic surveillance, Next-generation sequencing, IoT*

1. INTRODUCTION
The occurrence of hospital-associated infections (HAIs) in Indian intensive care units (ICUs) exceeds global averages by affecting 10–30% of ICU patients, while the standard rate remains 7–10%. The healthcare sector faces approximately 60% infection cases from bacterial pathogens that include multidrug-resistant (MDR) strains of *Staphylococcus aureus* (MRSA), *Escherichia coli*, *Klebsiella sp.*, *Enterococcus sp.*, and *Acinetobacter baumannii*.[1] India's HAI crisis worsens due to its specific social and economic framework that includes fast urban growth and sparsely funded healthcare institutions with multiple independent medical service providers that encourage pathogen spread. Carbapenem-resistant *Klebsiella* cell line outbreaks in Mumbai and Delhi tertiary care hospitals were driven by ventilator contamination along with non-adherence to hand hygiene guidelines, which exposed underlying healthcare system weaknesses.[2] The World Health Organization (WHO) declares HAIs among the 10 most significant threats to global health, yet in India, this risk becomes severely acute.[3] India faces significant challenges with HAIs because 40–60% of isolates discovered by the Indian Council of Medical Research (ICMR) in 2023 showed resistance to third-generation cephalosporins and carbapenems, making these antibiotics useless as a last resort.[4] Resistance among bacteria evolves from the continuous spread of antimicrobial resistance (AMR) genes, which occurs between hospital pathogens and environmental bacteria. The gene *blaNDM-1*, which provides carbapenem resistance, has been discovered in hospital wastewater along with municipal water systems and also in public locations across different settings.[5] Human deaths from hospital-acquired infections are tremendous in number. The healthcare system in India experiences 75,000 deaths annually from HAIs, but ICUs experience death rates exceeding 25% to 50% when patients contract MDR *Acinetobacter* or *Pseudomonas* infections. The medical burdens of extended hospital stays as well as surgical complications and permanent disabilities endured by survivors create substantial healthcare costs for Indian families and healthcare institutions.[6] The direct healthcare expenses from HAIs amount to ₹10,000–₹50,000 for each affected patient due to antibiotic costs and intensified ICU stays, resulting

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in numerous households falling into poverty.[7] Research from the World Bank in 2022 revealed that uncontrolled antibiotic resistance might lower India's economic output by 3-5% through 2050 by causing indirect financial loss as well as reduced worker performance.[8] Beyond individual suffering, HAIs erode trust in healthcare systems. Patients suffered from widespread neonatal sepsis outbreaks at public hospitals that highlighted unsterilized equipment, which led to severe public frustration and legal proceedings. AMR pathogens disseminate without control, which creates a threat to worldwide health security. The position of India as both a pharmaceutical manufacturing power and a major consumer of antibiotics (more than 5,000 million doses per year) make it a critical area where resistance genes spread freely.[9] The *mcr-1* gene that gives bacteria resistance to colistin as a last-resort antibiotic originated in Indian livestock; after detection, it later spread among human clinical strains across the globe.[10] Such interconnected systems require immediate action to protect lives in Indian healthcare settings since they present an impending threat for global antimicrobial resistance disasters. Bacterial HAIs make up 80% of all HAIs in India; therefore, this review analyzes their spread through multiple contributing factors. The pathogens use advanced survival mechanisms that utilize plasmids and transposons to transmit resistance genes responsible for *blaCTX-M-15* resistance and *qnrS*-mediated quinolone resistance between various species.[11]

Biofilm formation, on the other hand, complicates treatment, as *P. aeruginosa* and *S. epidermidis* embed themselves on medical devices such as catheters or ventilators, creating resilient colonies shielded from both antibiotics and immune responses. The drug expulsion system known as 'AcrAB-TolC' in *E. coli* worsens antibiotic resistance by forcefully removing medical treatments from bacterial cells, thus diminishing their therapeutic effectiveness.[12] The number of patients treated in public hospitals across Mumbai and Delhi requires ICUs to expand their capacity by 150 to 200%, which leads to patients being placed in close proximity to each other. Rational drug use in Delhi medical facilities has directly produced antibacterial resistance in 70% of HAIs-linked *Klebsiella* isolates, which show multidrug resistance.[13] Research studies across India showed medical equipment sterilization failures in addition to improper glove handling and contaminated surgical tools during their analysis of hospital conditions, as demonstrated by MRSA contamination in 22% of ICU gloves in Chennai in the year 2021.[14] The exchange of bacterial species between medical facilities and the surrounding environment introduces an advanced complication in transmission patterns. *Acinetobacter sp.* from environmental sources changes their virulence and resistance attributes through genetic exchanges with hospital strain populations to produce hybrid "superbugs" that resist almost every available medicine.[15] Inadequate hospital wastewater management creates conditions through which antimicrobial resistance genes transfer between different microbial populations when hospital wastewater mixes with the community water supply. India faces additional challenges in controlling HAIs because of both technological and diagnostic constraints. Frequent pathogen identification methods used by most hospitals depend on culture-based testing techniques that create diagnostic delays extending to multiple days. PCR-based molecular diagnostics for rapid detection of resistance genes are present in just 15% of health facilities, whereas next-generation sequencing (NGS) operates only from research institutes.[16] As a result of lacking genomic surveillance systems, hospitals remain unable to monitor live AMR gene evolution and identify outbreak origins. Medical professionals lack awareness about upcoming medical threats because the current system does not detect silent colistin-resistant Enterobacteriaceae strains carrying the *mcr-1* gene that initially appeared in Indian livestock and have since infected human patients.[17] The insufficient patient monitoring infrastructure powered by IoT technology makes manual health assessments in packed hospital wards ineffective for preventing bacterial spread. The convergence of these conditions results in an ideal situation that produces a sudden increase of untreatable infections and higher mortality rates along with skyrocketing healthcare costs.[18] The review examines healthcare-associated infection management challenges using modern scientific approaches to evaluate how NGS and IoT-based surveillance and receptor-altering diagnostics can transform HAI management. The real-time patient monitoring system, together with AMR gene network mapping and pathogen-environment interaction decoding, will enable India to replace its current reactive crisis approach with proactive disease containment.

2. BACTERIAL PHYSIOLOGY & ANTIMICROBIAL RESISTANCE

AMR at the genetic level stems from specifying resistance genes carrying the blueprint for proteins detrimental to antibiotics and their targets and drug-absorption mechanisms in bacterial cells. Clinical resistance genes that encompass extended-spectrum β-lactamases as well as the carbapenemase *blaNDM-1* and mobile colistin resistance *mcr-1* are considered the most critical resistance elements.[5, 17] The β-lactam antibiotics, penicillin, along with cephalosporins and monobactams, become ineffective against bacterial pathogens when treated with extended-spectrum β-lactamases (ESBLs), with the main variants of *blaCTX-M-15* and *blaTEM*, which hydrolyze these drugs.[19] The enzymes pose significant clinical challenges in Gram-negative pathogens like *E. coli* and *Klebsiella sp.* because they cause urinary tract infections (UTIs), pneumonia, and sepsis. The New

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Delhi metallo-β-lactamase (*NDM-1*), along with other carbapenemases, enhances antibiotic resistance by destroying last-resort carbapenem antibiotics that healthcare professionals use during MDR-infection cases.[20] The *blaNDM-1* gene appeared for the first time in India during 2008 and has spread internationally through plasmids that help bacterial species exchange it.[21] The recently discovered *mcr-1* gene bestows resistance toward colistin, which remains one of the last remaining polymyxin antibiotics for battling Gram-negative MDR-superbugs.[22] The mobile plasmid-carried gene has been identified in Enterobacteriaceae isolates obtained from human, livestock, and environmental specimens, which proves its capacity to spread resistance between different ecosystems. Horizontal gene transfer (HGT) acts as the main mechanism through which these resistance genes propagate. Plasmids function as mobile DNA elements that transfer resistant gene from one bacterial strain to another across species' lines. Plasmids that carry the *blaNDM-1* gene tend to contain extra resistance mechanisms that encode aminoglycoside-modifying enzymes alongside fluoroquinolone resistance genes, thus forming therapeutic barrier complexes.[23] Resistant genes become even more problematic due to transposons that allow such genes to insert into both plasmids and bacterial chromosomes.[24] The gene expression capabilities of integrons serve as important HGT drivers since these genetic elements enable bacterial storage of resistance genes under environmental pressure conditions. Genetic elements display special concern about their mobility inside hospital facilities because pathogenic bacteria maintain close contact with commensal and environmental isolates when these species are located near each other. *Acinetobacter baumannii*, an infamous nosocomial pathogen, becomes pan-resistant by receiving resistance genes from *P. aeruginosa* or Enterobacteriaceae through plasmid transfer as it develops resistance to almost every therapy that exists.[25] The genetic material of resistance genes defines AMR potential, but its functional capabilities depend on inhibitor checkpoints, which function as molecular or physical barriers that prevent antibiotics from getting to intended targets. The bacterial molecular structure known as efflux pumps works as pumps to eliminate antibiotics, thereby decreasing drug concentrations below effective levels inside cells.[26] Tetracyclines, along with fluoroquinolones and β-lactams, are effectively extruded by the resistance-nodulation-division (RND) family efflux pumps 'AcrAB-TolC' from *E. coli* and 'MexAB-OprM' from *P. aeruginosa*.[27] Microbial cells expose these pumps following antibiotic contact under specific genetic control mechanisms. Changes in the *marR* gene's DNA sequence trigger *marRA* operon dysfunction in *E. coli*, which subsequently boosts efflux pump performance and weakens membrane barriers, resulting in a combined drug-resistance mechanism for various antibiotic types.[28] The β-lactamase enzymes function as vital checkpoints through enzymatic disintegration of β-lactam antibiotics. AmpC β-lactamases found constitutively in *Enterobacter cloacae* destroy cephalosporins and resist clavulanic acid as well as other β-lactamase inhibitors.[29] β-Lactamase enzymes and efflux pumps show a beneficial relationship that makes resistance stronger, mainly because *P. aeruginosa* strains expressing MexAB-OprM efflux pumps survive β-lactam antibiotics despite low β-lactamase levels.[30]

Biofilms act as an extra layer of protection because their structure works with their functions to make bacteria less vulnerable to antibiotics and the body's immune defenses. These biofilms commonly develop on surfaces that include catheters, prosthetic devices, and respiratory tubing. A polysaccharide-protein-extracellular DNA mixture serves as a barrier in the matrix, which hinders antibiotic diffusion. Biofilm-associated bacteria transform into a resting state that makes them less vulnerable to anti-malarial treatments requiring active cell metabolism.[31] The implementation of biofilms plays a central role in *Staphylococcus epidermidis* ability to infect medical devices, whereas *Pseudomonas aeruginosa* biofilms within cystic fibrosis patients appear highly resistant to eradication. The cell-to-cell communication system known as quorum sensing (QS) maintains both biofilm advancement and pathogenic factor manufacturing, which elevates bacterial survival capabilities.[32] The persistence of sub-lethal doses of disinfectants and antiseptics combined with antibiotics forms a habitat where only resistant mutants will survive. *Staphylococcus aureus* develops resistance to both quaternary ammonium compounds (QACs) in hospital sanitizers and ciprofloxacin antibiotics when these agents trigger efflux pump expression.[33] The stress pathways in bacteria activate upon disinfectant exposure to hydrogen peroxide or ethanol-based chemicals through mechanisms controlled by the SoxRS and OxyR systems to boost DNA repair systems and antioxidant defenses.[34] The adaptations developed through disinfection exposure increase organisms' survival and mutation frequencies, which speed up the development of genetic mutations that cause drug resistance.

3. ENVIRONMENTAL INTERACTIONS AND GENE MODULATION

Hospital pathogens maintain continuous interactions with diverse microbial communities found in both health facilities and environmental systems, including hospital water sources and soil and air environments and various elements within the built healthcare infrastructure. Genetic information transfer that occurs between bacteria results in harmful microorganisms and also provides pathogens with immunity to treatment schemes and protection against host defense systems.[35] The combination of environmental conditions and genetic factors

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leads to major health complications, particularly in India, because of its dense patient population combined with inadequate sanitation and extensive antibiotic overuse. Additional examination followed of how environmental interactions with gene modification impact public health alongside clinical results as well as antimicrobial resistance patterns worldwide. Recent scientific evidence shows the emergence of *Candida auris*, antifungal-resistant yeast that spread through worldwide locations at the same time.[36] Environmental stress factors are shown to prompt gene modifications even though the emerging organism is not classified as a bacterium. Hospital patients with *C. auris* come into contact with *Pseudomonas* biofilms on catheters, through which the yeast might obtain efflux pump genes transported by extracellular vesicles.[37] The exchange of genetic information between different strains allows *C. auris* to develop resistance against 'azole' antifungal drugs, which fungi have never done before.[38] Such widespread adaptability occurs with much greater intensity in bacterial species. Research has shown *Mycobacterium tuberculosis* accepts plasmids acquired from environmental *Mycobacterium smegmatis* inside Indian TB wards, which could speed up its transformation into extensively drug-resistant strains. *S. maltophilia* establishes its strong presence within Indian hospital equipment like nebulizers and dialysis machines because it produces resistant biofilms against chlorhexidine.[39] The bacterium easily shares resistance genes between *Pseudomonas* and *Acinetobacter* through plasmids to create MDR strains, which are not susceptible to empirical treatment.[36, 37] Neonates are another high-risk group.[40] The major sources of *Klebsiella pneumoniae* outbreak transmission in Indian ICUs stem from contaminated incubators and breast milk substitutes. The environmental form of *Klebsiella* strain inhabiting hospital sink areas passes ESBL genes to clinical isolates, causing cephalosporins to become ineffective. The microbial makeup of premature infants' guts remains underdeveloped, so these pathogens cause necrotizing enterocolitis and sepsis, which kills over 50% of affected preterm infants.[41] The curing of plasmids through the administration of small molecules, including ascorbic acid or CRISPR-Cas systems, proves to be a beneficial technique for disrupting resistance gene transmission. The laboratory-based use of CRISPR-Cas nucleases allows scientists to target specific resistance genes, '*blaNDM-1*' or *'mcr-1*' on plasmids so they cease to function during conjugation.[42] The implementation of these tools inside hospital wastewater systems would allow resistance genes to be intercepted before their spread occurs.

3.1. Pathogen Mixing: Environmental bacteria acquire virulence traits from hospital-adapted organisms by means of HGT, even while clinical bacteria develop antibiotic resistance through gene exchange from agricultural or industrial environmental bacteria.[24, 25] Weakened immune systems of patients heighten the harm caused by pathogen mixing, as their bodies lack protective mechanisms to combat opportunistic infections. *Stenotrophomonas maltophilia* represents an antibiotic-resistant soil bacterium that normally does not cause sickness in healthy people yet causes fatal infections in chemotherapy-treated cancer patients.[43] The increase of immunosuppressive therapies in Indian hospitals enables environmental pathogens to access the bloodstream through medical devices, especially catheters. Biofilms facilitates genetic resistance transfers when *vanA* resistance genes from *Enterococcus faecium* strains within urinary catheter; biofilms get transmitted to *Staphylococcus aureus* through conjugation, which generates vancomycin-resistant *S. aureus* (VRSA) strains. Organizations handling limited resources are in greater danger since they continue to reuse equipment and maintain insufficient sterilization procedures.[44] Researchers have documented minimal information about the consequences of pathogen mixing, which happens through airborne pathogens and fomites in this field. The airborne transmission of tuberculosis pathogens, *Mycobacterium tuberculosis* and *Aspergillus fumigatus* leads to their establishment on hospital materials such as gloves, masks, and curtains in India's crowded patient wards. The pathogens create temporary reservoirs on these surfaces, which facilitates microbial connection.[45] The medical staff at Delhi hospital conveyed in 2023 that *E. coli* genetic variants with *mcr-1* alongside *Candida auris* existed on medical masks acquired in their facility.[46] The release of inter-kingdom gene transfer is slow, yet stress factors, which include disinfectants, can force individual adaptations within different organisms. Pathogen mixing disruption requires the establishment of healthcare facilities that enforce ecological decoupling measures for protecting clinical micro-organisms from environmental microbial interactions. Research indicates that the deployment of managed-spectrum UV-C air filters presents ongoing potential to terminate MDR bacteria along with pathogen-infected surfaces and aerosols. Synthetic biology gains its strength from the creation of "sentinel bacteria" capable of detecting and devouring mobile genetic elements (MGEs) during their existence in the environment.[47] The presence of bioengineered strains at hospital wastewater sites allows plasmids carrying *blaNDM-1* or *mcr-1* genes to be detected.

3.2. Sampling Strategies: The effectiveness of pathogen mixing surveillance relies on acquiring representative samples that monitor microbial relationships across every clinical and environmental setting. The successful monitoring of pathogen mixing needs sampling techniques that accurately record all microbial interactions between healthcare settings and environments. Patient-testing procedures as the main laboratory method fail to

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detect the pathogens that reside in medical equipment such as gloves and masks along with catheters.[48] Long-term sampling of three essential matrices includes both patient-derived elements (swabs, blood, and sputum) and environmental examples (air, water, surfaces) and medical instruments (catheters, ventilators). The limited resources present in Indian hospitals should focus on high-touch devices and surfaces that display high colonization rates, such as urinary catheters, which cause 40% of HAIs.[49] Metagenomics has emerged as an innovative technology that allows scientists to identify complex microbial interactions. Comparatively, shotgun metagenomic sequencing offers better outcomes than traditional culture-based techniques because it records the genetic makeup of all microbial communities, including species that cannot be cultured.[50] The sequencing of biofilms on endotracheal tubes from a Chennai ICU hospital demonstrated that *Acinetobacter* phages exist within a previously unknown complex microbial composition that fights multidrug-resistant strains by causing their death.[51] The combination of metagenomic methods with Hi-C sequencing enables scientists to establish physical DNA strand connections between resistance genes and their bacterial hosts and mobile genetic elements. Gene exchange requires immediate attention in Indian scenarios since it involves distant taxonomic species connections. Surveillance benefits from new sampling methods that enhance its capabilities.[50, 51] Hospital structures with built-in wireless sensor networks maintain continuous surface microbial monitoring, which activates automated swab devices through breaches of pathogen threshold values. Staff members in resource-restricted environments can use cheap paper-based samplers with dried primers to obtain and fix DNA from gloves or masks before conducting later sequencing tests.[52] The AI platform DeepAMR merges metagenomic information with patient movement patterns into spatial maps to forecast resistance gene spread, thereby assisting hospitals in outbreak prediction.[53] Through neural network analysis, the platform predicts outbreak risks while prioritizing the disinfection of high-touch zones like catheters and gloves for precise disinfection steps. The platform enables rural facilities to upload data using portable tools, including Oxford Nanopore MinION, and receive relevant results through low-bandwidth connection points because it operates on a cloud-based framework.[54] DeepAMR adaptive models assist in antimicrobial stewardship by correlating outcome-based resistome profiles, leading to real-time recommendations for antibiotic treatments.[54] [53] DeepAMR establishes itself as a scalable defensive tool against AMR through its fusion of genomic research with IoT capabilities and AI features that support India's progressive Ayushman Bharat Digital Mission for distributing treatment precision.

4. MODERN DIAGNOSTIC APPROACHES: REVOLUTIONIZING THE DETECTION & MANAGEMENT OF AMR

The combination of NGS with receptor-altering technologies maintains a revolutionary impact on our ability to detect resistance genes as well as trace outbreaks while developing specific treatment strategies as shown in **Figure 1**. Traditional diagnostic procedures using phenotypic testing and PCR present restricted capabilities because they work slowly and only identify specific targets. This process of whole-genome sequencing (WGS) with NGS provides complete views of resistance genes and virulence factors and pathogen evolutionary relationship information.[55] The ability to detect multi-resistant *K. pneumoniae* and *A. baumannii* strains at Indian healthcare facilities provides essential support. A World Data Centre for Microorganisms (WDCM) evaluation of *Klebsiella sp.* outbreaks in a Delhi ICU mentioned that damaged ventilators served as infection vectors through the dissemination of plasmids holding resistance genes '*blaNDM-1'* and '*qnrS*' within hospital patients.[56] Outbreak tracing becomes more effective through metagenomic sequencing, which belongs to NGS technology, because it examines all genetic material within a sample regardless of its pathogenic or commensal nature.

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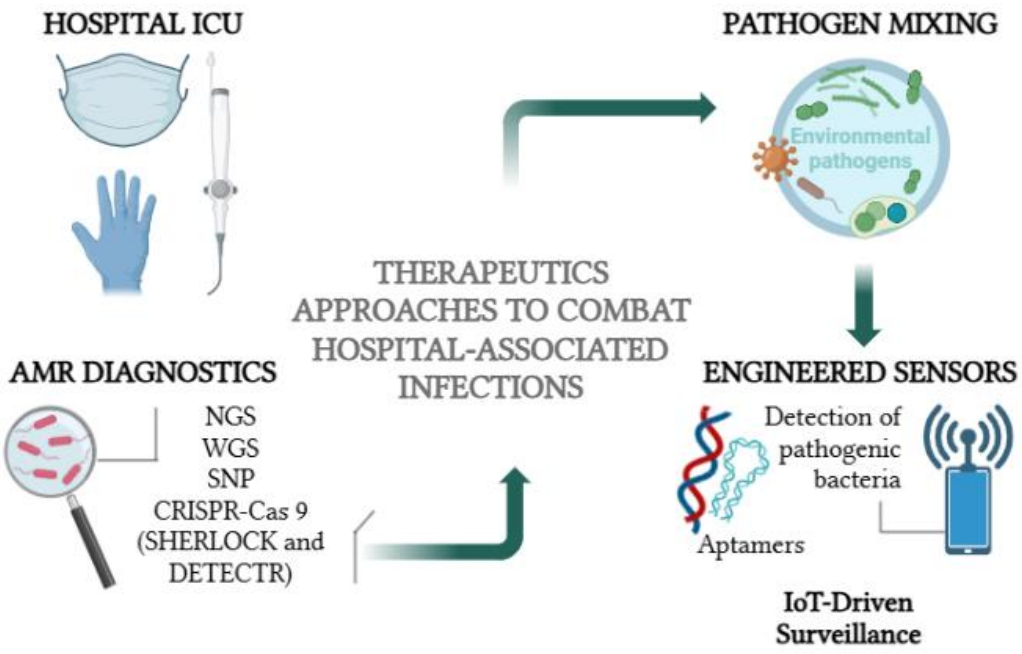

Figure 1: The illustration presents an extensive plan to control hospital-acquired infections while identifying ICU equipment as sources and demonstrating pathogen variants through environmental combinations as well as utilizing advanced testing approaches, including NGS, WGS, SNPs, and CRISPR-Cas9. Biosensor engineering shows two key parts for detection: aptamers and IoT-based systems that monitor pathogenic bacterial species in hospital settings. [Created by Biorender apk]

NGS serves distinct purposes to track outbreaks because it permits the identification of highly intricate and hard-to-culture or difficult-to-grow pathogens. Nucleic acid sequencing technology helped researchers identify *Elizabethkingia anophelis* in 2023 during a Mumbai hospital outbreak of neonatal sepsis, although this bacterial strain is not commonly linked to human infections.[57] The pathogen obtained *blaCMY-2* (a cephalosporinase gene) from gram-negative microbes during its residence in hospital wastewater, revealing that environmental reservoirs stimulate new infection threats.[58] The evaluation of transmission networks becomes possible through NGS, which helps direct public health measures.[59] Results from single-nucleotide polymorphism (SNP) analysis help identify the origin of bacterial strains between hospital-acquired and patient-carrying infections, which provides data to structure prevention approaches such as antibiotic treatment control measures and hospital cleaning protocols. The targeted sequencing method concentrates on precise genomic areas at an affordable level with high sequence depth, while WGS delivers broad sequencing capabilities.[57, 58, 59] Resistome (complete AMR-gene contingent) analysis—sequencing all AMR genes in a sample—is a prime example.[60] Clinical panels containing resistance markers enable medical staff to evaluate microbial resistome compositions for infections and surrounding environments.

The CRISPR-Cas systems, which serve as gene-editing tools, are now transforming targeted sequencing because of their capabilities. CRISPR-guided enrichment serves as a method to specifically magnify resistance genes that exist in complex biological samples. Cas9 sequence programming allows it to find and bind to *vanA* (vancomycin resistance) genes in stool samples; therefore producing sequencing results from minimal gene presence.[61] Medical researchers evaluated this testing method in Indian tuberculosis ward facilities as part of efforts to identify bedaquiline-antibiotic resistance trends. The pathogen detection system SHERLOCK (Specific High-sensitivity Enzymatic Reporter unLOCKing) makes use of CRISPR-based diagnostics, which repurpose Cas-enzymes.[62] A SHERLOCK assay with the *blaCTX-M-15* (an ESBL gene) detection purpose brought down UTI diagnostic timing from 72 hours to 40 minutes.[63] The basic functionality of SHERLOCK (Cas13) and DETECTR (Cas12) stems from a fundamental principle that states that Cas enzymes trigger collateral enzyme cleavage to produce reporter signals that appear as fluorescent changes or colored reactions.[64] The DETECTR system has been employed to identify *mcr-1* in livestock feces since agricultural country like India uses vast amounts of antibiotics on its farms.[65] These additional tools support NGS through their capacity to perform speedy onsite screening without sequencing actual data.

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4.1. Engineered Biosensors: Biosensors use molecular recognition mechanisms to identify pathogens while providing faster and more sensitive results than conventional detection systems. Researchers create phage receptors through a modern approach to detection systems. A breakthrough discovery from 2023 produced biosensors by uniting *E. coli*-specific phage receptors with luciferase enzymes while enabling the sensors to generate light after detecting carbapenem-resistant bacterial strains.[66] Researchers utilized this glowing phage method for testing urine samples, which delivered *blaNDM-1* results in less than 2 hours, quicker than conventional culture-based testing.[67] Aptamers (as shown in **Figure 1**) represent synthetic DNA/RNA molecules that function similarly to antibodies because they bind to targets with equal versatility. Researchers produced a graphene-based electrochemical sensor that incorporated aptamers specific for *P. aeruginosa* efflux pumps during development.[68] The attachment of the aptamers to its target substance modifies sensor conductivity, which enables signal detection. Tests demonstrated this device reached 98% accuracy when detecting MDR *Pseudomonas* in sputum specimens at point-of-care locations. The innovative diagnostics show particular potential for India due to its requirement of both low-cost and portable evaluation options.[69] Future versions of the system should integrate aptamers into smart-phone diagnostic applications through USB sensor technology to enable rural health workers for on-site resistance detection.

4.2. CRISPR-Enhanced Probiotics and Phage Therapies: Through synthetic biology, researchers have developed revolutionary methods that can reverse drug-resistant pathogen colonization while preventing their resistance gene exchange.[70] Engineered strains of *E. coli* and *Lactobacillus* function as CRISPR-enhanced probiotics, which contain programmed CRISPR-Cas systems designed to target specific AMR genes in pathogens.[71] Therapeutic "living substances" function through bacterial colonization of hospital environments and patient intestinal tracts to degrade plasmids using sequence-specific DNA cleavage methods that hinder HGT.[72] When efficiently activating Cas9 under regulatory promoters, the probiotics can break down MDR *Klebsiella pneumoniae* while leaving commensal microorganisms unharmed.[73] These systems maintain continuous operation while requiring minimal human interaction to avoid chemical disinfectants, which can produce stress-induced mutations. Patient use of nose-delivered probiotics containing CRISPR delivery systems represents a potential approach for MRSA decolonization in carriers and *E. coli* ESBL clearance from the gut.[74] This treatment strategy could be enhanced through integration with IoT sensor networks that monitor wastewater plasmid concentrations.

Researchers achieve advancements in phage therapies by implementing CRISPR edits.[75] The integration of phage-CRISPR hybrids creates a cutting-edge approach that both destroys MDR pathogens and rewrites their genetic material to eliminate resistance capabilities.[76] Research shows that merging the bacteriophages' natural lytic lifecycle with CRISPR-Cas systems, which target specific AMR genes and virulence factors, leads to the creation of these hybrid systems.[77] Phages engineered to target *Acinetobacter baumannii* possess CRISPR arrays that specifically recognize *blaOXA-23* (carbapenemase gene) and efflux pump regulatory targets.[78] Following infection, the phage introduces its CRISPR payload to a bacterial cell, through which Cas9 cleaves resistance genes while replicating to destroy the pathogen.[79] Hybrid phage development requires researchers to choose phages with wide bacterial target ranges using T7 or lambda phages while maintaining low immunological reactivity.[80] Science-based adjustments applied to CRISPR arrays specifically target fundamental DNA sequences of AMR plasmid promoters to enhance the system's effectiveness against various bacterial pathogens.[81] The utilization of tissue-specific ligand-modified phage capsids represents an advanced delivery system that improves delivery accuracy. Biofilms become vulnerable to CRISPR-Cas3-engineered phages, which penetrate extracellular matrices to destroy plasmid DNA and genomic DNA.[82] The combination of these methods meets India's requirement for affordable, deployable solutions by enabling CRISPR-phage cocktails to decontaminate ICU equipment and oral probiotics to protect against gut pathogen colonization. These approaches follow ecological decoupling principles by breaking down pathogenic interactions between organisms and their environments, thereby establishing a preemptive solution against antibiotic overuse.

4.3. IoT-Driven Surveillance in Hospitals: The integration of IoT surveillance through sensors and predictive methods along with wearable devices establishes an adaptable system to track patients' health needs, stop infections, and enhance resource distribution efficiency. Wearable Internet of Things devices cover a range from smart-watches to body patches and implantable sensors, which monitor heart rate along with body temperature, respiratory rate, and oxygen saturation levels in the blood. Intensive care unit patients can benefit from chest-mounted patches that include accelerometers and biosensors to monitor sepsis signs through heart variability analysis and increasing lactate measurements.[83] The smart bandages deployed in post-surgical wards use pH sensors to screen wound healing and track down infections through the detection of interleukin-6 cytokine variations, which indicate inflammation.[84] The abundance of patients over nurses in Indian hospitals is addressed by wearables through their ability to collect patient data automatically.[85] The use of these devices

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improves infection prevention by using geofencing tags attached to patient wearables, which activate warnings during entry into restricted areas, thus reducing the spread of contamination.

Wearables specifically protect chemotherapy patients from infections by determining changes in neutrophil counts to anticipate febrile neutropenia episodes before symptom onset.[84, 85] The complete potential of IoT exists when it gets connected to electronic health records (EHRs) along with machine learning algorithms. Hospitals utilizing real-time wearable device data entry into their central EHR systems enable the development of predictive analysis, which forecasts infections together with AMR behavior and patient health status deterioration.[86] The predictive analysis enables medical staff to take steps like catheter removal as well as targeted prophylaxis treatments,[87] which resulted in a 35% Catheter associated UTI (CAUTI) reduction in 2022 trials. Outbreak management strongly benefits from the use of predictive analytics systems. Near-real-time healthcare analytics detected a rising swarm of *K. pneumoniae* pathogen-density through sensor data, and wearable tech revealed patient clusters showing signs of escalated inflammatory indicators[88] during a 2023 outbreak. The analysis linking, EHRs uncovered the outbreak source to be a ventilator circuit contamination, thus enabling speedier sterilization and disease containment.[89] Hunter Health Systems provides critical value to Indian healthcare because response delays from outbreaks frequently lead to high mortality rates from healthcare-acquired infections. The national digital health ecosystem of India, named Ayushman Bharat Digital Mission (ABDM), intends to achieve standardized IoT-EHR integration in all public hospital facilities.[90] ABDM will achieve its objective of connecting 50,000 health center wearable data to a single cloud platform for national AMR pattern and HAIs surveillance by 2025.[91] The main interoperability challenge exists because private hospitals operate EHR systems that do not integrate with public healthcare systems.

5. CHALLENGES IN INDIAN HEALTHCARE SETTINGS

However, challenges remain. Different levels of hospital infrastructure and staffing complications prevent the implementation of standardized protocols throughout Indian medical facilities. The collection of patient-associated specimens leads to privacy-related problems. The solution demands cooperation between medical facilities to share anonymous metagenomic information in national AMR repositories, which enables community-based knowledge & development.[92] The adoption of these infection control approaches will guide India towards creating a new infection control model based on interconnected hospital nodes that form a dynamic microbial network. The combination of high implementation costs and processing requirements together with specialized training needs poses obstacles to large-scale adoption. Modern technology solutions that include portable sequencing devices such as the Oxford Nanopore MinION and cloud-based bioinformatics platforms are making advanced genomic assessment more widely available.[93] The implementation of MinION devices in rural Indian hospitals through pilot programs reduced outbreak investigation time from weeks to days, which demonstrated the feasibility of distributed sequencing systems. Reaching large-scale IoT deployment demands expensive investments for hardware and software development along with network infrastructure development. Most Indian public hospitals operate without dependable Wi-Fi or 5G connectivity throughout their facilities, especially in rural locations.[94] Due to high initial costs, district hospitals cannot obtain the wearable biosensors, which are priced between ₹8000 and ₹12000 per unit.[95] The large-scale collection of patient-sensitive data from IoT systems drives cyber attackers to target these systems. The development of phages and CRISPR-based therapeutic applications faces two major barriers: bacterial resistance development and the ability of bacteria to evade CRISPR detection by evolving genetic traits. Combining different phages as cocktails, along with targeting multiple CRISPR sites (e.g., 'mcr-1' + aac(6')-Ib-cr), reduces the risks of resistance development.[96] Community-based phage banks, developed using local microbial isolates, provide critical pathogen information suitable for their respective regional microbial communities.[97] India's Ayushman Bharat initiative should integrate phage-CRISPR therapies within national AMR action plans since phages naturally replicate while relying on existing healthcare infrastructure.

CONCLUSION

Hospital pathogens and environmental microbes work together in a hidden process that lets bacteria adapt more quickly than scientists develop counterstrategies. The infrastructure issues and socioeconomic conditions in India make this conflict worse, which results in extended hospital incubation periods, elevated fatalities, and increasing healthcare expenses. The crisis serves as a constructive opening for businesses to develop new strategies. Hospital resistance containment is achievable through medical sector applications of genomics along with synthetic biology & ecological modeling technologies. Pathogens should be recognized as network elements instead of solitary threats to develop successful interference through all connections, including plasmid exchange in wastewater along with biofilm creation on gloves. The challenge to hospital infection control becomes extensive because of AMR gene acquisition and inhibitor checkpoint activation and stress-induced evolution. The development of efflux pump blockers together with β-lactamase inhibitors and biofilm-

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dissolving agents relies on genomic resistance detection systems to enable health organizations to create customized prevention procedures. Managing the growing antimicrobial resistance crisis requires a comprehensive approach joining the practices of antimicrobial stewardship with modern technologies and extensive understanding of hospital bacterial ecosystem developments. The struggle against antibiotic resistance can be successfully managed with the use of present-day diagnostic tools grounded in NGS and receptor-altering technological systems. Operationally, the genomic knowledge from NGS enables resistance gene and outbreak monitoring, which, together with CRISPR tools and biosensors, creates decentralized access to timely and accurate diagnostic results. Through training investments and affordable sequencing and localized diagnostic platform development, India can guide the worldwide battle against AMR as it transforms advanced science into life-saving healthcare practice. Surveillance through IoT devices combined with genomic technology has established itself as a new method for fighting infections and drug-resistant microorganisms within India. The execution of strategic policy interventions, including budgeted funding strategies alongside workforce development programs and strong data governance frameworks shows potential for solving complex problems. The national healthcare system of India will benefit from integrated precision public health leadership while simultaneously reducing its antibacterial resistance challenges through these innovative innovations.

List of abbreviations

HAIs – Hospital-associated Infections

ICUs – Intensive Care Units

MDR – Multidrug-resistant

MRSA – Methicillin-resistant *Staphylococcus aureus*

WHO – World Health Organization

ICMR – Indian Council of Medical Research

AMR – Antimicrobial Resistance

PCR – Polymerase Chain Reaction

NGS – Next-Generation Sequencing

IoT – Internet of Things

ESBLs – Extended-Spectrum β-lactamases

UTI – Urinary Tract Infection

HGT – Horizontal Gene Transfer

RND – Resistance Nodulation Division

QS – Quorum Sensing

QACs – Quaternary Ammonium Compounds

VRSA – Vancomycin-resistant *S. aureus*

MGEs – Mobile Genetic Elements

WGS – Whole Genome Sequencing

WDCM – World Data Centre for Microorganisms

SNP – Single Nucleotide Polymorphism

SHERLOCK – Specific High-sensitivity Enzymatic Reporter unLOCKing

EHRs – Electronic Health Records

CAUTI – Catheter-associated UTI

ABDM – Ayushman Bharat Digital Mission

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infrastructural deficits shaped the article's critical direction. Our manuscript's interdisciplinary perspective benefited greatly from our colleagues who passionately debated about pathogen-environment dynamics and IoT security as well as CRISPR-based remedies. The authors retain final responsibility for the content, but this review represents a group effort that combines multiple unreported struggles alongside dialogues to reshape India's healthcare strength.

Author Contributions

a. Both the authors contributed equally to this work.

Shilpa Malakar: Conceptualization (equal); investigation (equal); methodology (equal); formal analysis (equal); validation (equal); writing—original draft (equal); data analysis (equal); resources (equal). **Swati Ganguly:** Conceptualization (equal); resources (equal); supervision (equal); project administration (equal); writing—review and editing (equal).

Conflict of Interest
The authors declare no conflict of interest.

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DECADE OF DYNAMIC TRADE: A QUANTITATIVE ASSESSMENT OF INDIA–UAE BILATERAL EXPORT PATTERNS (2015–2023)

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ABSTRACT
This study presents a quantitative assessment of India–UAE bilateral export patterns over the decade 2015–2023, with a focus on identifying structural trends, sectoral shifts, and trade concentration dynamics. The purpose of the study is to understand how trade between the two nations has evolved, particularly considering the Comprehensive Economic Partnership Agreement (CEPA) signed in 2022, and to evaluate India's positioning in terms of product diversification and trade resilience. Using descriptive trend analysis and the Herfindahl–Hirschman Index (HHI), the research investigates the changing composition of exports and concentration ratios. The results reveal a significant shift in India's export profile—from a traditional focus on gold and diamonds to more diversified and high-value sectors including broadcasting equipment, jewellery, and refined petroleum. In contrast, UAE's exports to India remain concentrated in hydrocarbons and precious metals, indicating limited diversification. The declining HHI for India's exports suggests a structurally resilient and increasingly diversified trade base. The practical implications of the findings are twofold: first, they provide evidence-based insight for Indian policymakers to further strengthen export diversification strategies and reduce dependence on a few key sectors; second, they highlight opportunities for UAE exporters to rebalance their trade portfolio in alignment with India's evolving import demands. The study also offers actionable insights for businesses and trade bodies aiming to leverage sectoral openings under CEPA. The originality and value of this paper lie in its decade-long comparative analysis of bilateral export patterns using quantitative metrics, supported by trade concentration indices. It offers a rare longitudinal perspective on India–UAE trade, situating the CEPA not just as a diplomatic milestone but as a driver of tangible trade transformation. The findings contribute to the limited empirical literature on India–UAE economic relations and inform ongoing trade policy discourse in the Global South.

Keyword: *India -UAE Trade, CEPA, the Herfindahl–Hirschman Index (HHI), Product Diversification, Policy.*

INTRODUCTION
Over the past decade, India and the United Arab Emirates (UAE) have witnessed a significant transformation in their bilateral trade relationship, underpinned by strategic partnerships, geopolitical alignment, and evolving trade dynamics. As two major players in Asia and the Gulf region respectively, both countries have progressively deepened their economic ties, culminating in the signing of the Comprehensive Economic Partnership Agreement (CEPA) in 2022, aimed at reducing tariffs, boosting investment flows, and enhancing trade in goods and services (Ministry of Commerce and Industry, 2022). This evolving relationship is particularly critical given that the UAE has consistently ranked among India's top trading partners, both in exports and imports, especially in sectors like energy, gems and jewellery, and electronics.The period from 2015 to 2023 marks a dynamic phase in India–UAE trade, characterized by both resilience and volatility. Trade volumes have been influenced by global factors such as oil price fluctuations, the COVID-19 pandemic, and supply chain disruptions, as well as domestic reforms like India's implementation of the Goods and Services Tax (GST) and push for export competitiveness (Chakraborty & Sengupta, 2020). During this period, bilateral trade not only expanded in volume but also shifted in composition—from traditional energy exports to a more diversified mix including electronics, and high-value commodities such as gold and diamonds.This paper presents a quantitative assessment of India–UAE bilateral export patterns from 2015 to 2023 using a commodity-level analysis of top exports and imports. By examining trade flows, product concentration, and shifts in key sectors, the study aims to offer insights into the evolving nature of this economic partnership and highlight opportunities for strategic policy formulation under the CEPA framework.

LITERATURE REVIEW
Bilateral trade relations between India and the United Arab Emirates (UAE) have drawn increasing scholarly attention over the last two decades, particularly due to the UAE's emergence as one of India's top trading partners in the Gulf region. Several studies have attempted to analyse the structural dynamics of this partnership, exploring trade flows, policy influences, and comparative advantages.

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1. India–UAE Trade Dynamics

India and the United Arab Emirates (UAE) share a robust trade relationship shaped by historical linkages and strategic cooperation. The bilateral trade has grown significantly, with UAE emerging as one of India's largest export destinations. Historically rooted in barter-based exchanges involving garments, spices, dates, and pearls, the relationship has transformed into a dynamic commercial alliance (Shahzeb et al.,2021). As of 2017–18, Indian exports to the UAE reached US$28.14 billion, constituting 9.27% of India's total exports.

Trade intensity between the two nations has consistently remained above unity, indicating a stronger-than-average trade link (Awatar, Vajid,2018). The Kojima Trade Intensity Index used in empirical analyses confirms this persistent strength, although slight declines were noted during global downturns. The bilateral exchange covers a broad range of commodities: India exports gems and jewellery, engineering goods, and agro-products, while importing crude oil, precious metals, and electronics.

Foreign Direct Investment (FDI) has also deepened ties, with the UAE ranking among the top ten investors in India. This investment is especially significant in infrastructure development, exemplified by the Abu Dhabi Investment Authority's pledge of US$2 billion (Awatar, Vajid,2018).

2. Impact of Trade Agreements

The **India–UAE Comprehensive Economic Partnership Agreement (CEPA)**, signed in 2022, marks a milestone in bilateral trade policy. According to Saeel and Chandran (2025), CEPA is expected to boost trade to approximately US$113 billion within five years. Their analysis, based on trade indicators such as Revealed Comparative Advantage (RCA), Revealed Trade Advantage (RTA), and Revealed Competitiveness (RC), underscores India's sustained comparative edge across key sectors.

Empirical studies utilizing the gravity model (FEVD and PPML estimation) provide robust validation for the positive impact of CEPA on trade flows. Moreover, the agreement is seen as a strategic model for future FTAs, offering insights into maximizing trade synergies and addressing regulatory bottlenecks (Saeel , Chandran,2025).

Kanojia et al. (2024) note that CEPA has the potential to significantly reshape trade and investment dynamics, particularly in sectors like electrical machinery and chemicals. Using the SMART Model, Ismail et al. (2022) predict that CEPA could increase trade by 70% due to tariff eliminations but warn of a potential 30% trade diversion effect from non-FTA partners.

3. Sectoral Trade Composition and Competitiveness

India's export profile to the UAE is marked by both strengths and vulnerabilities. Gems and jewellery account for nearly 30% of exports, indicating high value but also product concentration risk (Shahzeb et al.,2021). RCA analysis identifies India's competitiveness in 288 tariff lines, while trade intensity indices confirm robust engagement. However, the existence of 377 globally competitive products lacking bilateral competitiveness with the UAE signals untapped potential worth US$6.42 billion.

Sector-specific assessments further suggest that trade liberalization benefits are uneven across industries. Sectors such as mineral fuels, electronics, and chemicals stand to gain significantly under CEPA (Kanojia et al.). Nevertheless, the concentration of exports in a limited number of goods exposes India to global market volatility and underscores the need for diversification.

Shahzeb et al. recommend policy interventions to enhance India's export competitiveness, including strategic promotion of underutilized products and addressing supply-side inefficiencies. Efforts such as trade fairs, language training, and cultural exchanges are also proposed to deepen trade ties and mutual understanding (Awatar, Vajid ,2018).

RESEARCH GAP

While the existing literature provides valuable insights into the India–UAE trade relationship, few studies have conducted a **quantitative and time-series assessment** of bilateral **export patterns over an extended period**, especially covering the post-COVID phase and CEPA implementation. Furthermore, limited empirical work has been done to analyse **product concentration trends**, **export diversification**, and **emerging sectors** in the India–UAE export basket from 2015 to 2023. This study aims to fill this gap by conducting a commodity-level quantitative assessment, offering both retrospective and forward-looking perspectives on the bilateral trade relationship.

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DATA AND RESEARCH METHODOLOGY

Data Sources

This study is based on secondary data collected from The Observatory of Economic Complexity, reliable international trade databases and institutional reports.

The analysis covers the period from 2015 to 2023, with export data expressed in US dollars (USD) at current prices.

Research Objectives

1. **The study aims to:** Analyse the structural trends in India's exports to the UAE over a decade.
2. Identify the concentration and diversification patterns in UAE and India's export basket.

METHODOLOGICAL FRAMEWORK

1. Trend and Growth Analysis

Basic descriptive statistics, growth rates, and trend lines are used to examine overall export performance, sector-wise contributions, and year-wise changes.

2. Export Concentration Analysis

Export concentration is measured using the **Herfindahl–Hirschman Index (HHI)**.

Comprehensive Economic Partnership Agreement (CEPA)

The Comprehensive Economic Partnership Agreement (CEPA) between India and the United Arab Emirates (UAE), signed in 2022, marks a significant advancement in bilateral economic relations. The agreement aims to eliminate tariffs on over 80% of goods, with immediate benefits for key Indian export sectors such as gems and jewellery, textiles, and pharmaceuticals. In addition to goods trade, CEPA provides enhanced access for Indian service providers, simplifies customs procedures, and promotes investment cooperation across sectors including infrastructure and logistics. Strategically, CEPA is India's first such agreement in the MENA region and is expected to elevate bilateral trade to USD 100 billion within five years (Ministry of Commerce & Industry, 2022).

Table 1.

UNITED ARAB EMIRATES EXPORT TO INDIA						
year	Crude Petro(%)	Petro Gas(%)	Refined Petro(%)	Dia(%)	Gold(%)	HHI
2015	30.6829	5.0732	4.8000	18.4878	17.8049	0.1649
2016	29.0722	6.0309	5.4124	22.0103	13.4021	0.1575
2017	27.9060	5.9402	4.9145	21.8803	17.4786	0.1622
2018	33.2463	7.3134	5.3731	18.3582	8.1716	0.1591
2019	32.0724	8.2237	6.5132	17.1053	10.9211	0.1551
2020	32.7197	10.5021	4.8536	17.3222	10.7113	0.1619
2021	27.1462	11.2761	3.8283	20.3248	16.2645	0.1556
2022	33.2707	12.4248	4.3421	18.6842	5.8271	0.1663
2023	22.3822	15.0262	4.7120	17.5916	18.2984	0.1393
INDIA EXPORT TO UNITED ARAB EMIRATES						
year	BroadcastingEquip(%)	Jewellery(%)	RefinedPetro(%)	Dia(%)	Gold(%)	HHI
2015	0.5388	7.6712	2.0913	12.8767	26.2557	0.0919
2016	0.9014	10.6103	1.9859	13.9437	28.1690	0.1105
2017	0.6164	8.9655	5.9914	15.1724	17.8017	0.0664
2018	3.5680	30.3600	11.8000	8.2400	3.4240	0.1153
2019	8.9716	30.6738	13.6879	8.1560	2.4362	0.1281
2020	8.3799	13.5754	13.0726	9.3296	1.3520	0.0514
2021	11.3778	12.0889	8.1778	12.7556	0.9689	0.0506
2022	11.4909	11.9636	11.4182	12.0727	0.6764	0.0552
2023	14.8611	18.8194	9.0278	7.3611	0.5313	0.0711

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ANALYSIS

The analysis of structural trends in India's exports to the UAE from 2015 to 2023.

Over the past decade (2015–2023), India's export structure to the United Arab Emirates (UAE) has undergone a significant transformation, both in terms of value and composition. Total exports rose from USD 21.9 billion in 2015 to USD 28.8 billion in 2023, marking a cumulative growth of approximately 31.5%. This period was characterized by a notable shift from traditional commodities such as gold and diamonds toward higher value-added and technology-intensive goods. In 2015, gold and diamonds collectively contributed nearly 39.14% of total exports; however, by 2023, their share declined dramatically to just 7.89%, with gold exports falling from USD 5.75 billion (26.26%) in 2015 to USD 0.153 billion (0.53%) in 2023. Conversely, exports of broadcasting equipment surged from USD 0.118 billion (0.54%) in 2015 to USD 4.28 billion (14.86%) in 2023, reflecting India's growing capacity in electronics manufacturing and the UAE's demand for re-exportable technology goods. Similarly, jewellery exports witnessed substantial growth, rising from USD 1.68 billion (7.67%) to USD 5.42 billion (18.82%) during the same period, establishing it as the top export category by 2023. Refined petroleum exports also showed a steady increase, peaking in 2019 at USD 3.86 billion before moderating to USD 2.6 billion in 2023, indicating India's sustained presence in energy-related trade despite global oil market volatility. This structural transformation reflects India's broader trade strategy under initiatives like 'Make in India' and was further supported by the India-UAE Comprehensive Economic Partnership Agreement (CEPA), implemented in 2022, which facilitated market access and tariff reductions across various sectors (Ministry of Commerce and Industry, 2023). The diversification of India's export basket toward manufacturing and high-value goods underscores a maturing bilateral trade relationship and India's evolving export competitiveness in the Gulf region.

The structural trends in UAE exports to India from 2015 to 2023.

Between 2015 and 2023, the structure of the United Arab Emirates' (UAE) exports to India exhibited significant transformation in both composition and value. Total exports grew from USD 20.5 billion in 2015 to a peak of USD 53.2 billion in 2022, before moderating to USD 38.2 billion in 2023. Crude petroleum consistently remained the largest export item in absolute terms, rising from USD 6.29 billion (30.68%) in 2015 to a peak of USD 17.7 billion (33.27%) in 2022, then declining sharply to USD 8.55 billion (22.38%) in 2023. This fluctuation reflects the volatility in global oil markets and strategic shifts in India's energy sourcing. Exports of petroleum gas showed a strong upward trend, increasing both in volume and share—from USD 1.04 billion (5.07%) in 2015 to USD 5.74 billion (15.03%) in 2023—signifying India's growing preference for cleaner energy sources and diversification of fuel imports. Refined petroleum exports remained relatively modest, with minor fluctuations between USD 0.98 billion and USD 2.31 billion over the period, showing limited structural change. Notably, diamond exports maintained a steady contribution, oscillating around 17–22% of total exports, indicating the persistent strength of the UAE-India link in the global gems and jewellery supply chain. Conversely, gold exports fluctuated, falling from 17.8% in 2015 to just 5.83% in 2022, but rebounding to 18.3% in 2023, possibly due to changes in Indian import policies and shifting investment patterns. The compositional shift over the decade highlights a deepening bilateral engagement not only in hydrocarbons but also in high-value commodities like diamonds and gold. The entry into force of the India-UAE Comprehensive Economic Partnership Agreement (CEPA) in 2022 further accelerated trade integration by reducing tariffs and facilitating smoother market access (Ministry of Commerce and Industry, 2023). Overall, the export structure reveals a diversification trajectory underscored by energy security, strategic mineral trade, and policy-driven bilateral economic diplomacy.

2. The **Herfindahl–Hirschman Index (HHI)** is a useful quantitative tool to measure **export concentration or diversification** in trade studies. Analysis of **HHI for India exports to UAE** and **UAE exports to India**.

To assess the concentration and diversification of trade between India and the United Arab Emirates (UAE), the Herfindahl–Hirschman Index (HHI) serves as a critical metric. The HHI is calculated by squaring the percentage share of each product category in total exports and summing them. An HHI below 0.15 indicates a highly diversified export structure, between 0.15 and 0.25 suggests moderate concentration, and above 0.25 reflects high concentration.

The Herfindahl–Hirschman Index (HHI) was applied to evaluate the concentration and diversification of exports between India and the UAE from 2015 to 2023. The results indicate a notable divergence in the export structures of the two countries. UAE's exports to India consistently exhibited higher HHI values—ranging from 0.1393 (2023) to 0.1663 (2022)—demonstrating a more concentrated export basket, predominantly consisting of crude petroleum, petroleum gas, diamonds, and gold. Conversely, India's exports to the UAE showed lower

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HHI values throughout the decade, fluctuating from a peak of 0.1281 (2019) to a low of 0.0506 (2021), reflecting greater diversification across products such as electrical equipment, jewellery, and refined petroleum.

This comparative trend highlights that while the UAE relies heavily on a few key commodities in its export relationship with India, India maintains a broader and more evenly distributed range of export items to the UAE. The findings suggest that India's export strategy may be more resilient to sector-specific shocks, whereas the UAE's trade with India is more vulnerable to price or demand fluctuations in the energy and precious metals sectors.

DISCUSSION

The findings of this study underscore a profound structural transformation in the bilateral trade relationship between India and the UAE over the period 2015–2023. India's export basket evolved significantly from being heavily reliant on traditional sectors such as gold and diamonds to a more diversified portfolio featuring high-value and technology-intensive products like broadcasting equipment, refined petroleum, and jewellery. This shift aligns with India's national policies such as *Make in India* and *Digital India*, which aim to boost manufacturing competitiveness and export potential (Ministry of Commerce and Industry, 2023).

The implementation of the India–UAE Comprehensive Economic Partnership Agreement (CEPA) in 2022 appears to have catalysed these positive shifts. The reduction in tariffs and easing of regulatory barriers created new opportunities, particularly in sectors such as electronics, jewellery, and petrochemicals. These findings support the forecasts made by Banga et al. (2022) and Mehta and Sengupta (2023), who posited that CEPA would generate substantial export gains for India.

Conversely, the UAE's export structure to India remained relatively concentrated, dominated by crude petroleum, petroleum gas, and precious metals. Although gold exports experienced fluctuations due to policy and investment dynamics, diamonds maintained a steady share, confirming the UAE's central role in the global gems and jewellery trade network (Kumar & Ahmed, 2017; Khan & Raza, 2020). The high Herfindahl–Hirschman Index (HHI) values for UAE exports point to a structural reliance on a few sectors, rendering it more vulnerable to commodity price shocks and demand volatility.

The comparative analysis of HHI values reveals that India's export diversification strategy may offer greater long-term resilience. The declining concentration index in Indian exports post-2019 suggests a conscious pivot toward reducing dependency on a narrow set of products, a finding also observed in the export performance of electronics and machinery in earlier studies (Joshi & Roy, 2018). In contrast, the UAE's persistent reliance on energy-related commodities and precious metals may necessitate structural reforms to broaden its export base and reduce trade vulnerability.

CONCLUSION

This study provides a comprehensive, quantitative evaluation of India–UAE bilateral export patterns over the decade from 2015 to 2023. The analysis reveals that:

- India's exports to the UAE have become significantly more diversified, moving away from traditional commodities toward value-added and technology-driven products.
- The UAE's exports to India, while growing in value, remain concentrated in hydrocarbons and precious metals, highlighting the need for diversification.
- CEPA, implemented in 2022, has played a pivotal role in accelerating trade integration and fostering structural transformation in India's export profile.
- HHI analysis confirms that India's export structure is more diversified than the UAE's, indicating a more resilient trade strategy amid global disruptions.

Overall, the bilateral trade relationship is maturing, with emerging complementarities and mutual benefits. However, sustained efforts are needed from both countries to address sectoral imbalances and harness the full potential of CEPA.

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A STUDY TO ASSESS THE IMPACT OF ENVIRONMENTAL TOBACCO SMOKEEXPOSURE ON SEVERITY OF RESPIRATORY INFECTION AMONG PRESCHOOLERS AT KOYAMBEDU

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ABSTRACT

Background: *Knowledge of the harmful influence of environmental tobacco smoke (ETS) has apositive impact on changing social behaviors worldwide. In many homes smoking is totally prohibited; in some others, partial limitations of tobacco consumption have been introduced.*

Objective: *To study the correlation between the adopted rules of tobacco use in homes of 4-5- year-olds, and the kind and frequency of acute respiratory system infections within a 6-month period of attending preschooler.* ***Materials and methods****. The study was performed among Children attending Municipality Pre-schools in Chennai.The data was collected from Environmental Tobacco Smoke Questionnaire (ETS) administered questionnaires completed by the parents of 175 children aged 3-5 years chosen randomly from 220 children attending 5 Pre- schools.* ***Interventions: The*** *exposure of children to tobacco smoke was measured by determining cotinine to creatinine ratio (CCR) in urine****. Results****. In the 220 families of children who were surveyed,175 were smokers. Every day, the smokers consisted of fathers (89.2%) and mothers (10.8%). The 3-year-old children were divided into 3 groups according to smoking habits in their homes: 28.5% of the children under examination came from homes where tobacco smoking was forbidden (mean CCR – 15.21ng/ mg, SD=11.86), 26.2% came from homes wheretobacco was smoked in separate rooms (mean CCR – 65.75 ng/ml, SD=81.51), 45.4% lived in*

homes where no rules connected with smoking had been established (mean CCR – 61.75 ng/ml, SD= 70.29). During the analyzed period of 6 months, 85% of the children had at least 1 respiratory tract infection (60% – upper, 16.9%– lower, 16.5% – upper and lower, 7.1% – otitis media). ***Conclusion: The*** *majority of the 3- 5 year-old children who had lower respiratory tract infections required antibiotics and hospitalization. Living in a home where no tobacco rules wereestablished may cause an increase of respiratory tract infections.*

Keywords: *Pre-schooler, Respiratory Tract Infections, Environmental Tobacco Exposure*

INTRODUCTION

The tobacco epidemic is one of the biggest public health threats the world has ever faced, killing more than 8 million people a year, including around 1.2 million deaths from exposure to Second-Cigarette smoking is the most common form of tobacco use worldwide.[1] Tobacco smoke contains approximately 4,000 toxic chemicals, including oxidative gases, heavy metals, cyanide, and at least 50 carcinogens. [2]Tobacco use is the most preventable cause of death and the most serious risk factor for cancer. Currently, 1.3 billion people smoke or use tobacco, and nearly 5 million worldwide die of diseases associated with tobacco smoke each year. Over 80% of the 1.3billion tobacco users worldwide live in low- and middle-income countries, where the burden of tobacco-related illness and death is heaviest[3.] Tobacco use contributes to poverty by diverting household spending from basic needs such as food and shelter to tobacco. Environmental tobacco smoke (ETS) consists of particles much smaller than those in mainstream smoke, and therefore has greater penetrability to the airways of children.[4] Passive exposure to tobacco smokesignificantly contributes to morbidity and mortality in children. Children, in particular, seem to be the most susceptible population to the harmful effects of ETS[5]

Children are exposed to tobacco smoke not only in their homes but also in schools, restaurants, child-care settings, cars, buses, and other public places.[6]The home is the greatest single source of ETS for children.[7] Paternal smoking inside the home leads to significant maternal and fetal exposure to ETS and may subsequently affect fetal health.[8]ETS is defined as tobacco smoke produced by an active smoker both from the exhalation of smoked tobacco and by the burning end of the cigarette, which is inhaled by nonsmokers[9].Childhood respiratory illness remains a major challenge for global health. Pneumonia is the leading cause of under-5 mortalities outside the neonatal period in low- and middle-income countries (LMICs) [10,11]ETS have been associated with adverse effects on pediatric health, including preterm birth, intrauterine growth retardation, perinatal mortality, respiratory illness, neurobehavioral problems, and decreased performance in school[12]. Prenatal maternal smoking and postnatal ETS lead to a dose-dependent decrease in lung function and respiratory morbidity in infants and children.[13,14]Exposure of children to ETS in the home increases the incidence of middle ear disease, asthma, wheeze, cough, bronchitis, bronchiolitis, pneumonia, and impaired pulmonary function.[15]Acute

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respiratory system diseases in pre-school children are a significant problem in the practice of a GP, especially when the infections are recurrent. The moment of firstcontact with infectious factors in a large group of children is often the turning point in a child's medical history, but the kind and frequency of respiratory system infections are influenced by various endo- and exogenous factors.[17,18] Tobacco smoke is one of the main elements of indoor air pollution, and is a factor inducing and modifying the course of respiratory system diseases[19]. It is highlighted in literature that children of parents who smoke are grow up in worse living conditions and become ill more frequently, compared to their peers not exposed to environmentaltobacco smoke [20,21]

METHODS AND MATERIALS

Study design: Cross sectional non experimental research design was adopted for the current study to assess the exposure to environmental tobacco smoke and respiratory tract infections inpre-school children. **Study Setting:** The study was conducted for the duration of 3 months fromFebruary,2022 till April 2023 in the Pre-school in and around Koyambedu. **Ethical Approval:** After obtaining the ethical clearance from the Institutional Ethical Committee (IEC) of Saveetha Institute of Medical and Technical Science Formal permission from the Departmental head of Child health Nursing the Study was conducted. **Study Participants:** A total of 175 preschooler children who fulfil and Meets the inclusion criteria were recruited as study participants. The inclusion criteria include preschooler children, Child with respiratory infection child's parents who smoke inside the home and child living in over polluted place, Exclusive criteria such as Unwilling child, Child with developmental age group of infants, toddler, school age, children with severe respiratory infection, **Sampling Technique:** A total of 175 Pre schooler were recruited based on the inclusion criteria by using Convenience sampling technique. **Informed Consent:** The purpose of the study was Explained clearly in depth to each of the study participantand a written informed Content was obtained from them. **Pre Assessment:** The demographic and clinical Information was collected by using a self- environmental Tobacco Smoke Questionnaire. The questionnaire was composed of 3 Modules to evaluate environmental conditions, incidence of Respiratory system diseases among children and the structure of the tobacco use in their families.

The Modules devoted to previous respiratory system disease included questions referring to the medical history and the treatment in the first 3 years of life Interventions: The exposure of children to tobacco smoke was measured by determining cotinine to creatinine ratio (CCR) in urine. 15 ml samples of morning urine were obtained from 200 children. Among the received samples 175 samples were randomly chosen for Cotinine and Creatinine Ratio. The urine samples were stored at the temperature of –70ºC. The extraction and quantitative analysis of cotinine was performed by high-performance liquid chromatography method (HPLC). The limits of linearity (LOL) were in the range 5–1,000 ng/ml; limit of determination (LOD) – 3 ng/ml; limit of quantification (LOQ) – 5 ng/ml. The coefficient of variation of cotinine in concentrations 20 and 100 ng/ml did not exceed 10% and amounted up to 4.8% (inter-day CV) and 7.8% (intra-days CV). Creatinine was determined by the kinetic colorimetric method with alkaline picrate without deproteinization, with the use of Creatinine kinetic reagent set (CREA) and a biochemistry analyzer (Konelab 60)

RESULTS AND DISCUSSION

Classification of children classified according to ETS exposure and CCR values

Among 175 Children In 47.9% of the analyzed families (150), 210 smokers were found: 37.3%

were fathers (112), 23.6% were mothers (71), and 27 other household members (grandfathers, grandmothers, relatives). The fathers smoked 14 cigarettes a day, on average (SD=10.23), smoking mothers – 8 cigarettes, on average (SD=8.18), and other household members – 15 cigarettes, on average (SD=11.14).

Table 1: Classification of Children classified according to ETS Exposure

	Cotinine/creatinine (CCR) [ng/mg]					
Group	**No of Children**	**Highest Value**	**Lowest Value**	**Mean Value**	**SD**	**No of Analyzed Urine Samples**
Group 0	86	45.7	0.0	15.2	11.9	43
Group 1	79	350.3	0.5	65.8	81.5	40
Group 2	137	379.1	0.2	61.8	70.3	57
Grp0- Grp P<0.001Grp 0- Gr2 P<0.001 Grp1-Gr2 P<2.824						

- In the basis of the rules of tobacco use at home provided by the parents, the children were divided into 3 groups
- Group 0 (Gr0) – children from families where smoking is totally forbidden

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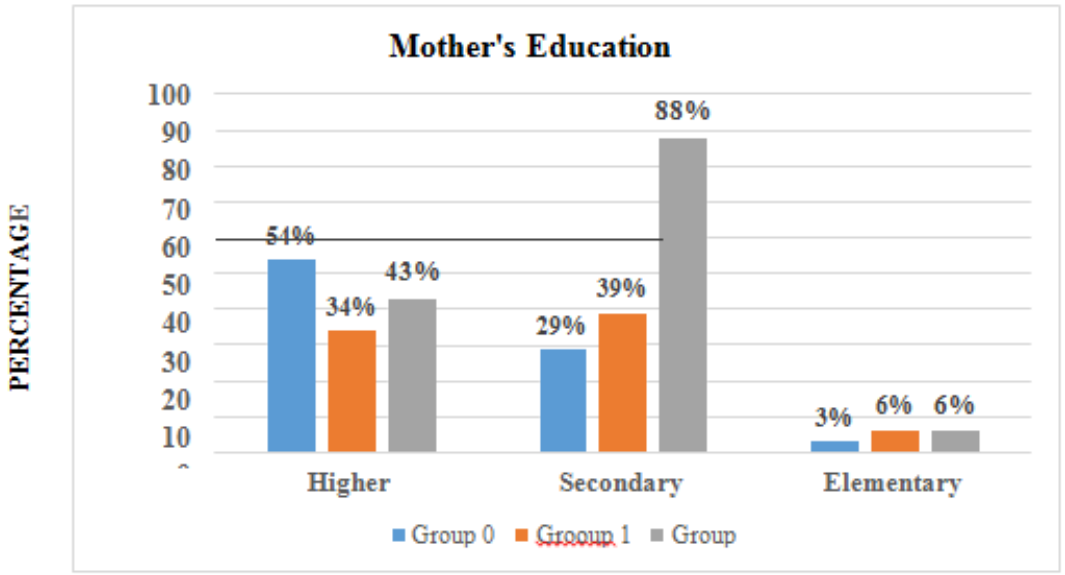
- Group 1 (Gr1) – children from homes where smoking is permitted in separated rooms (kitchen,bathroom or hall).
- Group 2 (Gr2) – children from homes where there are no rules concerning tobacco use. The number of children in individual groups and the CCR values are presented in Table 1



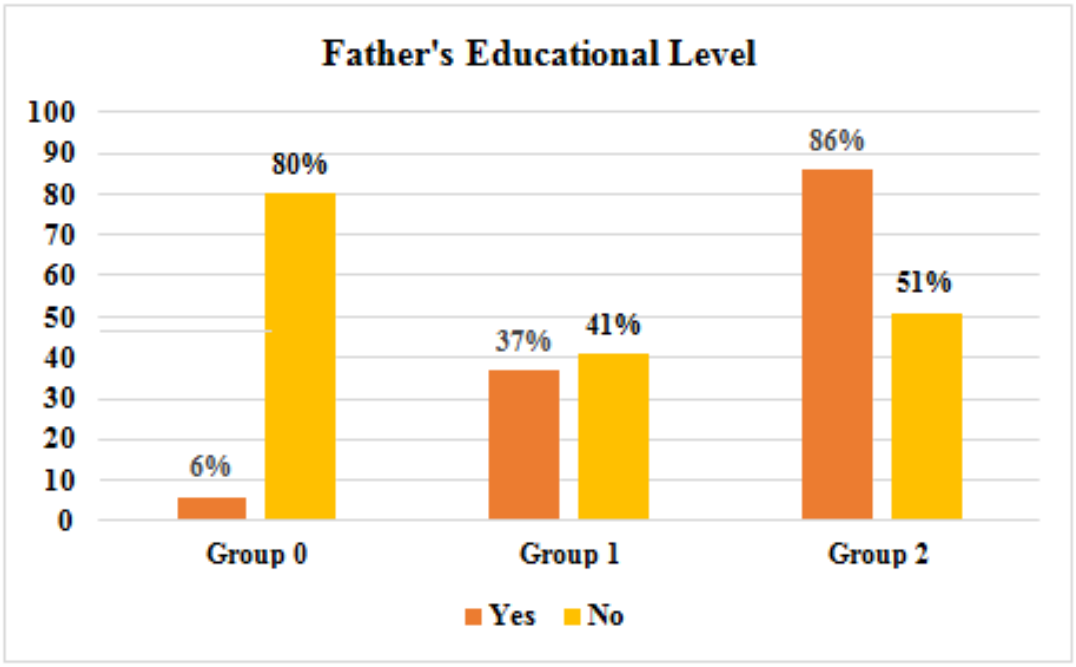


Figure 2. Educational Level of Mother's in Each Group of Ets Exposure

80 % fathers' smokes & 6 % of then were non-smoker in group 0, in Grp 1 41% fathers werenon- smoker and 37 % had history of smoking 86% of the fathers smoked in Grp 2 & 51 % remained as Non-smoker

Table 4. Children by Frequency Of Occurrence Of AcuteRespiratory Tract Infections

InfectionType	Gr	No of Percentage of Children with number of Acute Infections														P
		1		2		3		4		5		6		7		
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Pneumonia	0	10	11.6	2	2.3											
	1	1	1.3	2	2.5											
	2	11	11.6	3	2.2											0.098
Bronchitis	0	10	11.6	1	1.2	1	1.2									

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	1	6	7.6	4	5											
	2	21	15.3	18	13.1											
Laryngitis	0	4	4.6	2	2.3											
	1	4	5													
	2	6	4.3	1	0.7	1	0.7									
Pharyngitis	0	12	14	7	8.1	9	10.4									
	1	17	21.5	7	8.9	6	7.6	1	1.3	1	1.3					0.228
	2	19	13.6	16	11.7	10	7.3	1	0.7	6	4.3	1	0.7	1	0.7	
Acute Rhinitis	0	6	8	13	15.1	5	5.8	2	2.3	1	1.2	3	3.4	1	1.2	
	1	6	7.6	11	13.6	4	5	2	2.5	4	5					
	2	10	7.3	8	5.8	5	3.6	3	2.2	4	2.9	3	2.2			
Otitis Media	0	3	3.4	2	2.3											0.558
	1	3	3.8	1	1.3	1	1.3	1	1.3	1	1.3					
	2	5	3.6	1	0.7											

The occurrence of at least one acute respiratory system infection in the subjects over 6 months ofattending pre-schools was reported by 87.2% of parents of children from Gr0, 78.5% in Gr1 and87.6% in Gr2 (Tab. 4)

Table 5. Number and percentage of children with frequency of occurrence of acuterespiratory tract infection

Group	Types of Acute Respiratory Tract Infection	1	2	3	4	5	6	7	8
0	Infections	20 2.3%	3 3.4%	1 1.2%					
	Infections	22 25.5%	14 16.2%	2 2.3%	2 2.3%	4 4.7%	2 2.3%	2 2.3%%	2 2.3%
	Otitis Media	3	2		1				
		3.4%	2.3%		1.2%				
1	Infections	7 8.9%	6 7.6%			1 1.3%			2 3.8%
	Infections	27 34.1%	18 25.3%	10 12.7%	3 3.8%	5 6.3%	1 1.3%		
	Otitis Media	3	1	1	1	1			
		3.8%	1.3%	1.3%	1.3%	1.3%			
2	Infections	32 23.8%	21 15.3%	5 3.6%	4 2.9%		1 0.7%		
	Infections	35 25.5%	25 18.2%	26 11.7%	4 2.9%	10 7.3%	3 2.1%	3 2.1%	4 2.9%
	Otitis Media								

In all the groups, recurrences of acute upper respiratory tract infections prevailed – the biggest number of them occurred in children from Gr2. Acute lower respiratory tract infections were also the most common among children from Gr2, whereas they were least frequently found in children from Gr1. Between the number of children in Group 1 and 2 who had up to 4 lower respiratory tract infections within 6 months, statistically significant differences (p=0.001) were found. In the analyzed 6-month period, 77.2% of children from Group 2, 64% of children from Group 0and 59.5% of children from Group 1 (p=0.014) needed antibiotic treatment, which proportionally reflects the quantitative distribution of frequency of occurrence of lower respiratory tract infections in the respective studied groups. 9.5% of children from Group 0, 7.6% of children from Group 1 and 15.7% of children from Group 2 needed hospitalization for different reason

CONCLUSION

Exposure to environmental tobacco smoke is common in children aged below five years who areunder regular follow-up. The frequency of acute respiratory infection increases in proportion to the presence of indoor smokers and increased number of cigarettes smoked in children exposed to environmental tobacco smoke. Exposure to ETS should be addressed in the scope of ‘child neglect. ‘The status of exposure to ETS should definitely be investigated in children who present to healthcare institutions with any reason or who are

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hospitalized and individual consultancy service should be provided to parents in this issue. Aeration and methods including dividing public areas as smoking and non-smoking areas do not prevent ETS.

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CONFLICT OF INTEREST
Authors declare no conflict of interest

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A STUDY ON THE IMPACT OF FACTORS RELATED TO HOSPITAL STAY AND DISCHARGE OF PATIENTS IN A NABH-ACCREDITED MULTISPECIALTY HOSPITAL

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ABSTRACT

Background:*The quality management practices is critical to the health care organization as it improves the operational efficiency, enhances the patient satisfaction. The patients face issues from delayed admission and discharge procedures. It is the prime responsibility of the hospital administration in identifying the elements related to these procedures and apply improvement strategies.*

Objective: *This study aims to explore the elements associated with the discharge in a NABH accredited multispecialty hospital.*

Methodology: *The study employs a* ***quantitative descriptive cross-sectional approach*** *using surveys to measure the percentage of people with a specific condition or attitudes towards a particular issue. And the study also used* ***Analytical Cross-Sectional Study approach*** *to explore the relationships between different variables at a single point in time.*

Results: *The study reveals that most of the patients were using cash payment method and majority admitted under medical management then surgical management. The average Length of stay (LOS) is 4 -5 days but majority stayed for 2 days. There is a slight significance related to the specialty, registration time, length of stay, treatment expenses, discharge time etc. The longer waiting time in registration happens for the certain specialty such as Urology Pulmonology, and Family Medicine. The patients in the specialty of Pulmonology, Nephrology, Radiotherapy and Orthopedics waiting for long time for preliminary diagnosis. The study found the slight correlations related to specialty, length of stay, waiting time , payment type, discharge waiting time of the patients. This suggest that the hospital organisation can flow separate strategies to address the delay and issues.*

Keywords: *Patient discharge, discharge related factors, inpatient satisfaction.*

• INTRODUCTION

The evolving technology and advancement of the healthcare industry keep increasing the expectations of patients with multispecialty hospitals. Patient satisfaction is being assessed with the dimensions of quality such as access, relevance to need, effectiveness, and efficiency (2001, International Encyclopedia of the Social & Behavioral Sciences J. Weinman). On the other hand, the hospital organization develops quality systems following national accreditation standards for patient care management to ensure quality of care. The hospital management established health care policies, protocols, and provides training to hospital staff on these systems to maintain high-quality service for patients. The collective efforts of the medical, paramedical, and administrative services of the hospital result in patient satisfaction.

The hospitals render diagnostic, preventive, curative, and rehabilitative care through inpatients, outpatients, and day care services. Among these inpatients were exposed to most of the hospital services as they stayed inside and experienced the various medical and paramedical services provided by the hospital. Nowadays, most hospitals use the patient feedback system as a marker of quality. The feedback provided by patients assists hospital management in evaluating the effectiveness of the hospital's services and supports in upholding patient satisfaction and quality of services.

Researchers are conducting numerous studies on patient satisfaction; however, this remains a field ripe for further exploration. So, the researcher likes to study few factors affecting the inpatient quality and care. This study was conducted from October 2024 to November 2024 among the inpatients of a multispecialty hospital in Madurai. The hospital is accredited with the 5th edition of NABH surveillance. The opinions of patients and their accompanying attendants were solicited through feedback regarding their experiences throughout the hospital stay at their time of discharge.

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- **REVIEW OF LITERATURE**

According to World Health Organization, patient satisfaction defined as the measures how content a patient is with the healthcare they received, encompassing their perceptions of quality, access, and the overall experience. The evaluation of the hospital services in Madurai, highlighting the implications for the quality of the service (Faisal and Chandra mohan), cleanliness is fundamental, as reported by various studies (Paul et al., N.D. Priya) of professional satisfaction between nurses in improving the quality of the service. Empathy experiences (Bharath, 2023), in addition, the factors that influence managerial productivity the continuous training and evaluation of the empathetic commitment of the clinical staff (Santanaraj, 2020). The study carried out in Hong Kong (by Carrie HK Yam, Eliza LY Wong, 1, 2011) stated that the hospital staff involved in patient discharge planning expressed a lack of manpower, skills, and time during weekends, and also issues in providing transportation and the necessary equipment to patients. The organization needs to establish explicit guidelines to put the patient in focus and encourage participation.

The healthcare team member must be allowed to develop communicative skills to support the active participation of patients. The study (Angela Bangsbo, Anna Duner, 2014) illuminates that patient participation in discharge planning conferences is also possible. A Study on the discharge process (Maria Flink and Mirjam Ekstedt 3, 2017) at three hospitals in Sweden identifies the significance of a discharge letter from the physician supporting the patient going home to manage the post-discharge needs at home and also helping to address the patient's motivation and skills going forward. A review article (Amamda C. Everall, Sara J. 2019) from seven journal articles has presented 5 overarching elements of delayed discharge experience overall uncertainty related to discharge, the impact of hospital staff and environment, mental and physical deterioration, lack of engagement in decision-making making, and need for advocacy and initial disbelief followed by reluctant acceptance of the situation. The patients' moods were directly affected by the attitudes and behavior of the hospital staff, while hospital rules were selectively applied to and preferred patients were favored over others. This study suggested including participant demographics for better understanding and enhanced communication with patients and families, and programs to reduce deconditioning. The study by Sofi Nordmark1,2 Karin Zingmark showed the importance and need for understanding the existing practices in discharge planning before implementing the new practices.

- **OBJECTIVES OF THE STUDY**

1. To understand the demographic profile of the respondents related to age, gender and payment type (cash, insurance), and to analyze their length of stay, specialty under treatment etc.
2. To analyze the impact of the payment method (cash and insurance) on the patient registration waiting time., and on the time taken for discharging the patient.
3. To analyze relationships between the specialty of admission with length of stay, time of admission registration, treatment expenses and discharge delay.

3. a) Hypothesis testing

1. **H_0:** There is no significant relationship between Specialty and the treatment expenses.

   H_1: There is a significant relationship between Specialty and the treatment expenses.

2. **H_0:** There is no significant relationship between specialty and the length of stay.

   H_1: There is a significant relationship between specialty and the length of stay.

3. **H_0:** There is no significant relationship between Treatment expenses and the time taken for discharge.

   H_1: There is a significant relationship between treatment expenses and the time taken for discharge.

4. **H_0:** There is no significant relationship between Length of hospital stay time taken for discharge.

   H_1: There is a significant relationship between Length of hospital stay time taken for discharge.

5. **H_0:** There is no significant relationship between Payment Type and Registration Waiting Time.

   H_1: There is a significant relationship between Payment Type and Registration Waiting Time.

6. **H_0:** There is no significant relationship between Payment Type and Time Taken for Discharge.

   H_1: There is a significant relationship between Payment Type and Time Taken for Discharge.

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4. SCOPE OF THE STUDY

The study is about the factors associated with the patient's admission and discharge delay, and the study area is the inpatient department. The few factors like consultation, length of stay, treatment expenses, discharge plan, time taken for admission, and discharge activities etc., measured by the patient or their family members. The hospital is a NABH-accredited hospital, where all the quality systems are followed by the hospital management. The study results and suggestions are relevant only to the hospital under study. The study was conducted in a multispecialty hospital located in Madurai, South Tamil Nadu, India.

5. RESEARCH GAP

The previous studies conducted in the inpatient area related to discharge suggested including the patient and family to establish explicit guidelines to put the patient in focus and encourage participation, including participant demographics for better understanding and enhanced communication with patients and families. So the researcher concentrated to identify the influence of few factors and relationship between these factors.

6. RESEARCH METHODOLOGY

6.1. Research Study

This is a **quantitative descriptive cross-sectional study** that aims to describe the prevalence or characteristics of a variable within a population by collecting numerical data. Examples include using surveys to measure the percentage of people with a specific condition or attitudes towards a particular issue.

The **Analytical Cross-Sectional analysis** applied to explore the relationships between different variables at a single point in time. These studies often use statistical analysis to examine associations between exposures and outcomes of the service provided by the organization

6.2. Sources of data and data collection methods

The data collected were both primary and secondary data. The primary data was collected directly from the patients and their attendants. The secondary data were collected from books, e-journals (Del net), and hospital documents. The data collection tool is the feedback form (Paper and Pen), through which responses of the patients and patient attendees were gathered using a Likert scale. The period of data collection was 72 days.

The Primary data were collected through a feedback form that consisted of 10 patients' personal information (independent variable) and 10 elements (dependent variable) as assessment criteria. The data were collected for 2 months from October 2024 to November 2024. The 5 rating "Likert scale" used in the feedback form"1" as Highly unsatisfied to "5" as Highly satisfied, for assessing the care The Patient's personal information related variables such as. Patient name, Gender, Age group, Room number, Specialty, Treating Consultant, Date of admission, Date of Discharge, Length of Stay, and Payment Type were observed and collected. The satisfaction assessment criteria related to the Time taken for admission and preliminary diagnosis, and the Patient care variables, Hospital Facility, and Supportive Services, Hospital stay, and discharge were assessed by the patient and family using a 5-point Likert Scale "1" as highly unsatisfied and "5" a highly satisfied.

Month	2023	2024
January	829	890
February	811	826
March	889	811
April	755	840
May	812	1029
June	865	899
July	805	926
August	824	900
September	841	908
October	930	916
November	970	898
December	993	1021

Courtesy – from hospital records
Table 1 – number of discharge/month

Time taken for admission procedures and preliminary diagnosis: The time consumed for registration at the admission counter and the time taken for the Doctor/Nurse visit for preliminary diagnosis. **Patient care variables:** The care provided by the consultant, the Duty medical officer, and the Nursing staff of the hospital.

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Hospital Stay and discharge plan: The length of stay, time taken for discharge, and treatment expenses were assessed by the patient and family using a 5-point Likert Scale, "1" as highly unsatisfied and "5" a highly satisfied.

6.3. Sampling Frame

As per the hospital records, the number of patients discharged from the hospital was an average of 29 per day and 890 per month. The data is planned to be collected for two months thus the sampling frame is taken as 1780 samples.

Table 1- discharge month wise This table-1 shows the number of discharges of two years monthly wise. The total number of discharges in the year 2023 from January to December is 10324 calculated the monthly average is 860.333, daily average number of discharges 28.67 per day. The study conducted between September and October of 2024. The total discharge of Jan – August of 2024 were 7124 leads to 890.125 per month and 29.6 per day.

6.4. Sample size

The sample size is calculated with the help of the formula. The sample size formula for a known population using Slovin's formula is: n = N / (1 + Ne^2), where "n" is the sample size, "N" is the total population size, and "e" is the desired margin of error.

The population is 1780 with a confidence level of 95% that the real value is within ±5% of the measured/surveyed value. This means 323 samples are needed.

Formula

$$n = \frac{n_0}{1 + \frac{(n_0 - 1)}{N}}$$

when using Cochran's equation together with a population of 1780 the sample size 317

n=n01+(n0−1) N. Precision Level is the margin of error prepared to tolerate - e.g., 5% means a result that is within 5 percentage points of the true population value. Confidence Level is a measure of confidence in the precision of the result. For example, selecting 5% as the level of precision, and 95% as the confidence level, indicates a result that is within 5% of the real population value 95% of the time. https://www.socscistatistics.com/tests/samplesize/default.aspx used calculator for calculating the sample size.

7. ANALYSIS AND INTERPRETATION OF THE DATA

7.1. Data Analysis of demographic- independent variables

The data was analyzed with the help of the JASP 0.18.3 version and SPSS 20 version. The patient feedback form given to 415 discharged patients, only 312 were accepted and filled the form and the collected data were verified for validity and missing data, and 0 variance was considered nonperforming. The normality analysis was done. From the 255 samples, no missing cases were found and all the samples were taken for the analysis

Gender	Frequency	Percent	Valid Percent	Cumulative Percent
Female	105	41.2	41.2	41.2
Male	150	58.8	58.8	100.0
Total	255	100.0	100.0	

Table – Gender

Table – Gender interprets that the female respondents of the study were 41.2 percent and the male respondents were 58.8 percent. Among the respondents, the number of male patients was 17.6 percent higher than that of female patients.

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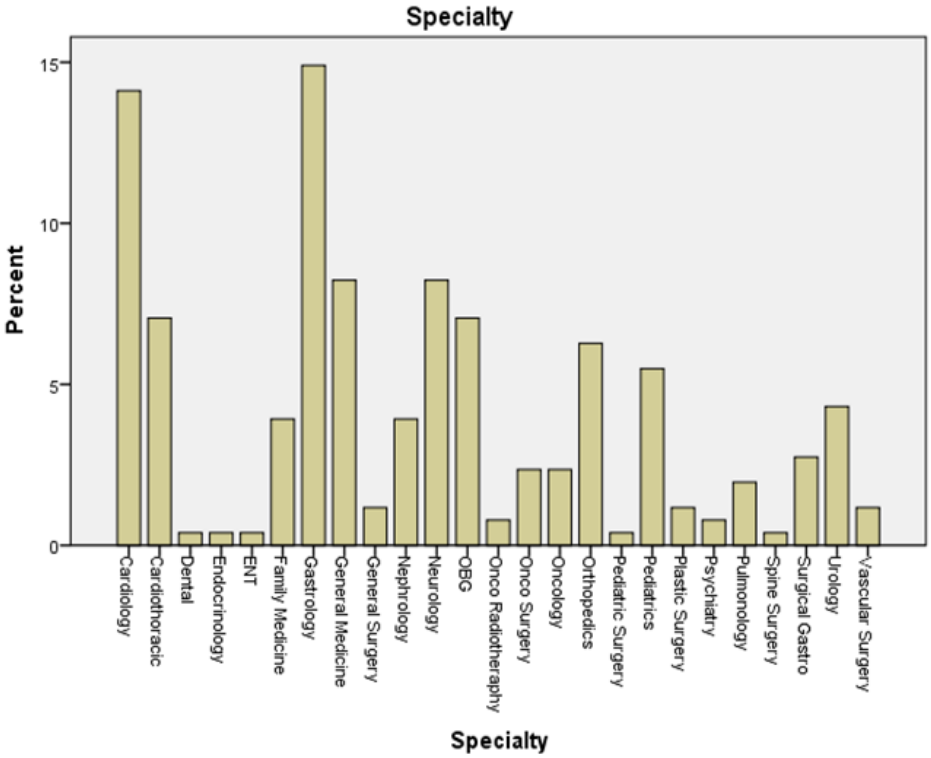
Age group		Table Gender * Age Group Crosstabulation							Total
		Zero to 5	16 to 25	26 to 35	36 to 45	46 to 55	56 to 65	66 to 75	
Gender	Female	9	8	12	12	34	22	8	105
	Male	5	1	8	33	44	44	15	150
Total		14	9	20	45	78	66	23	255

The Table Age and gender cross-tabulation shows that the majority of the patients were male belonged to the age group of 36 to 45 years, 46 to 55 years, and 56 to 65 years. Most of the patients were female in the age groups of zero to 5 years, 16 to 25 years, 26 to 35 years, and 66 to 75 years. Majority of the respondents were in the age group of 46 to 55 years, and 56 to 65 years.



The Histogram shows that the highest number of respondents belongs to gastroenterology, cardiology specialties and the lowest belongs to ENT, dental and endocrinology. The specialty wise respondent shows that the majority 14.9 percent were belongs to the specialty of gastrology and 14.1 percent were belongs to the specialty of cardiology and 8.2 percent in nephrology and 8.2 percent in general medicine,7.1 percent in OBG and 7.1 percent in cardiothoracic surgery, 6.3 percent in ortho, 5.5 in pediatrics 4.3 percent in urology department, 3.9 percent in nephrology, 3.9 percent in family medicine, 2.7 percent in surgical gastrology 2.4 in oncology and 2.4 percent in onco-surgery, 2.0 percent in pulmonology, 1.2 percent in vascular surgery and 1.2 percent in general surgery. 1.2 percent in plastic surgery, 0.8 percent in psychiatry and 0.8 percent in onco-radiotherapy, 0.4 percent in spine surgery, 0.4 percent in pediatric surgery, 0.4 percent in dental, 0.4 percent in endocrinology, and 0.4 percent in ENT

Length of stay in hospital

The length of stay denotes the number of days the patient staying at the hospital for taking the treatment. The histogram picture reveals the maximum patients stays for 2 days and the minimum patients stays for 31 and 23 days in the hospital

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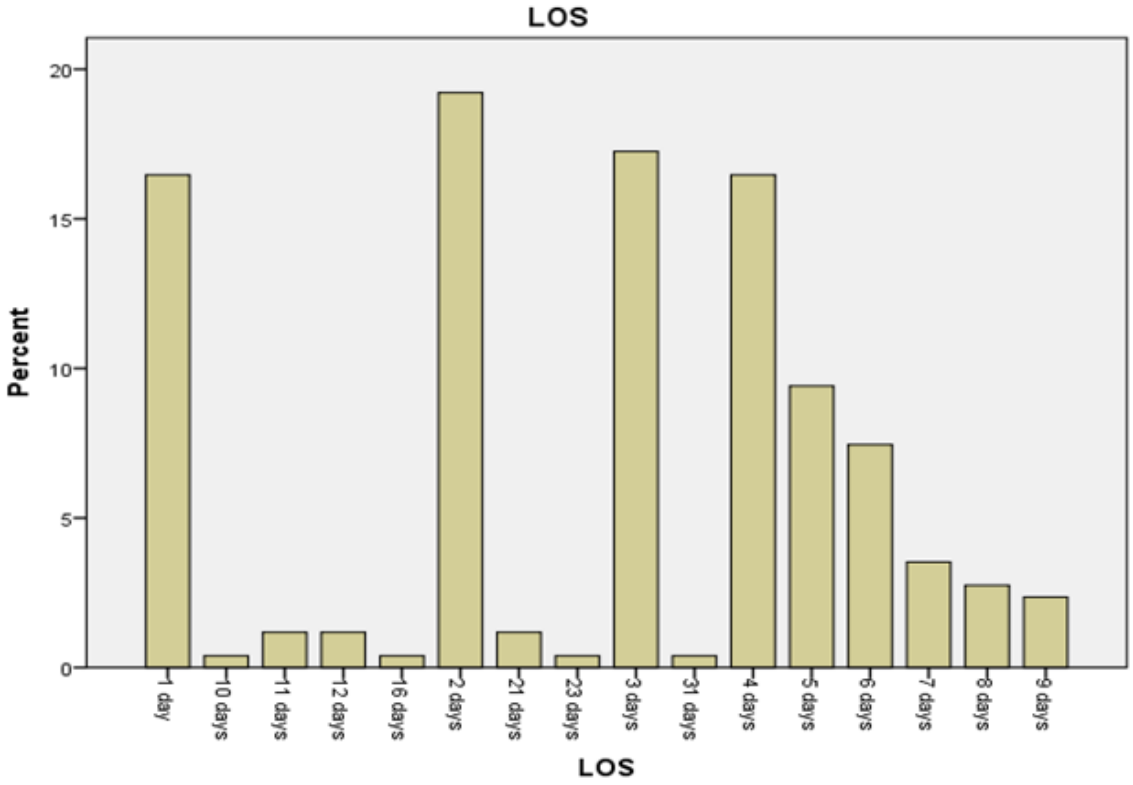

Valid	255
Missing	1
Mode	2.000
Median	3.000
Mean	4.149
Std. Deviation	3.731
Minimum	1.000
Maximum	31.000
Statistics - length of stay of respondents	

The table length of stay denotes the descriptive statistics of mode of stay of the respondents is 2 days and the mean value of the stay is 4.149 days. The minimum number of days is 1 and the maximum number of days are 31 days

Payment Type	Frequency	Percent	Valid Percent	Cumulative Percent
Cash Payment	174	68.2	68.2	68.2
FHPL	3	1.2	1.2	69.4
Care Insurance	4	1.6	1.6	71.0
MediAssist	11	4.3	4.3	75.3
TNEHS	14	5.5	5.5	80.8
ECHS	13	5.1	5.1	85.9
VIDAL	4	1.6	1.6	87.5
NHISP	7	2.7	2.7	90.2
Star Health	8	3.1	3.1	93.3
Bajaj	1	.4	.4	93.7
Health India	3	1.2	1.2	94.9
ICICI	3	1.2	1.2	96.1
Safe way	1	.4	.4	96.5
GHPL	1	.4	.4	96.9
IFFCO	1	.4	.4	97.3
Railway	2	.8	.8	98.0
ERICSON	1	.4	.4	98.4
HDFC	1	.4	.4	98.8

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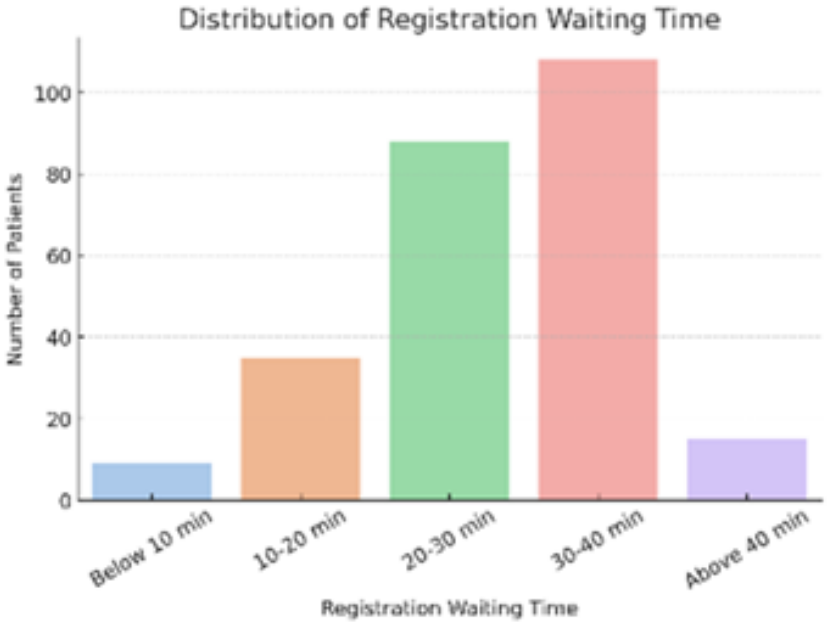
Paramount	1	.4	.4	99.2
CM Scheme	2	.8	.8	
Total	255	100.0	100.0	100.0

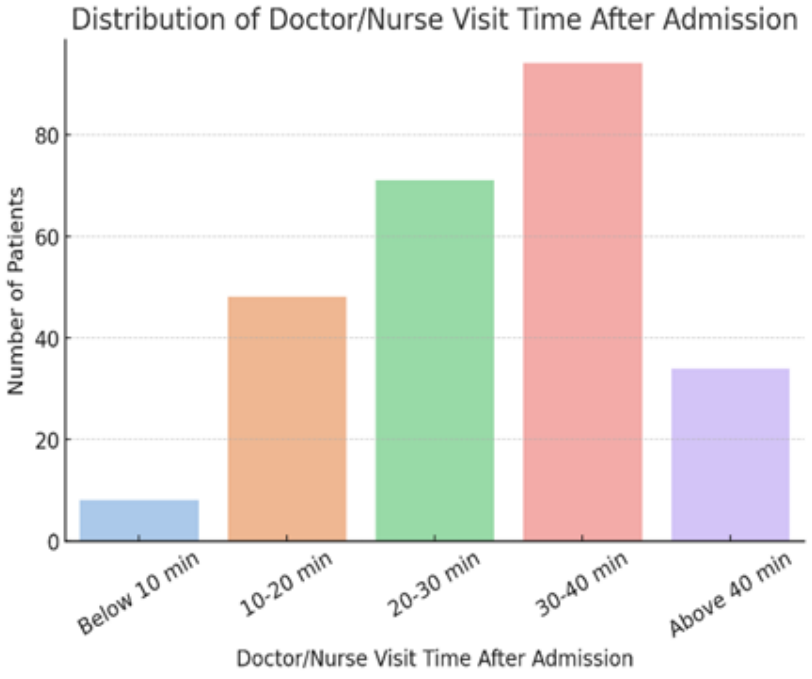
Table – Payment type of patients

The patients (68.2%) paid using cash. The remaining **31.8%** of patients used various insurance schemes for payment. **TNEHS (5.5%)**, **ECHS (5.1%)**, and **Medi Assist (4.3%)** are the most frequently used claim-based payments. Other claim-based payment methods (e.g., **Star Health (3.1%)**, **NHISP (2.7%)**) are used by fewer patients. Several insurance providers, such as **Bajaj, Safe Way, GHPL, IFFCO, ERICSON, HDFC, and Paramount**, each have **only one patient (0.4%)** using them. This indicates that these claim types are much less common in the patient population.

7.2. Data analysis related to the waiting time



Here is the **bar chart** representing the distribution of registration waiting times. It clearly shows that most patients wait between **20 to 30 minutes**, and **30 to 40 minutes** with very few experiencing short wait times.



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The bar chart illustrating the distribution of doctor/nurse visit times after admission. It highlights that most patients wait **20-40 minutes**, with some experiencing delays beyond **40 minutes**

Statistical Analysis of Waiting Times			
		Registration Waiting Time	Doctor Nurse visit time after admission
N	Valid	255	255
	Missing	0	0
Mode		4.00	4.00
Std. Deviation		.91071	1.03547

The table **Statistical Analysis of Waiting Times** provides statistics on two important time-based metrics: **Registration Waiting Time Mode = 4.00** → The most frequently occurring category is **30-40 minutes.** Standard Deviation = 0.91071 → Indicates **moderate variability** in waiting times. Doctor/**Nurse Visit Time After Admission Mode = 4.00** → The most common waiting time for a doctor/nurse visit is also in a higher category, likely **30-40 minutes**. **Standard Deviation = 1.03547** → Slightly higher variability than registration waiting time suggests **inconsistencies in patient care response time**.

7.3. Correlations analysis

Correlations: Specialty, Payment Type, Treatment Expenses, Time Taken for Discharge, and Length of Stay in Hospital.						
		Specialty	**Payment Type**	**Treatment Expenses**	**Time Taken for Discharge**	**Length of stay in hospital**
Specialty	**Pearson Correlation**	**1**	**.150***	**.125***	**.044**	**.146***
	Sig. (2-tailed)		**.017**	**.046**	**.485**	**.020**
Payment Type	**Pearson Correlation**	**.150***	**1**	**-.027**	**.078**	**.019**
	Sig. (2-tailed)	**.017**		**.673**	**.214**	**.766**
Treatment Expenses	**Pearson Correlation**	**.125***	**-.027**	**1**	**.147***	**.124***
	Sig. (2-tailed)	**.046**	**.673**		**.019**	**.048**
Time Taken for Discharge	**Pearson Correlation**	**.044**	**.078**	**.147***	**1**	**.147***
	Sig. (2-tailed)	**.485**	**.214**	**.019**		**.019**
Length of stay in hospital	**Pearson Correlation**	**.146***	**.019**	**.124***	**.147***	**1**
	Sig. (2-tailed)	**.020**	**.766**	**.048**	**.019**	
***. Correlation is significant at the 0.05 level (2-tailed).**						
b. Listwise N=255						

The correlation table provides insights into the relationships between **Specialty, Payment Type, Treatment Expenses, Time Taken for Discharge, and Length of Stay in Hospital**. Below is a detailed interpretation:

Hypothesis 1. Relationship Between Specialty and Treatment Expenses
The correlation (r = 0.125, p = 0.046) is significant, indicating that different specialties incur varying levels of expenses. So, the null hypothesis is rejected and the **alternative hypothesis is accepted.**

Hypothesis 2. Relationship Between Specialty and Length of Hospital Stay
The correlation (r = 0.146, p = 0.020) is significant, implying that some specialties require longer hospitalization periods. So, the null hypothesis is rejected, and the **alternative hypothesis is accepted.**

Hypothesis 3. Relationship Between Treatment Expenses and Time Taken for Discharge
The correlation (r = 0.147, p = 0.019) suggests that expensive treatments may lead to **longer administrative or medical discharge processes**. So, the null hypothesis is rejected and the **alternative hypothesis is accepted.**

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Hypothesis 4. Relationship Between Length of Stay and Time Taken for Discharge
The correlation (r = 0.147, p = 0.019) suggests a significant link, indicating that **longer hospital stays often result in more extended discharge procedures**. So, the null hypothesis is rejected and the **alternative hypothesis is accepted.**

Correlations - Payment Type with Registration Waiting Time, and Time Taken for Discharge					
			Payment Type	Registration Waiting Time	Time Taken for Discharge
Spearman's rho	Payment Type	Correlation Coefficient	1.000	.128*	.065
		Sig. (2-tailed)	.	.041	.299
		N	255	255	255
	Registration Waiting Time	Correlation Coefficient	.128*	1.000	-.051
		Sig. (2-tailed)	.041	.	.413
		N	255	255	255
	Time Taken for Discharge	Correlation Coefficient	.065	-.051	1.000
		Sig. (2-tailed)	.299	.413	.
		N	255	255	255
*. Correlation is significant at the 0.05 level (2-tailed).					

The correlation analysis was conducted using Spearman's rho to examine the relationships between Payment Type & Registration Waiting Time, and Payment Type & Time Taken for Discharge based on a sample of 255 observations.

Hypothesis 5: Relationship Between Payment Type and Registration Waiting Time
The Spearman's correlation coefficient (r = 0.128) indicates a weak positive correlation between Payment Type and Registration Waiting Time. The **p-value (0.041)** is less than 0.05, meaning the correlation is **statistically significant** at the 5% significance level. So, Reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1), meaning there is a slight relationship between Payment Type and Registration Waiting Time.

Hypothesis 6: Relationship Between Payment Type and Time Taken for Discharge
The correlation coefficient (**r = 0.065**) suggests an extremely weak **positive** relationship between Payment Type and Time Taken for Discharge. However, the **p-value (0.299)** is greater than 0.05, indicating that this relationship is **not statistically significant**. Accept the null hypothesis (H_0), and reject the alternative hypothesis as indicating no significant relationships between Payment Type & Discharge Time.

8. FINDINGS

The study reveals that the number of male patients were 17.6 percent higher than that of female patients, and the majority fell in the age group of 46 to 55 years and 56 to 65 years. And, 70.2 percentage of patients taking medical management, 22.7 percent under surgical management, consequently gastroenterology, cardiology specialties and 7.1 percent were admitted with obstetrics and gynecology. About the length of stay (LOS), most of the patients stay for 2 days, and the average LOS is 4.149 days. The minimum and the maximum LOS are 1, 31 days. Maximum, 174 patients (68.2%) used cash payment for the services, and 31.8% used various insurance schemes for payment. In that, TNEHS (5.5%), ECHS (5.1%), and Medi Assist (4.3%) are the most frequently used claim-based payments. Fewer patients used Star Health (3.1%), NHISP (2.7%) but Bajaj, Safe Way, GHPL, IFFCO, ERICSON, HDFC, and Paramount, used by only one patient (0.4%).

Patient waiting time for admission registration, 76.9% of patients experience a waiting time between 20 to 40 minutes. Only 3.5% of patients are registered in under 10 minutes. 13.7% wait between 10-20 minutes. Mean 3.33, Mode is 4.00 denotes that the most frequently occurring category is 30-40 minutes, and the Standard Deviation is 0.91071, indicating moderate variability in waiting times. The longer waiting time in registration happens for the specialty of Urology 4.30, Pulmonology 3.40, Family Medicine 4.00 and the Shortest Registration Waiting Times in the specialty of surgical oncology 2.14, Pediatric Surgery and Nephrology 2.90.

The time taken by the Duty Medical officer and Nurse for initial assessment of the patients after admitting to the room (Mean -3.38, Mode is 4.00), likely 30-40 minutes, and the Standard Deviation 1.03547 denotes slightly higher variability compared to registration waiting time. The longest Doctor/Nurse Visit Times After Admission in the specialties of Pulmonology: 4.20, Nephrology: 4.40, Radiotherapy: 4.50, *and* Orthopedics: 4.06. The

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Shortest Doctor/Nurse Visit Times After Admission in the specialties of Family Medicine: 2.22 and Psychiatry: 2.50, identifies the inconsistencies in patient care response time.

The influence of **Specialty & Other Variables** i) Specialty & Payment Type ($r = 0.150$, $p = 0.017$) shows that a weak but significant correlation suggests that the type of specialty influences the mode of payment. Some specialties may have more patients relying on insurance claims, while others have more cash-paying patients. ii)Specialty & Treatment Expenses ($r = 0.125$, $p = 0.046$) shows that different specialties incur different levels of expenses. Some treatments (e.g., ICU, surgery) might be more expensive than others (e.g., general medicine). iii)Specialty & Length of Stay ($r = 0.146$, $p = 0.020$) shows that Certain specialties require longer hospitalization than others (e.g., ICU or post-surgical care compared to outpatient or short-term care specialties). **Payment Type & Other Variables** (all p-values > 0.05) shows that no significant correlations interprets that the mode of payment is independent of treatment expenses, discharge time, and length of stay. **Treatment Expenses & Other Variable** i)Treatment Expenses & Time Taken for Discharge: ($r = 0.147$, $p = 0.019$) denotes Higher treatment expenses may be linked to longer discharge processing times (possibly due to billing, insurance approvals, or administrative procedures) ii)Treatment Expenses & Length of Stay ($r = 0.124$, $p = 0.048$) denotes Patients with higher treatment expenses tend to stay longer in the hospital, which is logical since longer stays often result in higher costs. **Time Taken for Discharge & Length of Stay** ($r = 0.147$, $p = 0.019$) denotes weak but significant correlation indicates that patients who stay longer in the hospital may also take more time to be discharged. This could be due to additional documentation, medical clearance, or financial settlements.

Relationship Between Payment Type and Registration Waiting Time: Spearman's correlation coefficient ($r = 0.128$) indicates a weak positive correlation between Payment Type and Registration Waiting Time. The **p-value (0.041)** is less than 0.05, meaning the correlation is **statistically significant** at the 5% significance level. This implies that the type of payment method used by patients has a minor yet statistically meaningful influence on the time they wait for registration. Patients using different payment methods may experience slight variations in their waiting time, possibly due to procedural differences associated with each method (e.g., cash payments, insurance claims, or digital transactions). **Relationship Between Payment Type and Time Taken for Discharge:** The correlation coefficient (**$r = 0.065$**) suggests an extremely weak **positive** relationship between Payment Type and Time Taken for Discharge. However, the **p-value (0.299)** is greater than 0.05, indicating that this relationship is **not statistically significant**. This suggests that the type of payment method used by patients does **not** have a meaningful impact on the overall discharge process. Whether a patient pays by cash, card, or insurance does not appear to influence how long it takes for them to be discharged from the hospital.

9. DISCUSSIONS AND CONCLUSION

Cash Payment is the Most Common Method used by the majority of patients rather than insurance claims. Insurance Claims Are Diverse but Less Frequent 31.8% of patients used various insurance schemes for payment. No single insurance provider dominates, but some have slightly higher usage: This indicates that these claim types are much less common in the patient population. The dominance of cash payments (68.2%) suggests that most patients may either lack insurance coverage or prefer cash transactions for faster processing. The variation in claim-based payments indicates that hospitals may need to streamline their processing systems for different insurance providers to avoid delays. The hospital wants to encourage more insurance-based payments, partnering with popular insurance providers to facilitate a smoother claims process. Educating patients on available claim options and how to use them effectively. Improving claim processing efficiency to reduce wait times for patients using insurance.

Short Waiting Time (Below 20 Minutes) is Rare, only 17.2% of patients experience quick registration. Long Waits Above 40 Minutes Are Uncommon 5.9% of patients wait for more than 40 minutes before registration is completed. The majority of patients (76.9%) face moderate to long registration times (20-40 min). This suggests a bottleneck in the registration process that could be improved. A small portion (5.9%) wait longer than 40 minutes, which may indicate occasional administrative inefficiencies or peak-hour congestion. Implementing digital pre-registration to reduce wait times. Increasing staff availability during peak hours to enhance efficiency.

Doctor/Nurse visit time also has delays, with high variability, so Implement a structured rounding system to ensure timely first visits post-admission. Pulmonology & Nephrology showed longer post-admission visit times, which might suggest either more intensive care needs or slower workflows. Departments with high registration waiting times and high post-admission delays (e.g., Pulmonology, Urology) might benefit from process optimization or additional staffing. Departments with low variance and efficient processes (like Family Medicine and Surgery) could serve as models for best practices.

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Specialty affects payment method, expenses, and hospital stay duration, so the hospitals should analyze which specialties have higher insurance claims vs. cash payments to improve financial processing. Treatment expenses are linked to hospital stay and discharge time Reducing administrative delays for costly treatments can help improve patient experience. Longer hospital stays are associated with extended discharge processes, it is necessary to Implement faster discharge protocols especially for high LOS patients could enhance efficiency.

Relationship Between Specialty and Payment Type. ($r = 0.150$, $p = 0.017$) is significant at the 0.05 level, suggesting a weak but meaningful relationship. The Relationship Between Specialty and Treatment Expenses ($r = 0.125$, $p = 0.046$) is significant, indicating that patients admitted to different specialties incur varying levels of expenses. The Relationship Between Specialty and Length of Hospital Stay ($r = 0.146$, $p = 0.020$) is significant, implying that some specialties require longer hospitalization periods.

The Relationship Between Treatment Expenses and Time Taken for Discharge ($r = 0.147$, $p = 0.019$) suggests that expensive treatments may lead to longer administrative or medical discharge processes. The Relationship Between Length of Hospital Stay and Time Taken for Discharge ($r = 0.147$, $p = 0.019$) suggests a significant link, indicating that longer hospital stays often result in more extended discharge procedures.

Future studies could incorporate other operational, administrative, or medical factors to gain a more comprehensive understanding of hospital workflow efficiency such as analyzing peak-time trends in in patient registration, doctor/nurse rounds pattern etc..

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ASSESSING THE PSYCHOLOGICAL IMPACT OF SOCIAL MEDIA ON YOUTH SELF-ESTEEM: THE ROLE OF VIRTUAL VALIDATION

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ABSTRACT
This study examines the psychological impact of social media on youth self-esteem, focusing on the role of virtual validation. Social media platforms like Instagram, Snapchat, and Facebook have become central to self-expression and social interaction among adolescents and young adults. These platforms offer opportunities for connection and creativity, but also foster a reliance on external approval in the form of likes, comments, and shares. The research aims to assess how virtual validation influences self-worth among youth aged 15 to 24 in Vellore city, Tamil Nadu. Data was collected from 100 respondents using a structured questionnaire incorporating the Rosenberg Self-Esteem Scale (RSES). Key variables examined included social media usage patterns, emotional responses to online feedback, and perceived importance of digital affirmation. Results showed that 28% of respondents have low self-esteem, while only 12% exhibit high self-esteem. A moderate but statistically significant negative relationship was found between virtual validation and self-esteem levels, indicating that higher dependence on online approval is associated with lower self-esteem. The findings underscore that virtual validation has both behavioral and emotional consequences for youth. It reinforces self-worth through positive feedback loops, encourages constant identity curation, and intensifies social comparison, often leading to anxiety, disappointment, or diminished self-worth when validation is lacking. Digital interactions can foster peer support and connectedness, but overreliance on them for personal affirmation may result in fragile, externally-based self-esteem.

Keywords: *Virtual Validation, Self-Esteem, Youth Psychology, Social Media*

INTRODUCTION
Social media platforms like Facebook, Instagram, and Snapchat have significantly influenced young people's communication, expression, and interaction. These platforms facilitate networking, creativity, and information exchange, but also introduce psychological dynamics that impact mental health and self-perception. One such dynamic is virtual validation, where one's self-worth is measured by online comments, likes, shares, and feedback. Self-esteem is crucial for how people see themselves and interact with others, and adolescents and young adults are particularly susceptible to outside validation.

New research suggests that social comparisons, the desire for online approval, and frequent exposure to carefully chosen content may lead to a distorted self-image, elevated anxiety, and insecurity. Users may base their sense of self-worth on the volume and type of digital affirmations they receive as a result of the feedback loop created by virtual validation. This dependency on external validation may not always be positive or sustainable. There is a need for comprehensive, context-specific studies exploring the psychological implications of social media on youth, particularly through the lens of virtual validation. This study aims to evaluate the psychological effects of youth social media use on self-esteem, focusing on the ways in which virtual validation affects how people view themselves. The results should help shape strategies for young people to use social media in a healthier way and contribute to the larger conversation on digital well-being.

SOCIAL MEDIA
Social media refers to promote communication, teamwork, and community building across virtual networks, social media refers to digital platforms and applications that let users create, share, and engage with content in real time. People can express their opinions, keep up social connections, and look for feedback in the form of likes, comments, and shares on these platforms, which include Facebook, Instagram, TikTok, Twitter (X), Snapchat, and YouTube.

According to this study, social media is seen as a place where young people regularly engage in social comparison and look for virtual validation, two activities that have a substantial impact on their psychological health and confidence in themselves. It is also seen as a medium for interaction.

YOUTH SELF-ESTEEM
Youth self-esteem refers to the overall sense of self-worth and personal value that adolescents and young adults (typically aged 15 to 24) have about themselves. It includes young people's attitudes, convictions, and emotions about their skills, looks, interpersonal connections, and sense of self. Young people's self-esteem is influenced

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by a number of things, such as their own accomplishments, peer and adult criticism, and cultural or societal expectations. Social media validation in the form of likes, comments, and shares, as well as the propensity to evaluate oneself against others based on carefully curated online representations, frequently impact young people's self-esteem.

VIRTUAL VALIDATION

The process by which people use digital interactions on social media platforms to look for affirmation, approval, and recognition is known as virtual validation. It entails getting praise from peers and followers in the form of likes, comments, shares, and other positive reinforcement. When people evaluate their value or social standing based on the digital responses and engagement they receive, this validation acts as a barometer for self-worth. Virtual validation is frequently at the heart of social media use, especially among young people who may depend on this outside input to mould their identity, sense of self, and emotional health.

Key Factors Influencing the Impact Of Social Media On Youth Self-Esteem:

- **Frequency and Duration of Use**: Excessive usage can lead to anxiety, depression, and lower self-worth.
- **Social Comparison**: Youth often compare themselves to peers or influencers, leading to feelings of inadequacy and lower self-esteem.
- **Virtual Validation**: Overreliance on online feedback can lead to fragile self-esteem based on external approval.
- **Peer Interaction and Social Support**: Positive engagement can build self-confidence, while negative interactions can undermine it.
- **Type of Social Media Platform**: Image-centric platforms like Instagram or TikTok are associated with body dissatisfaction and appearance-based self-esteem issues.
- **Online Identity Management:** Constantly curating a "perfect" image online can cause self-doubt and diminished self-esteem.
- **Fear of Missing Out (FOMO):** Seeing others engage in enjoyable activities can lead to feelings of exclusion and lower self-image.
- **Psychological Resilience**: Strong self-awareness, critical thinking, and family support can be more resilient to negative influences.
- **Parental and Educational Guidance**: Digital literacy training and parental involvement can help navigate challenges.

Role of Virtual Validation On Social Media Among Youth

- **Reinforces Self-Worth**: High engagement often leads to a dependency on others' approval, creating a sense of confidence.
- **Encourages Behavior Regulation**: Positive feedback encourages repeating similar content or behavior, reinforcing specific attitudes or appearances.
- **Triggers Emotional and Mental Impact**: Lack of validation can lead to emotional distress, anxiety, or insecurity.
- **Signals Social Belonging and Peer Acceptance**: Validation serves as a benchmark for peer worthiness.
- **Promotes Social Comparison**: Users compare their likes with others, impacting self-esteem and leading to competition or feelings of inadequacy.
- **Motivates Continued Engagement**: Virtual validation becomes a reward loop, keeping youth engaged.
- **Influences Identity Formation**: Shapes self-concept and influences how youth view themselves online and offline.
- **Encourages Filtered or Unrealistic Standards**: Promotes idealized self-presentation, causing identity tension and lower authentic self-esteem.

REVIEW OF LITERATURE

Fardouly, J., Diedrichs, P. C., Vartanian, L. R., & Halliwell, E. (2015), examine the psychological effects of social media, particularly Instagram, on young people's body image and self-esteem. The study shows that

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individuals who frequently compare themselves to idealized images on social media platforms suffer from lower self-esteem. Virtual validation, such as likes and comments, was found to enhance these negative feelings. The authors highlight the importance of cultivating awareness about the implications of social media exposure on mental health, especially for vulnerable youth populations.

Kuss, D. J., & Griffiths, M. D. (2017), provide an overview of the addictive potential of social media and its impact on mental health, including self-esteem. They argue that the pursuit of virtual validation creates a cycle of dependence on social feedback, contributing to anxiety and depression. This literature review indicates that the continuous need for online approval is linked to diminished self-worth, particularly when young users do not receive the expected positive reinforcement from their social media networks.

Marino, C., Gini, G., Vieno, A., & Spada, M. M. (2018), investigates the relationship between social media use and self-esteem in adolescents. The authors found that frequent engagement with social media, coupled with a strong reliance on virtual validation, was linked to lower self-esteem. Youth who experienced negative feedback or social comparison on social media platforms reported higher levels of anxiety and depression. The authors stress the importance of promoting healthy social media habits to protect young people's psychological well-being**.**

Kerr, G., & O'Reilly, N. (2019), focus on the role of social media in shaping the self-esteem of young individuals. They argue that the quest for virtual validation, particularly through likes and comments, often leads to feelings of inadequacy and emotional distress. The research emphasizes that the youth who experience negative or minimal feedback on social media platforms may develop diminished self-worth. The authors suggest that social media platforms must implement features that promote healthier engagement and self-esteem protection.

Ding, K., & Zhang, H. (2020), explore how social media influences the self-esteem of adolescents through the lens of virtual validation. Their research indicates that while social media provides opportunities for positive reinforcement, it can also lead to psychological harm, particularly when users seek external validation through comments and likes. The authors note that these virtual interactions are especially impactful when users compare themselves to others, reinforcing negative self-perceptions.

Sherman, L. E., Greenfield, P. M., & Hernandez, L. M. (2018), analyse the role of social media feedback in shaping adolescent self-esteem. The study shows that youth who actively seek virtual validation from their online networks are more likely to experience fluctuations in self-esteem based on the feedback they receive. The authors argue that the emotional consequences of online feedback—both positive and negative—underscore the need for interventions that help young people build self-esteem independent of social media validation.

RESEARCH METHODOLOGY

RESEARCH DESIGN

This study adopts a quantitative research design to systematically assess the psychological impact of social media usage on self-esteem among youth in Vellore city, with an emphasis on the role of virtual validation. A descriptive and correlational approach was utilized to quantify the relationship between social media behavior and self-esteem outcomes.

OBJECTIVES OF THE STUDY

- To examine patterns of social media usage among youth in Vellore city.
- To assess self-esteem levels using a standardized psychological instrument.
- To explore correlations between virtual validation and frequency of social media usage.

AREA OF STUDY

The study was conducted within the urban and semi-urban regions of Vellore city, Tamil Nadu. The choice of Vellore is driven by its diverse youth demographic comprising students, working professionals, and digital natives, offering a meaningful context for studying online psychological behaviors.

POPULATION AND SAMPLE SIZE

The target population consisted of youth aged 15 to 24 years residing in Vellore and actively using at least one social media platform. A sample size of 100 respondents was chosen for the study, which is considered adequate for descriptive and correlational analyses in small-scope behavioral studies. A stratified random

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sampling technique was employed to ensure balanced representation across various age groups, genders, and educational backgrounds.

DATA COLLECTION METHOD

Primary data was collected through a structured questionnaire designed using Google Forms. The questionnaire was circulated online among students of local colleges, coaching centres, and through youth-focused community networks in Vellore.

DATA ANALYSIS TECHNIQUES

The data were analysed using SPSS (Statistical Package for the Social Sciences). The following techniques were used:

- **Descriptive Statistics:** To summarize demographic data and overall trends in social media usage and self-esteem.
- **Pearson Correlation Analysis:** To examine the relationship between virtual validation and self-esteem levels.
- **T-tests:** To explore differences in self-esteem across various demographic groups (e.g., male vs. female, high vs. low social media users).

LIMITATIONS OF THE STUDY

- The study is geographically limited to Vellore, which may affect the generalizability of results.
- The use of self-reported questionnaires may introduce subjective bias.
- A sample size of 100, though adequate for basic analysis, limits the depth of subgroup analysis.

DATA ANALYSIS

Table 4.1 Demographic Profile of the Study

Variable	Categories	Frequency	Percentage (%)
Age Group	15–18	20	20%
	19–22	45	45%
	23–25	35	35%
Gender	Male	52	52%
	Female	48	48%
Education Level	Higher Secondary	26	26%
	Undergraduate	58	58%
	Postgraduate	16	16%
Internet Usage	< 2 hours/day	12	12%
	2–4 hours/day	36	36%
	4–6 hours/day	32	32%
	> 6 hours/day	20	20%

(***Source:*** Primary Data)

The majority of respondents (45%) are aged 19-22, with 35% aged 23-25, and 20% aged 15-18. The gender distribution is nearly balanced, with 52% male and 48% female. The majority of participants are undergraduates, with 26% at higher secondary level

and 16% having completed postgraduate studies. The majority of respondents use the internet between 2-6 hours daily, with 36% using it for 2-4 hours and 32% for 4-6 hours. A smaller group (20%) uses the internet for more than 6 hours daily, and only 12% uses it for less than 2 hours. This indicates a high level of internet engagement among the sample population.

Table 4.2 Social Media Behaviour

Variable	Categories	Percentage
Preferred Platforms	Instagram	45%
	WhatsApp	25%
	Snapchat	15%
	Facebook	10%
	Others	5%
Average Time Spent on social media Daily	< 1 hour	8%
	1–3 hours	42%
	3–5 hours	30%

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	5 hours	20%
Posting Frequency	Daily	22%
	Weekly	48%
	Occasionally	30%
Checking Feedback Frequency	Frequently	55%
	Sometimes	35%
	Rarely	10%

(***Source:*** Primary Data)

The table shows that 45% of respondents using Instagram, it is the most popular social networking platform. WhatsApp comes in second with 25%. The reduced usage of Facebook and Snapchat may be the result of shifting platform relevance or generational preferences. 42% of people spend an average of 4 hours a day on social media, with 20% spending more than 5 hours. 22% of responder's post every day, and nearly half post once a week. 30% only post infrequently. The fact that more than half of respondents often monitor comments suggests that they are highly engaged or concerned about audience involvement. The majority of users are constantly watching comments to their postings, as evidenced by the 10% who check feedback seldom.

Table 4.3 Virtual Validation Indicators

Variable	Categories	Percentage
Perceived Importance of Likes/Comments	Very Important	40%
	Somewhat Important	38%
	Not Important	22%
Emotional Response to Positive Feedback	Strongly Positive	46%
	Mildly Positive	38%
	Neutral/No Change	16%
Emotional Response to Lack of Feedback or Negative Comments	Hurt/Anxious	41%
	Disappointed	37%
	Indifferent	22%

(***Source:*** Primary Data)

The table shows that 38% of respondents think likes and comments are somewhat important, while 40% of respondents think they are Very important. Just 22% think they are unimportant. 38% of respondents feel slightly pleased, while 46% of respondents experience strong pleasant emotions as a result of receiving favorable feedback. Emotional changes are neutral or nonexistent for only sixteen percent. On the other hand, 37% feel disappointed and 41% feel wounded or anxious when they receive minimal or unfavorable feedback. There is a significant emotional reliance on social media contacts, as evidenced by the mere 22% who are apathetic. The fact that most respondents seek social media validation shows how digital participation affects social presence and self-perception.

ROSENBERG SELF-ESTEEM SCALE (RSES)

Table 4.4 Distribution of Self-Esteem Scores Based On

Level of Self-Esteem	Score Range (RSES)	Percentage (%)
Low	0 – 14	28%
Moderate	15 – 25	60%
High	26 – 30	12%

(***Source:*** Primary Data)

The majority of responders (60%) have a balanced feeling of self-worth, with a moderate level of self-esteem. Nonetheless, 28% of respondents had low self-esteem scores (0–14), which may indicate that they have trouble accepting or believing in themselves. A small percentage of the sample has a strong and stable feeling of self-worth, as only 12% of respondents have high self-esteem.

SELF-ESTEEM BASED ON DEMOGRAPHIC VARIABLES

Table 4.5 T-Test Analysis

Demographic Variable	t-value	p=value	Significance Level
Gender	-1.92	0.057	**Not significant**
Age Group	2.27	0.025 *	**Significant**
Education Level	2.15	0.034 *	**Significant**
Internet Usage	4.18	0.000 **	**Significant**

(***Source:*** Primary Data)

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- **Gender: No significant difference** between males and females at 0.057 level, indicating no significant impact.
- **Age Group: Significant differences** between different age groups, indicating age may be an influencing factor.
- **Education Level: Significant difference** based on education level, indicating noticeable effect of educational background.
- **Internet Usage: Strong and statistically significant relationship,** indicating significant impact of time spent online

VIRTUAL VALIDATION AND SELF-ESTEEM LEVELS

Table 4.6 Pearson Correlation Analysis

Variables	Correlation Coefficient (r)	Significance (p-value)
Virtual Validation ↔ Self-Esteem	-0.482	0.001 **(Significant)**

(***Source:*** Primary Data)

This table reveals a significant negative correlation between virtual validation and self-esteem, with a coefficient of -0.482 and a p-value of 0.001. This indicates that individuals who prioritize virtual validation may experience a decrease in self-esteem, indicating a dependence on external online approval. The statistical significance confirms this relationship is unlikely due to chance.

PRE- AND POST-HYPOTHESES BASED ON RESEARCH OBJECTIVES RELATED TO SOCIAL MEDIA USAGE AND SELF-ESTEEM AMONG YOUTH IN VELLORE CITY

Objective	Pre-Hypothesis (H_0)	Post-Hypothesis (H_1)
1. To examine patterns of social media usage among youth in Vellore city	There is **no significant** pattern or variation in social media usage among youth in terms of time, platform, and use.	There is a **significant** pattern in social media usage among youth in terms of time, platform, and usage purpose.
2. To assess self-esteem levels using a standardized psychological instrument	There is **no significant** variation in self-esteem levels among youth as measured by a standardized scale.	There is a **significant** variation in self-esteem levels among youth using a standardized psychological instrument.
3. To explore correlations between virtual validation and frequency of usage	There is **no significant** correlation between virtual validation and social media usage frequency among youth.	There is a **significant** positive correlation between virtual validation and social media usage frequency among youth.

The pre-hypotheses (H_0) reflect initial null assumptions, suggesting no significant patterns, variations, or correlations related to social media usage, self-esteem, and virtual validation among youth in Vellore city. In contrast, the post-hypotheses (H_1), informed by the study's findings, reveal significant insights. The analysis indicates that youth exhibit discernible patterns in how they use social media—regarding time spent, preferred platforms, and purpose of use. Additionally, there is notable variability in self-esteem levels, and a statistically significant positive correlation exists between the pursuit of virtual validation (likes, comments, shares) and the frequency of social media use. These conclusions underscore the psychological and behavioral impact of social media, suggesting the importance of fostering digital literacy and emotional well-being among youth.

FINDINGS

Demographic Profile

- The majority of respondents (45%) belong to the 19–22 age group, indicating a predominantly young sample.
- Gender distribution is nearly balanced, with 52% males and 48% females.
- Most participants (58%) are undergraduates, suggesting a student-dominated population.
- A significant proportion of respondents (68%) use the internet for 2 to 6 hours daily, indicating high digital engagement.

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Social Media Behavior

- Instagram is the most preferred platform (45%), followed by WhatsApp (25%), reflecting current social media trends.
- 42% of respondents spend 1–3 hours daily on social media, with another 30% spending 3–5 hours.
- Posting activity varies, with 22% posting daily, 48% weekly, and 30% occasionally.
- Feedback engagement is high—55% frequently check responses to their posts, reflecting a strong concern for audience interaction.

Virtual Validation

- A majority (78%) perceive likes and comments as either very or somewhat important, indicating a reliance on external validation.
- 84% of respondents experience positive emotions in response to favorable feedback, whereas 78% feel hurt or disappointed in its absence.
- Only 22% are emotionally indifferent to negative or absent feedback, suggesting emotional vulnerability linked to online engagement.

Self-Esteem Levels

- 60% of respondents have moderate self-esteem, while 28% fall into the low self-esteem category.
- Only 12% exhibit high self-esteem, indicating that strong self-worth is relatively uncommon in the sample.

T-Test Analysis

- Gender does not significantly influence self-esteem ($p = 0.057$).
- Age group, education level, and internet usage show statistically significant effects on self-esteem, with internet usage having the strongest impact ($p = 0.000$).

Correlation Analysis

- A statistically significant negative correlation ($r = -0.482$, $p = 0.001$) exists between virtual validation and self-esteem.

Suggestions

- Integrate Digital Literacy and Emotional Wellness Programs
- Launch Self-Esteem Building Initiatives
- Promote Mindful Social Media Usage
- Facilitate Access to Counseling Services
- Conduct Educational Workshops on Online Validation
- Customize Interventions Based on Age and Education
- Introduce Peer-Led Digital Responsibility Clubs
- Raise Awareness About the Psychological Risks of Overuse
- Foster Offline Social and Creative Engagement
- Collaborate with Influencers to Promote Healthy Online Behavior

CONCLUSION

The study highlights the significant impact of social media on the emotional well-being and self-esteem of young individuals. Many users value virtual validation, particularly through likes and comments, which can lead to highs and lows in self-worth. Excessive social media use is linked to lower self-esteem, with users more emotionally reliant on virtual validation exhibiting lower levels of self-worth. This suggests that the psychological costs of seeking approval from online interactions may outweigh the benefits, especially for those without strong offline sources of self-esteem or a resilient sense of self-worth.

Demographic factors such as age, education level, and internet usage also play a role in determining an individual's self-perception. Age has a statistically significant effect on self-esteem, with younger users more likely to be influenced by social media feedback. Education level is another factor that influences self-esteem,

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suggesting that individuals with higher levels of education may be better equipped to navigate the psychological impacts of social media. Internet usage, particularly in terms of time spent online, has the strongest impact, reinforcing the need for moderation in online engagement to protect mental well-being.

The findings suggest that young people are navigating a complex landscape where their self-worth is often shaped by their digital interactions. Urgent interventions aimed at promoting healthier digital behaviors, educational programs focused on digital literacy, emotional resilience, and strategies for cultivating offline sources of self-esteem could help mitigate the negative effects of excessive social media engagement. A balanced approach to social media use, where online validation is not the sole source of self-worth, is essential for protecting the mental health of young individuals.

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MICROFINANCE AND ITS ROLE ON SOCIO-ECONOMIC EMPOWERMENT OF TRIBAL COMMUNITIES IN ASSAM

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ABSTRACT
Suffering from discrimination, marginalization, extreme poverty and conflict always exist among the tribal communities. The financial requirement is one of the basic needs of this section of society for socio-economic development. Microfinance to Self Help Groups (SHGs) may be considered as a vital option for meeting these types of financial needs. The present research paper is an attempt to study the role of Micro-Finance and Self-Help-Groups (SHGs) for the socio-economic empowerment of Tribal women living in the rural areas of Assam, India. A survey on the social and economic impact of SHGs of the selected respondents was conducted at Lakhimpur and Dhemaji district of Assam. Primary and secondary data have been considered for the present study. For collecting primary data 10 numbers of Tribal member SHGs from sample development blocks were selected by using stratified random sampling method. Again from each SHGs 4 tribal members have been randomly selected to make the total respondents as 200 (5X10x4=200 respondents). From the study it has been found that after joining the SHGs the poor tribal people have improved their living standard by performing various economic activities independently. The result of the data analysis revealed that the SHGs have been playing an important role in social-economic empowerment of the tribal women in the area under study.

Keyword: *Micro finance, Self Help Group (SHG), Socio-economic Empowerment and Tribal Women.*

1. INTRODUCTION

The economic development of each place is depends on the development of rural economy particularly development of tribal communities living in the rural areas. But it has been seen that many of the poor tribals living in the rural areas are still deprived of their basic needs of life today. These people are socially and economically not upgraded. Thus their development is to be very much concentrated in the process of socio-economic development. In India the tribal are considered as an integral part of social fabric (*Awais & et al 2009*). The life style, community habits and habitats of tribals have made it difficult for them to keep pace with modern society; they are not well placed economically, politically, educationally or industrially but they are trying hard to catch up with the rest of India (*Awais & Singh, 2007*).

In most of the developing countries, the tribals living in the rural areas are engaged in agriculture or other allied rural activities. Moreover they have remained ignorant and relegated from the main streams of national life. It is seen that more than 50 percent of rural tribal still live in below the poverty line and they comprise a large section of agricultural, informal, plantation, industrial labourers etc. (*Hazra, 2010*). The prominent tribal areas constitute about 15 percent of the total geographical area of the country (*Sukai, 2010*). According to 2001 census, 72.6 percent of total population of India resides in rural areas and about 8.19 percent (84.3 million) of India's population are Scheduled Tribes (ST) (*Census, 2001*). The 2011 census (Provisional) shows that the total population of India is 1,210,193,422 and the percentage decadal in growth rate from 21.54 percent in 1991-01 to 17.64 percent in 2001-11 (*Census, 2011*). It has been seen that the total population of STs increasing after 1951 from 19.1 million (about 5.29 percent of total population) to 84.3 millions (about 8.19 percent of total population) in 2001. Meanwhile, India has been successful in reducing the proportion of poor people from about 55 percent in 1973 to about 27 percent in 2004. But about one-third of country's population of more than 1.1 billion still lives below the Poverty line (*Census, 2001*). The Planning Commission estimates that 62.5 million people are still living in Below the Poverty Line in 2011. Although a vast majority of rural tribals are dependent on their livelihood on farm and non-farm activities, even it does not provide strong financial position and employment opportunities throughout the years. Agriculture is a seasonal and the existing farming is also primitive, which provides for low land and low labour productivity to the rural tribals. Due to slow industrialisation, alternative employment opportunities cannot always be created for the rural tribals. The tribal population are still deprived of adequate access in the basic needs of life such as health, education, housing, food, security, employment, justice and equity. Some of the tribal people are evicted of their own habitual land and thus their livelihoods are being undermined. All these factors are thus responsible for higher incidence of poverty in rural India.

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2. OBJECTIVES OF THE STUDY:

The major objective of the present research paper was to study the role of Microfinance on socio-economic empowerment of the tribal communities particularly under Lakhimpur and Dhemaji districts of Assam. For attaining the main objective the following sub- objectives have been developed-

a. To study the demographic background of the respondents;

b. To understand the involvement of the tribal communities in income generating economic activities;

c. To study the socio-economic impact of microfinance through SHGs on the tribal communities under the study area;

3. METHODOLOGY OF THE STUDY

For the purpose of the study the primary data were collected through field survey. The primary data were supplemented by the data collected from secondary sources like District Rural Development Agency (DRDA), District National Informatics Centre (DNIC), Office of the Block Development, Office of the Gram Panchayat, records of Banks, SHGs etc. Some secondary data were also be used for the present study which had been collected through various books, journals, magazines, relevant documents, brochures, reports and newspapers. For the purpose of the study three development blocks (namely Boginadi, Telahi, and Karunabari development blocks from Lakhimpur district and Bordoloni and Murkongselek Tribal blocks have been purposively selected. By using stratified random sampling method 10 tribal member SHGs from each sample blocks and from each sample SHGs 4 tribal members were selected. Thus, the total respondents for the present study were 200 (5X10x4=200). For analysing the data simple average method and percentage analysis have been used.

4. RESULTS FROM THE STUDY

The Findings of the present investigation have been presented under the following heads:

6.1 Demographic background of the respondents.

6.2 Involvement in different income generating activities.

6.3 Benefits gained from the income generating activity by the respondents.

6.4 Socio-economic impact of SHG activities on the respondents.

6.1 Demographic background of the respondents:

The analysis on socio-economic background of the tribal members under the study area revealed that:

i) 54.0 percent of the tribal members were belonged to middle aged (31 -50 yrs.) group category, while 44.0 per cent were young (18-30 yrs.) and remaining i.e. 2.0 per cent were old aged (above 50 yrs.) group.

ii) 35.0 percent of the respondents were belonged to Mising caste followed by Kochari (30.0 percent) and only 5 percent were Bodo community.

iii) 20 percent of the tribal members were found illiterate, 26.0 per cent of them were functionally literate, 24.5 per cent of the respondents had education upto primary school, 15 per cent had received high school level education, 10 per cent received middle school education and only 4.5 per cent of them received college level education.

iv) 75.5 percent of the respondents were married, 12.0 per cent were separated, 6.5 per cent of the respondents were unmarried and 6.0 per cent were reported as widows.

v) 85.5 percent of the respondents had nuclear family while 14.5 per cent had belonged to joint family.

vi) Economic position of the family of the respondents indicated that 35.0 percent of the respondents were belonged to semi-medium income category (₹ 10,000- ₹. 30,000) followed by 29 percent respondents belonging to medium income category (₹.30,001- ₹ 50,000), 26.0 per cent of the respondents belonged to high income category (above ₹ 50,000), and only 10.0 per cent of them belonged to low income category (less than ₹ 10,000).

6.2 Involvement of tribal members in income generating activities:

The involvement of the tribal members on the income generating economic activities in pre-SHG and post-SHG period were analyzed in Table 1 as follows.

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Table-1 Economic activities adopted by tribal members in pre-SHG and post-SHG stage

Activities Engaged	Before Joining SHG	After Joining SHG
No activity	49 (24.5)	Nil
Piggery	35 (17.5)	57 (28.5)
Goatery	19 (09.5)	21 (10.5)
Duckery	17 (08.5)	24 (12.0)
Weaving	12 (06.0)	19 (09.5)
Food Processing	Nil	04 (02.0)
Fishery	04 (02.0)	11 (05.5)
Poultry	06 (03.0)	20 (10.0)
Bee keeping	Nil	Nil
Dairy	02 (01.0)	08 (04.0)
Mushroom	Nil	Nil
Petty Business	02 (01.0)	10 (05.0)
Agricultural Farm	54 (27.0)	08 (04.0)
Other income generating activities	Nil	18 (09.0)
Total	***200(100)***	***200 (100)***

Note- () shows the percentage.

Source: Field Survey

Table 1 revealed that 24.5 percent of the respondents have no activity before joining the Self-Help Groups but in the post-SHG stage there has not a single person without any activity. Another significant aspect is that during the post-SHG period agricultural firm activities have reduced from 27.6 percent to 4.0 percent. From the Table 6.2.(i) it has been observed that 28.5 percent of the respondents involved in Piggery business followed by Duckery (12.0 percent), Goatery (10.5percent), Poultry (10.5percent), weaving (9.5 percent), other income generating activities (9.0percent), Fishery (5.5percent), Petty Business (5.0 percent), Dairy (4.0 percent) and only 2 percent were engaged in food processing activities. It has also been observed that the food processing activities were started by these 2 percent of the respondents only after joining the groups which was nil at pre-SHG stage. As far as the bee-keeping and mushroom cultivation was concerned there was not a single respondent who has started the activities before and after joining the SHGs. From the Table 6.2.(i) it can be concluded that the piggery activity emerged as the major activity started under SHGs by the respondents followed by Duckery, Goatery, Poultry, weaving, other income generating activities, Fishery etc.

6.3 Monetary and non-monetary benefits from activities by the respondents:

The monetary and non-monetary benefits received from the different income generating activities by the respondents were analysed in Table 2 as follows:

Table 2 Benefits gained from the income generating activity by the respondents (Multiple responses)

Benefits	Variables	Frequency (No.)	Percentage (percent)
a) Monetary (₹./month)	Upto ₹ 500/-	27	13.5
	₹ 501 to ₹1000	31	15.5
	₹ 1001 to ₹ 1500	61	30.5
	₹ 1501 to ₹ 2000	41	20.5
	₹ 2001 to ₹ 2500	24	12.0
	₹ 2501 to ₹ 3000	12	06.0
	₹ 3001 and above	04	02.0
b) Non-monetary benefits	Improved communication ability	191	95.5
	Improved confidence level	167	83.5
	Respect from the society	152	76.0
	Respect from the family members	135	67.5
	Enhanced household consumption of products	125	62.5

Source: *Field Survey.*

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It has been observed from the Table 2 that 59.5 per cent of the respondents had opined about their low incremental income which came upto ₹ 1500, while 38.5 per cent had medium income in the range of ₹ 1500 to ₹ 3000 and only 2 per cent had high incremental income of more than ₹ 3000. Vast majority of the respondents felt that their communication ability was increased (95.5 percent), followed by increase in their confidence level (83.5 percent). 76.0 percent and 67.5 percent of respondents opined that they were respected by society and family members, respectively. And only 62.5 percent of the respondents opined about their enhancement of household consumption of products.

6.4 Social impact of SHG activities on the respondents:

The social impact of SHG activities on the respondents after joining the group has been presented in Table 3 as under:

Table 3 Social impact of the respondents (Multiple Responses)

Sl. No.	Social Factors	SA	A	U	D	SD
i.	Better Social acceptability	132(66.0)	48(24.0)	10(5.0)	06(3.0)	04(2.0)
ii.	Well recognition in the family	131(65.5)	55(27.5)	10(5.0)	4(2.0)	0(0.0)
iii.	Equally participated with husband in family decisions	101(50.5)	79(39.5)	4(2.0)	14(7.0)	2(1.0)
iv.	Well recognition in the community	114(57.0)	80(40.0)	4(2.0)	2(1.0)	0(0.0)
v.	Active participation in social services	120(60.0)	74(37.0)	4(2.0)	2(1.0)	0(0.0)
vi.	Self dependence	133(66.5)	64(32.0)	2(1.0)	1(0.5)	0(0.0)
vii.	Improved in Literacy (e.g. able to read, sign etc.)	177(88.5)	20(10.0)	3(1.5)	0(0.0)	0(0.0)
viii.	Provided better schooling to my children	143(71.5)	23(11.5)	6(3.0)	18(9.0)	10(5.0)
ix.	Improved inter-personal relationships	155(77.5)	37(18.5)	4(2.0)	4(2.0)	0(0.0)
x.	Better contact (network) with outsiders	108(54.0)	74(37.0)	16(8.0)	2(1.0)	0(0.0)
xi.	No prejudice or class biases	181(90.5)	15(7.5)	4(2.0)	0(0.0)	0(0.0)
xii.	Little Improved standard of living	85(42.5)	67(33.5)	20(10.0)	16(8.0)	12(6.0)
xiii.	Gender inequalities	110(55.0)	78(39.0)	6(3.0)	6(3.0)	0(0.0)
xiv.	Better access to health services	131(65.5)	55(27.5)	10(5.0)	4(2.0)	0(0.0)
xv.	Better access to sanitation facility	101(50.5)	79(39.5)	4(4.0)	14(7.0)	2(1.0)

Source: Field Survey

Note: - 'SA'- *Strongly Agree,* 'A'- *Agree*, 'U'- *Undecided*, 'D'- *Disagree*, 'SD'- *Strongly Disagree*- ( ) Shows the percentage.

From the Table 3 it has been observed that after joining the group many people have come to know about the respondents and their activity and show more interest in interacting with them. 90 percent of the respondents were opined about their social acceptability, while 5 percent were disagreed with that. More than fifty percent i.e. 50.5 percent of the women respondents were strongly agreed that they were equally take important decisions and issues connecting with their family along with their husbands. 97 percent of the respondents were agreed about their recognition in the community whereas only 1 percent was disagreed with that. 97 percent of the respondents agreed that they were actively participated in the social services in the area under study where only 1 percent was disagreed and 3.5 percent were undecided about that. As far as the self dependence was concerned 66.5 percent were strongly agreed and only 0.5 percent was disagreed with that. After joining the group 98.5 percent of the respondents have improved their literacy position and thereby provided better schooling facilities and improved health security to their children.

The study disclosed that after joining the groups, 96 percent of the respondents were improved their inter-personal relationship and had established well contract with the outsiders in the study area. The study also disclosed that 98 percent and 94 percent of the respondents respectively agreed that they had no class bias and

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gender inequalities in the study area, whereas only 3 percent were disagreed and 5 percent were undecided about that. After joining the group the standard of living of the respondents had also improved in the study area as 76 percent were agreed about that. They were improved their housing and sanitation conditions upto a certain extent after joining the groups.

6.5 Economic impact of SHG activities on the respondents:

The economic impact of the respondents through microfinance has been presented and analyzed in Table 4 as under:

Table 4 Economic impact of the respondents (Multiple Responses)

Sl. No.	Economic Factors	SA	A	U	D	SD
i.	Access to credit facilities	164(82.0)	24(12.0)	08(04.0)	4(02.0)	0(0.0)
ii.	Access/control of financial resources & households	133(66.5)	32(16.0)	21(10.5)	10(05.0)	4(02.0)
iii.	Improved in food consumption pattern	150(75.0)	28(14.0)	20(10.0)	2(01.0)	0(0.0)
iv.	Increased in savings per month	137(68.5)	50(25.0)	13(06.5)	0(0.0)	0(0.0)
v.	Have own premises (land) to run business	49(24.5)	44(22.0)	0(0.0)	67(33.5)	40(20.0)
vi.	Minimized family dependence to money lenders	96(48.0)	69(34.5)	11(05.5)	24(12.0)	0(0.0)
vii.	Economically independent	87(43.5)	51(25.5)	25(12.5)	27(13.5)	10(05.0)
viii.	Minimized dependence to the husband	90(45.0)	56(28.0)	38(19.0)	14(07.0)	2(01.0)
ix.	Purchased gold for the children	08(04.0)	04(02.0)	78(39.0)	70(35.0)	40(20.0)
x.	Minimized family indebtedness	87(43.5)	44(22.0)	51(25.5)	16(08.0)	2(01.0)
xi.	Better access to necessary modern technologies	39(19.5)	19(09.5)	96(48.0)	40(20.0)	6(03.0)

Source: Field Survey

Note: - 'SA'- *Strongly Agree,* 'A'- *Agree*, 'U'- *Undecided*, 'D'- *Disagree*, 'SD'- *Strongly Disagree* - ( ) Shows the percentage.

It has been observed from the above Table 4 that 94 per cent of the respondents agreed that they were better access to the credit facilities after joining the group. 82.5 percent of the respondents have control of their financial resources and households whereas 7 percent of them were unable to control of their financial resources. On the other hand 89 percent of the respondents have changed their food consumption pattern and 10 percent were remained unchanged. 41 percent of the respondents had agreed that they were access to different business trainings, 10 percent were disagreed and 49 percent were undecided on that. The study also revealed that 82.5 percent, 73 percent and 65.5 percent of the respondents had minimised their family dependence on moneylenders, dependence to husband and family indebtedness respectively. As a result 93.5 percent of the respondents had increased their savings per month after joining the group. Economic independence from the family members, relatives etc. was also found to be encouraging as 69 percent of the respondents were feeling economically independent. On the other hand the results of the study indicate that more than half of the respondents had not their own premises to run their business and unable to purchase gold for their children's as 46.5 percent of the respondents had their own premises and only 6 percent were purchased gold for their children. 29 percent of the respondents had agreed that they were access to necessary modern technologies after joining the SHGs in the area under study.

5. SUGGESTIONS

The following suggestions have been given forward by the researcher based on the present study:

i) Training and awareness programme should be conducted regularly on accounts keeping procedures and an interactive session with the accounting experts should also be made so that the beneficiaries can develop their accounting knowledge and learn about the procedure of maintaining the cash books etc. properly.

ii) For better functioning of the SHGs, the women should be targeted for proper education so that they can contribute a lot in the nation building.

6. CONCLUSIONS

Reducing poverty and maintain the social solidity is the basic spotlight of any development activity particularly in a economically backward region. So, initiatives will be required to take care of the growing socio-economic

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differences among the communities, especially the tribal. In an economically underdeveloped place like Lakhimpur, where the problem of flood always takes place, finance is a key to overcome the daily needs of the tribal. Instant finance on regular basis can play a significant role for improvement in social and economic life of the people living in the rural areas. In this regard, microfinance is expected to play a significant role in poverty alleviation and rural development particularly among the rural tribals. If microfinance has grown in its faster pace, definitely majority of the weaker section of the society will be economically benefited. It can be concluded from the present study that members of the SHGs were started savings and created funds only after joining the groups which was definitely helped them benefited not only socially but also economically in the area under study.

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MYTH, IDENTITY, AND RESISTANCE: THE ART OF STORYTELLING IN THE WHALE RIDER

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ABSTRACT
Ecosystems demonstrate resilience by reviving and recovering from natural disasters such as floods, storms, and wildfires. How communities adjust to adversity while maintaining their essential identities is examined by resilience theory. An invaluable scope for analyzing literary cultural durability is offered by this paradigm. At its core, Resilience Theory explores how individuals and communities draw on internal and external strengths to survive and adapt to adversity. Humans exhibit resilience in a variety of situations. Folklore and folktales have a repertory that reflects the quality of persistence. Witi Ihimaera explores the deep connection between human beings and nature in her novel *The Whale Rider*. Using resilience theory as a lens, this research paper emphasizes the vitality of Indigenous culture during the colonization period. It depicts the meeting point of modern experiences and conventional ideas. The adaptability of Indigenous identity is emphasized by Ihimaera through the character of Kahu, who opposes patriarchal leadership. In this study, however, a deep understanding of how indigenous stories and myths provide insights into cultural identity, resilience, and adaptation is analyzed. This paper argues that *The Whale Rider* embodies resilience by showcasing the adaptive strength of Māori culture and identity through ecological and gender lenses.

Keywords: *Resilience, Folklore, Indigenous Wisdom, Adaptation, Identity, Sustainability.*

INTRODUCTION
"Nature is a temple where living pillars sometimes emit words that blend together; in passing through it, Man traverses forests of symbols that observe him with a familiar eye" (Baudelaire,2006)

In Ecosystem, resilience refers to its ability to withstand disturbances and recover, maintaining its essential functions and structures. This concept has parallels in human communities, where resilience involves the capacity to sustain and recover from crises, with cultural endurance often playing a significant role. It also tells about the vicious cycle of the ecosystem in facing many disturbances with a consequent recovery. The destructive events often include floods, forest fires ,deforestation and pollution. Environmental resilience is vital for safeguarding biodiversity and mitigating climate change, and it involves the ability of natural systems to absorb change, reorganize, and adapt to new environment.

Resilience Theory explores how systems, both natural and social, recover from disruptions while retaining the essential characteristics. It offers a powerful framework for analysing cultural endurance in literature. Both ecosystems and human communities are complex adaptive systems, allowing for comparison of systemic properties such as resilience and adaptive capacity. Understanding vulnerabilities is crucial for mitigating the effects of disasters in both ecosystems and human communities. Building resilience involves strengthening systems, promoting health and wellness, expanding communication and collaboration, engaging at-risk individuals, and building social connectedness. The themes related to climate resilience have existed ever since 1960.The term resilience had its roots for the ecological system at its beginning and later expanded to social ecosystems also.

This paper applies Resilience Theory to Witi Ihimaera's *The Whale Rider*, a novel that intricately weaves the profound connection between humanity and nature. By examining the vitality of indigenous Māori culture amid the pressures of colonization, this study reveals how resilience manifests in both ecological and cultural contexts. The narrative's fusion of traditional beliefs with contemporary challenges underscores its relevance to broader human experiences of adaptation and identity preservation.

LITERATURE REVIEW
The article 'Resilience definitions, theory, and challenges: interdisciplinary perspectives' discusses and highlights the concept of resilience in multidisciplinary approach using empirical study. The paper was written based on the plenary panel discussion held in the year of 2013(Southwick, Bonanno, Masten, Panter-Brick, & Yehuda, 2014). The article 'Resiliency Theory: A Strengths-Based Approach to Research and Practice for

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Adolescent Health' analyses the process of our understanding of resilience to overcome adversity in health-related studies (Zimmerman, 2013). The article 'Embracing change: how cultural resilience is increased through cultural heritage' explores the complex relationship between heritage and resilience that proposes an understanding of heritage's transformation over time to promote adaptability'(Holtorf, 2018).

The article 'Resilience Components in Mexican Whale-Watching Regulation' studies the mitigation of whale watching by the tourists in Mexico (Espinoza-Rodríguez, Chávez-Dagostino, & Heckel, 2024). The Research paper 'Indigenous Girl Power' examines how movie portrays a journey of an young indigenous girl to assert her agency within her own community, challenging the traditional notion of girlhood through her experiences from feminist point of view (Gonick, 2010). The article 'Fight against Patriarchy in Witi Ihimaera's *The Whale Rider'* discusses gender discrimination and shifting attitudes (Ravindran, 2022). The novel concentrates on the struggle of female characters in a male dominated society (Ravindran, 2022). The article 'Film as a Mirror: Redefining Witi Ihimaera's *The Whale Rider'* examines the Moari culture and compares how the novel *Whale Rider* differs from the film in cultural aspects(Uthaman, 2019). The article 'Reconfiguring Ocean Life by Thinking with Oceans and Whales Witi Ihimaera's *The Whale Rider* and Zakes Mda's *The Whale Caller*' studies the acoustic ecology by connecting the sounds of whales and their relationship with the environment (Concilio, 2023).

METHODOLOGY

A method of qualitative analysis is used to scan and comprehend the primary sources used in this research paper. This paper uses the theoretical framework of Resilience theory to investigate the novel *The Whale Rider*. Meticulous research has been done in the areas of resilience and the role of indigenous knowledge by reviewing various journals and scholarly articles. The criteria used to select the primary text is based on the reliability of context folklore and storytelling. This systematic methodology aims to provide beneficial insights into indigenous epistemologies and envisions a future sustainable community.

Resilience theory emerged from the work of Norman Garmezy who is referred to as a pioneer in resilience studies, especially in children's literature. Ann Maston developed this later by focusing on children's adaptive processes in facing the challenges (Zimmerman, 2013). In contemporary era, resilience theory has been expanded to include how individuals and communities cope up with problems. The theory often emphasizes the significance of cultural identity in overcoming adversity.

Resilience theory, in its most basic form, tells about the strength of an individual or a community in facing challenges and hardships for their survival in this planet. It emphasizes the dynamic interaction between individuals and their environment and how they can draw upon their strengths and resources to cope up with or to transform critical situations. In *The Whale Rider*, resilience theory, mirrored through the journey of the protagonist Kahu, redefines cultural identity and postulates her leadership role in the Māori community. The connection between folklore, resilience and identity in the fiction honour the wisdom of the past and explore cultural continuity and adaptation.

Resilience Theory: A Framework for Cultural Analysis

Resilience Theory, originating in ecological studies, posits that systems can absorb disturbances, reorganize, and persist without losing their core identity (Holling). In human communities, this translates to cultural resilience, the ability to adapt to external threats like colonization while safeguarding traditions and values. Literature, particularly Indigenous narratives, serves as a repository for such resilience, reflecting how societies navigate change. This paper leverages Resilience Theory to interpret *The Whale Rider*, arguing that its portrayal of Māori endurance exemplifies adaptive strength. By bridging ecological and cultural resilience, the novel provides a lens to explore how folklore and storytelling sustain identity across generations.

Folklore and Resilience: Echoes of Endurance in Oral Traditions

The repertoire of folklore and folktales has long been a vehicle for resilience, encoding lessons of survival and adaptability within mythic structures. Māori oral traditions, rich with tales of nature's power and human agency, exemplify this dynamic. In *The Whale Rider*, the legend of the whale rider, passed down through generations, anchors the community's identity amid modern disruptions. It examines how Ihimaera draws on folklore to depict resilience, using the character of Kahu to challenge patriarchal norms and reaffirm Indigenous wisdom. These narratives, rooted in the past, become tools for navigating the present, illustrating resilience as both a cultural and personal attribute.

Witi Ihimaera's *The Whale Rider* uses Resilience Theory to show how the Indigenous Māori culture adapts to colonization by blending traditional beliefs with modern realities through the character of Kahu. The novel emphasizes adaptability and sustainability as essential for the survival of Māori culture.

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Conceptual Genesis and Epistemological Foundations

Resilience Theory, originally emergent from ecological discourse, states that systems, whether biological, social or cultural, possess an intrinsic capacity to withstand, adapt to and recuperate from exogenous perturbations while preserving its quintessential structures and functionalities. Conceived by C. S. Holling in the 1970s, the theory transcends its ecological provenance to interrogate the dynamism of human communities and their adaptive stratagems in the face of cataclysmic disruptions. At its core, resilience is not merely a passive endurance but an active, dialectical process of transformation and continuity.

Resilience as a Literary Trope

Within the literary domain, resilience manifests as a thematic and structural trope, illuminating the capacity of characters, communities or narrative forms to surmount adversity. It eschews static depictions of survival, instead privileging a narrative teleology wherein adaptation engenders renewal. Characters may embody resilience through their agency in confronting hegemonic forces, while texts themselves, through their stylistic evolution or intertextual dialogues, reflect the resilience of literary traditions.

The theory's emphasis on adaptive capacity dovetails with literature's propensity for polyphony and metamorphosis. Just as ecosystems recalibrate in response to disturbance, literary works often refract cultural crises through innovative forms, be it the syncretism of oral and written modes or the subversion of canonical norms, thereby sustaining their relevance and vitality.

Analytical Utility in Cultural Narratives

When applied to cultural narratives, Resilience Theory elucidates how literature serves as a repository of collective memory and a mechanism for cultural perpetuation. It foregrounds the symbiosis between narrative and identity, positing that stories, folklore, myth or novelistic discourse, function as resilient artifacts that encode adaptive wisdom. In this schema, literary texts are not inert relics but dynamic systems, capable of absorbing external pressures (e.g., colonial imposition) and rearticulating them within indigenous epistemologies.

APPLICATION TO THE WHALE RIDER

In Witi Ihimaera's *The Whale Rider*, Resilience Theory finds a compelling instantiation. The novel's portrayal of Kahu's defiance of patriarchal strictures exemplifies adaptive resilience, as she reconfigures Māori leadership traditions without jettisoning their spiritual moorings. The whale, a leitmotif of ancestral wisdom, embodies the cultural ecosystem's capacity to regenerate amidst colonial fragmentation. Ihimaera's narrative, suffused with folkloric cadences, enacts a resilient synthesis of tradition and modernity, offering a testament to the enduring vitality of Indigenous identity. Colonization significantly disrupted Māori society and culture in 19th century. This disruption led to a plummet in the Māori population, the undermining of traditional practices, and the reshaping of daily life due to European influences.

Colonization resulted in immense socio-cultural and economic disadvantage for Māori. Breaches of the Treaty of Waitangi (1840) led to wars in the 1860s and legislation like the New Zealand Settlements Act 1863 and the Native Lands Act 1865 deprived natives of their land and resources. The colonial experiences in Aotearoa, New Zealand significantly shifted the levels of engagement with Māori language, culture, and identity. Intergenerational trauma, poor health outcomes and poverty are ongoing issues resulting from colonization. The Doctrine of Discovery, which the British brought to Aotearoa New Zealand, advanced the idea that European culture and religion were superior, leading to the takeover of lands and resources from the natives.

Māori Resistance and Activism

It is from the period of 1970 that the Māori leaders strongly demanded social equality in terms of justice, education and wished to have a parallel shift in its course. The history began with the colonisation which led to many boycotts, marches and many protests. They sought recognition for their culture in new Zealand. Their traditional practices like haka and gatherings at marae serve as a form of cultural expression.

Traditional Beliefs

Resilience theory is evident in the Māori's ability to adapt to new knowledge and blend traditional beliefs with contemporary realities. Culture and tradition are constantly reshaping themselves to survive, allowing for adaptation and compromise. Colonization has significantly impacted indigenous groups, leading to shifts in engagement with language, culture and identity. Colonial experiences have resulted in intergenerational trauma, poor health outcomes and poverty, with the Doctrine of Discovery promoting the idea of European superiority.

Many indigenous groups face the challenge of preserving dying traditions and practices, especially those affected by colonization and globalization. Language has become less practiced, necessitating initiatives such as

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Māori Language Week to celebrate the language and culture. Generational tensions often arise between those who uphold older traditions, like Koro, and younger generations.

Symbols of Resilience

In *The Whale Rider*, whales symbolize strength, wisdom and a sacred connection to ancestry and identity for the Māori people. The whale's presence in the narrative underscores the importance of cultural adaptation and continuity in the face of modern challenges, illustrating resilience. In Māori tradition, whales are not only a source of food and utensils but also feature prominently in tribal traditions as guardians, symbolizing strength, wisdom, and spirituality. The whale's role connects Kahu to her lineage and societal traditions, emphasizing the importance of adapting and maintaining Māori culture amidst modern challenges. The spiritual bond between the Māori and whales underscores the resilience required to preserve cultural identity when faced with external pressures. The whale songs represent the connection between humans, animals and the natural world.

The whale's symbolic role is central to the narrative of *The Whale Rider*, illustrating the resilience arc through Kahu's connection with her heritage. As an ancient symbol, the whale links Kahu to her ancestors and societal traditions, which is vital for cultural continuity amidst modern challenges. The whale serves as a reminder of the Māori people's heritage and their connection to the land and sea, reinforcing the themes of identity, tradition and resilience.

Kahu is a symbol of adaptive strength and resilience, challenging patriarchal leadership within her community. Despite facing discrimination due to her gender, Kahu's deep connection to her culture and the whales underscores her strength and determination to lead. Kahu challenges patriarchal leadership by defying traditional gender roles and expectations within her Māori community. Her great-grandfather, Koro Apirana, deeply rooted in his traditional beliefs about Māori leadership, initially refuses to accept her as a future leader because she is a girl. Despite facing this rejection, Kahu's actions and abilities demonstrate her potential and suitability for leadership, challenging the patriarchal norms upheld by Koro.

Kahu demonstrates resilience through her unwavering connection to the whales and the sea. She overcomes self-doubt and fear through training, developing leadership skills and connecting with the ocean. Her ability to communicate with the whales sets her apart and symbolizes her innate strength, reverence for nature and role as a bridge between the past and the present. Kahu's resilience is further highlighted in her efforts to win her great-grandfather's love and acceptance while revitalizing her community's commitment to its traditions.

Kahu exemplifies female power by not only proving herself equal to the role of leader but also by saving the whale herd. Strong-willed women like Kahu and Nanny Flowers challenge social conventions within a misogynistic society. Kahu's connection to her heritage and societal traditions emphasizes the importance of adapting and maintaining Māori culture amidst modern challenges. Nanny Flowers also challenges Koro's traditional beliefs, disagreeing with the exclusion of women from instruction and asserting that rules are made to be broken. Kahu's defiance of gender norms in *The Whale Rider* illustrates an adaptive reinterpretation of Māori identity. Through her actions, Kahu redefines traditional expectations, proving that gender is not a barrier to leadership and cultural significance.

Kahu defies traditional gender roles, which dictate that leadership is a male domain, by striving to become the leader of her tribe. In Māori society, men are often expected to be leaders, while women are expected to be subservient, focusing on domestic tasks. Kahu's birthright as the firstborn is disregarded by her great-grandfather, Koro Apirana, because he expects the leader to be a man, reflecting deeply ingrained gender norms. Despite this rejection, Kahu's actions demonstrate her potential for leadership, challenging these patriarchal norms.

'Afterall, it was Kahu who was there at the end, and it was Kahu's intervention which perhaps saved us all. We always knew there would be such a child, but when Kahu was born, well, we were looking the other way, really. We were over at our Koro's place, me and the boys, having a few drinks and a party, when the phone rang. 'A girl,' Koro Apirana said, disgusted.' ((Ihimaera, 1987,14)

Nature and Humanity in *The Whale Rider*: An Indigenous Perspective

Ihimaera's *The Whale Rider* foregrounds the symbiotic relationship between nature and humanity, a cornerstone of Indigenous Māori worldview. The novel's central motif, the whales symbolize ecological and cultural continuity, disrupted yet revitalized through human intervention. Kahu's bond with the whales reflects resilience, embodying the Māori principle of kaitiakitanga (guardianship of the environment). Through this lens, the paper highlights how Indigenous culture adapts to colonial pressures by reaffirming its ecological roots, offering a model of sustainability that resonates beyond the text.

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Kahu's Challenge: Resilience Through Adaptive Identity

At the heart of *The Whale Rider* lies Kahu, whose defiance of patriarchal leadership redefines Māori identity. Her journey, culminating in her role as the whale rider, illustrates adaptive strength, blending traditional roles with contemporary agency. Kahu's actions mirror ecological resilience: just as ecosystems reorganize after disturbance, she reshapes cultural norms without abandoning their essence. Ihimaera uses her character to underscore the resilience of Indigenous identity, showing how adaptation ensures survival in a colonized world. Kahu's triumph is both personal and communal, reflecting the broader capacity of Māori culture to endure.

Colonization and Cultural Vitality: A Resilience Narrative

Colonization posed an existential threat to Māori culture, eroding traditions and imposing foreign values. Yet, *The Whale Rider* portrays a community that resists erasure by integrating traditional beliefs with modern realities, investigating how Ihimaera illustrates cultural vitality through resilience, focusing on the interplay of past and present. The novel's setting, a contemporary Māori village grappling with colonial legacies, serves as a microcosm for Indigenous adaptation worldwide. By emphasizing sustainability and identity, Ihimaera crafts a narrative that celebrates endurance while critiquing the forces that necessitate it.

Literary Craftsmanship: Verbal Dexterity and Thematic Depth

Ihimaera's novel is not only a study in resilience but also a literary feast, enriched by his mastery in the use of language and symbolism. His verbal dexterity, evident in vivid imagery and rhythmic prose, enhances the themes of adaptability and sustainability. The narrative's accessibility invites readers into a complex world, delivering invaluable lessons through emotional resonance. By intertwining folklore with modern storytelling, Ihimaera ensures that *The Whale Rider* speaks to both Māori and global audience, reinforcing its status as a testament to cultural endurance.

CONCLUSION: LESSONS OF ADAPTABILITY AND SUSTAINABILITY

The Whale Rider stands as a powerful exploration of resilience, weaving together ecological, cultural and personal dimensions through an indigenous lens. Kahu's journey, rooted in Māori folklore and realized in a colonized present, exemplifies how adaptation sustains identity. This paper concludes that Ihimaera's work offers more than a narrative, it provides a model for understanding resilience in literature and life. By highlighting the vitality of Indigenous culture, the novel drives home lessons of adaptability and sustainability, urging readers to reconsider their relationship with nature, culture and tradition in an ever-evolving world.

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AI-DRIVEN VEHICLE SPEED ESTIMATION: A REVIEW ON DEEP LEARNING TECHNOLOGY AND REAL-WORLD IMPLEMENTATION

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ABSTRACT
Nowadays it is very difficult to drive a car in urban areas, be it a highway or a normal road. Therefore, vehicle speed estimation has become critical so that road accidents and traffic can be reduced, while many techniques have already been developed to calculate vehicle speed, but in this paper, we will review Artificial Intelligence-based Deep Learning techniques like Convolutional Neural Networks, Recurrent Neural Networks, and hybrid models. Apart from this, we will also discuss real-world implementation, challenges, and future trends.

Keywords— *Speed Estimation, YOLO, Convolutional Neural Network, Deep Learning, Artificial Intelligence, Traffic*

INTRODUCTION (*HEADING 1*)

In the past few years, the instant development of an intelligent transportation system (ITS) has greatly changed traffic administration and the road protection process. Among the many improvements, vehicle speed estimation has received substantial attention due to its influential role in accident prevention, traffic law enforcement, and urban mobility optimisation. The use of conventional speed estimation approaches, such as radar, LiDAR, inductive loop sensors, and GPS-based tracking, has been widespread. Nevertheless, these methods predominantly present challenges such as high installation and maintenance expenses, limited scalability, and environmental obstruction. With the progress of deep learning powered by artificial intelligence (AI), vision-based vehicle speed estimation has become a useful and inexpensive alternative. AI-powered methodologies leverage sophisticated computer vision methods and deep learning styles to investigate video feeds and assess vehicle speeds with extreme precision. When it comes to processing spatial and temporal characteristics from video data, convolutional neural networks (CNNs) and recurrent neural networks (RNNs), like Long Short-Term Memory (LSTM) models, excel. This functionality facilitates accurate speed estimation in real-time applications [1]. Employing AI to estimate speed in the real world is promptly growing and is being used in more and more fields, such as smart observation, traffic observing, and self-driving car navigation. Governments and smart city developments are progressively adopting AI-based solutions to augment traffic administration and augment road safety. Furthermore, automotive manufacturers are incorporating AI-powered discernment systems into self-driving vehicles to progress real-time policymaking and navigation. Notwithstanding its probable, AI-based vehicle speed estimation aspects numerous challenges, comprising the need for widespread labelled datasets, real-time processing constrictions, and performance dissimilarities because of environmental factors such as lighting and weather circumstances. The purpose of this paper is to deliver a comprehensive review of AI-driven vehicle speed estimation methods, concentrating on deep learning methods, real-world applications, and future research directions. By exploring the state-of-the-art developments and recognizing key challenges, we aim to subsidize to the ongoing progress of intelligent and efficient speed estimation systems for contemporary transportation networks.

DEEP LEARNING METHODS FOR VEHICLE SPEED ESTIMATION

CNN

In deep learning, a convolutional neural network (CNN/ConvNet) is a category of deep neural networks, most frequently applied to analyze visual imagery. The CNN architecture utilizes a specific approach called Convolution instead of relying merely on matrix multiplications like conventional neural networks. Convolutional networks utilize a process called convolution, which merge two functions to show how one alters the shape of the other [2]. Here figure 1 shows the architecture of convolutional neural network.

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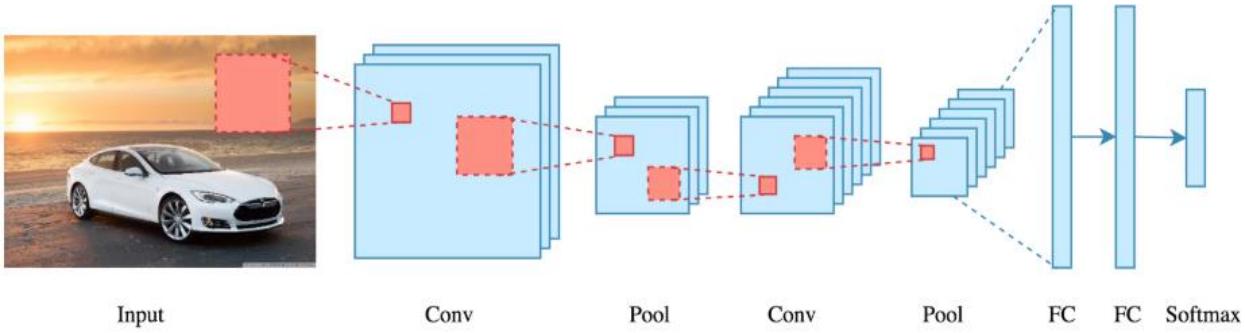

Figure 1: Architecture of CNN

But we don't necessarily have to go behind the mathematics division to comprehend what a CNN is or how it works. The bottom line is that the task of the convolutional networks is to lessen the images into a build that is simpler to process, deprived of losing features that are difficult for getting an outstanding prediction.

RNN

Recurrent Neural networks impersonate the function of the human brain in the meadows of data science, machine learning, and deep learning, acknowledging computer programs to admit patterns and explain communal issues [3]. Here figure 2 shows the architecture of recurrent neural network.

RNNs are a kind of neural network that can model order data. RNNs, which are produced from feedforward networks, are analogous to human brains in their behaviour. Obviously said, recurrent neural networks can anticipate ordered data in a way that early algorithms can't.

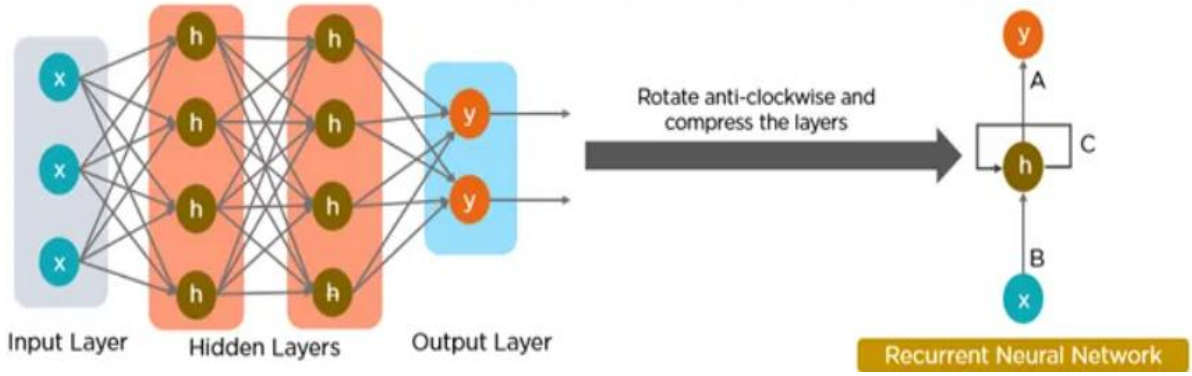

Figure 2: Architecture of RNN

Each of the inputs and outputs in typical neural networks are unrelated of one another. Nonetheless, in certain specifications, for instance when predicting the next word of a phrase, the aforementioned words are required, and so the earlier words must be memorized. Consequently, RNN was formed, which used a hidden layer to solve the problem. The most significant component of RNN is the hidden state, which retains explicit information about an order.

RNNs have a Memory that stores complete information about the computations. They employ the identical settings for every input since they generate the same consequence by performing the identical task on every input or hidden layers.

- With their distinct features, recurrent neural networks (RNNs) distinguish themselves from other neural networks:
- Internal Memory: This is RNNs' primary characteristic. It enables them to retain previous inputs and use that context to the processing of new data.
- Sequential Data Processing: RNNs excel at processing sequential data where element order is important due to their memory. They are therefore perfect for text generation, natural language processing (NLP), machine translation, and speech recognition.
- Contextual Understanding: RNNs are able to evaluate the input at hand in light of their prior "sights." For jobs where meaning is dependent on past knowledge, this contextual understanding is essential.
- Dynamic Processing: RNNs may adjust to shifting patterns within a sequence by continuously updating their internal memory as they process fresh data.

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LSTM

Using AI technology for estimating vehicle speed marks a new slope in the field of intelligent transportation systems due to its incorporation in traffic management, road safety, and autonomous vehicle systems [4]. These systems employ Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) deep learning methods, which analyze extensive amounts of visual and sensor data in real-time to issue accurate vehicle speed estimates. Irrespective of these capabilities, some obstacles still remain such as the integration of components, environmental variability, data quality, and computational demands. To meet these challenges, further research focusing on the augmentation of data diversity, the optimization of computational efficiency, and the environmental insensitivity of the models is needed. Forthcoming research should also aim towards the integration of multimodal data, usage of sophisticated neural models, and explainable AI model integration to formulate less opaque and more reliable systems. Solving these issues and following these paths will enable AI vehicle speed estimation technology to facilitate the development of advanced transportation systems that are smarter, safer, and more efficient. Here figure 3 shows the architecture of LSTM.

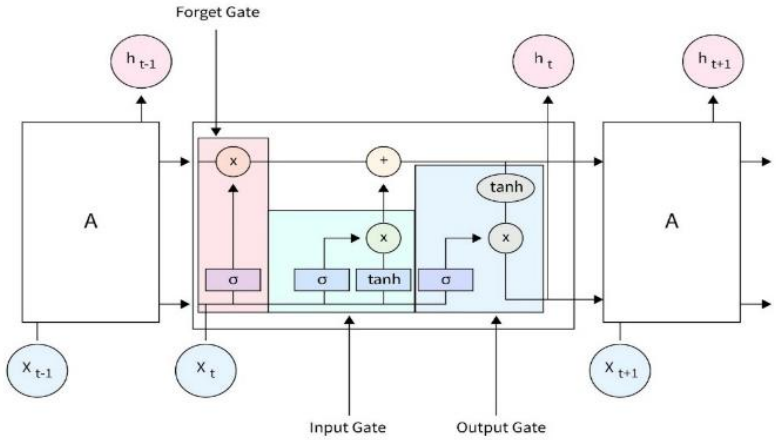

Figure 3: LSTM architecture

COMPONENTS OF LSTM

The architecture of Long Short-Term Memory (LSTM) revolves around its three main gates—forget, input, and output gates—that work together to manage the flow of information in the network [5]:

1. Forget Gate

The forget gate decides what information should be removed from the previous cell state. It produces inputs ranging from 0 to 1 with a sigmoid function, with 0 being "forget everything" and 1 being "retention full," It helps the LSTM to forget unnecessary information without losing important context, managing memory effectively. Forget gate decides which elements of the previous cell state should be deleted. It leverages a sigmoid function to output values between 0 and 1, where 0 suggests "forget and discard this information" and 1 indicates "retain fully."

$$f_t = \sigma(W_f \cdot [h_{t-1}, x_t] + b_f) \quad (1)$$

2. Input Gate

The input gate decides what information should be added to the cell state. It uses both a tanh activation (to create a candidate vector of an amount of new information) and sigmoid activations (to determine how much to update). This approach allows the LSTM to update its memory with the new yet relevant information. The forget gate decides what parts of the previous cell state should be removed. It applies a sigmoid function to generate values in the range of 0 to 1, in which 0 implies "forget this knowledge" and 1 indicates "retain completely."

$$i_t = \sigma(W_i \cdot [h_{t-1}, x_t] + b_i)$$

$$C_t = \tanh(W_C \cdot [h_{t-1}, x_t] + b_C) \quad (2)$$

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3. Output Gate

The output gate decides on what to pass to the next layer (or time step). The updated cell state is utilized with a sigmoid activation to filter useful outputs. The LSTM expects the input to be scaled into the range of (−1,1), so using a tanh to process the data helps to minimize any noise and instead lead the LSTM towards only the features that matter. The output gate determines what portion of the cell state is reflected in the hidden states (h_t). It then uses a sigmoid to choose the relevant parts and a tanh to create the final hidden state:

$$o_t = \sigma(W_o \cdot [h_{t-1}, x_t] + b_o)$$

$$h_t = o_t * \tanh(C_t) \quad (3)$$

These gates collectively empower LSTMs to address long-term dependencies by dynamically retaining or discarding information, making them highly effective in sequence-based tasks.

HYBRID MODEL

CNN-LSTM: The CNN and LSTM layers are stacked together in the CNN LSTM architecture, featuring CNN to extract the image features from the input and LSTMs for sequence prediction [6]. CNN LSTMs were developed you could try here to generate textual descriptions from image sequences (e.g., movies). They were also used for visual time series prediction problems. The problems with, specifically:

- **Activity Recognition:** Writing an explanation of an activity represented in a sequence of images.
- **Image Description:** A written summary for one image
- **Video Description:** Generating a written description of a sequence of images.

From this point forward we will refer to LSTMs with a CNN front end as "CNN LSTM" but the original designation for this architecture was Long-term Recurrent Convolutional Network or LRCN model. This architecture is in charge of generating textual descriptions from photographs. The performance of the caption producing challenge requires using a CNN which has undergone pre-training on a complex image classification task to serve as a feature extractor.

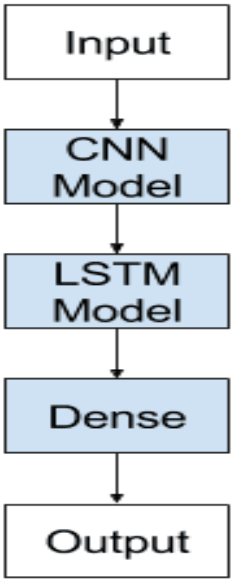

Figure 4: CNN-LSTM architecture

This architecture is suitable for problems that:

- Input has spatial organization, such as the 1D structure of words in a sentence, paragraph, or page, or the 2D structure of pixels in a picture.
- Either need the creation of output with time organization, like words in a textual description, or have temporal structure in their input, like the order of images in a video or words in text.

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RNN-LSTM

A Hybrid RNN - LSTM Model is a mixture of traditional Recurrent Neural Networks (RNNs) and Long Short-Term Memory networks (LSTM) working together [7]. Each have their own set of advantages that allow sequential data to be processed more efficiently. RNNs look after a set of time-related inputs with the utilization of memory through hidden states as they are mainly intended for the sequential data. This makes RNNs effective for time series forecasting, speech recognition, and natural language processing. Traditional RNNs face challenges in managing long-term dependencies due to the 'vanishing gradient' problem which is a mental block that prevents the recognizing of patterns in extensive sequences of inputs.

An LSTM RNN is a hybrid form of RNN which comes with an improvement of the basic version with the addition of gating mechanisms, which allows storage to be managed easily and regulate input. These mechanisms include an input gate, forget gate, and an output gate. All these mechanisms assist in filtering out the noise while making sure useful data can be retained for long durations of time. Due to these features, LSTMs are highly effective in any type of task that utilizes long-term memory. The hybrid method combines short-term dependency capturing RNN layers to long-term dependency managing LSTM layers that offer a robust solution for issues pertaining to sequential learning [8].

With this hybrid model, an RNN layer is able to cope with short-term sequences while the LSTM layer focuses on long-term dependencies within data patterns. Both components work in tandem to provide the most effective utility, ensuring the most efficient learning process. For example, the RNN-layer has the capability to capture local trends at the same time as the LSTM layer can preserve patterns over an extended period. In comparison to using RNNs or LSTMs independently, this hybridization enhances the gradient flow, mitigates maximum memory bottleneck, and increases model performance. An RNN-LSTM hybrid model architecture usually comprises of input and dense output layers, an RNN layer, and an LSTM layer. Input sequential data, like words in a sentence or stock prices, is processed by the input layer. The LSTM retains critical information for long term learning while the RNN processes short term dependencies. A predicted word of the language model or the stock price being forecast are possible outputs generated by the dense layer. This model in particular significantly improves the handling of long term dependencies, complex sequential tasks, and propagating gradients. Owing to such properties, it has become popular with applications like fraud detection and financial market prediction, as well as speech recognition and text generation. By combining the benefits of both RNNs and LSTMs, this hybrid approach creates a more efficient and powerful deep learning model for various real-world problems. Here table 1 shows the difference between vehicle speed estimation models such as CNN, RNN, and Hybrid model which are shown below.

Table 1: Shows the difference between CNN, RNN, and Hybrid model of vehicle speed estimation

Feature	CNN (Convolutional Neural Network)	RNN (Recurrent Neural Network)	CNN-LSTM (Hybrid of CNN & LSTM)	RNN-LSTM (Hybrid of RNN & LSTM)
Data Type	Image or video frames (spatial data).	Time-series data (sensor readings, IMU data).	Video frames (spatial + temporal data).	Time-series data (short-term & long-term dependencies).
Memory Handling	No memory; processes each frame independently.	Maintains short-term memory but struggles with long-term dependencies.	Uses CNN for spatial features and LSTM for long-term dependencies.	RNN handles short-term dependencies, LSTM retains long-term dependencies.
Temporal Dependencies	Not considered (each frame processed separately).	Captures temporal dependencies but suffers from vanishing gradients.	Efficiently captures both spatial and temporal dependencies.	Better memory handling for sequential dependencies.
Best For	Speed estimation from images or video snapshots.	Speed estimation from sequential sensor readings.	Speed estimation from video sequences.	Speed estimation from sequential numerical data (e.g., sensor fusion).
Computational Complexity	Lower (efficient for static image processing).	Moderate (depends on sequence length).	High (due to CNN + LSTM integration).	High (due to RNN + LSTM complexity).
Gradient	No, as CNN does	Yes, affects long-	No, since LSTM	No, LSTM prevents

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Vanishing Issue	not rely on recurrent layers.	term dependencies.	mitigates vanishing gradients.	gradient loss.
Training Time	Fast (parallel computation possible).	Slow (due to sequential processing).	Slower than CNN but better for video.	Slowest due to complex memory management.
Accuracy in Speed Estimation	Good for image-based methods but lacks time-awareness.	Moderate, can struggle with long-term dependencies.	High, as it learns spatial and temporal patterns.	High, especially for sequential numerical data.
Suitability for Real-time Applications	High (fast inference).	Moderate (depends on sequence length).	Moderate to high (depends on model optimization).	Moderate to low (slow processing for long sequences).

REAL WORLD IMPLEMENTATION

AI-driven vehicle speed estimation has seen significant advancements, leading to various real-world implementations that enhance traffic management, road safety, and autonomous vehicle navigation. Below are detailed examples of such implementations [9]:

1. Traffic Surveillance Systems

Traffic surveillance systems now employ AI models using Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs) to monitor vehicle speeds in real-time. Researchers use Ultralights' YOLOv8 model to track vehicles and estimate their speed through movement analysis in video frames. OpenCV working together with deep learning approaches enables vehicle detection and tracking in video streams while calculating their speeds which serves as important information for both traffic monitoring and law enforcement purposes.

2. Autonomous Vehicles

Safe navigation and decision-making in autonomous driving depends on accurate speed estimation. Modern AI technologies including Long Short-Term Memory (LSTM) networks and Transformers process video data to enable vehicles to determine their speed as well as the speed of nearby vehicles with high accuracy. Recent research shows that these models successfully handle long-term dependencies in video frame sequences which improves speed estimation reliability in changing conditions.

3. Smart City Applications

The development of smart cities benefits from AI-driven speed estimation which helps optimize traffic management and infrastructure planning. Michigan's Interstate 94 section operates as a futuristic road system from Cavnue that deploys sensors every 200 meters to track and analyze road status and traffic flow as it happens. Authorities receive actionable insights from this system which supports faster road improvements while providing essential information to connected and autonomous vehicles about current road conditions [9].

4. High-Speed Autonomous Vehicles

Autonomous vehicles can be controlled quickly and safely with AI. One such prominent instance of an autonomous vehicle is the AI-powered Maserati, which achieved a world record by hitting 197.7 mph on the Kennedy Space Center runway in Florida. It successfully integrated advanced AI algorithms that enable accurate speed estimation and control, showcasing the power of AI in rapid autonomous technology navigation [9].

5. Satellite-Based Traffic Monitoring

Satellite imagery has been mined using AI models to measure the speeds of vehicles in extensive regions. In one study that focuses on tracking vehicles, a Keypoint R-CNN model was employed to analyze RGB bands of satellite images, to track vehicle trajectories and estimate speed, which may provide a scalable solution for monitoring traffic to scale in time. Such an approach can provide valuable insight into the dynamics of traffic, which can help in designing infrastructure and relieving congestion [9].

6. Inertial Sensor-Based Speed Estimation

AI-driven speed estimation goes beyond visual data. Deep neural networks have been trained to predict vehicle speed by utilizing information from affordable inertial measurement units (IMUs). By analyzing acceleration and angular velocity data, these models can precisely determine speed, offering a GPS-independent solution and improving dead reckoning navigation systems.

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Examples of this are seen in projects that utilize AI-based speed estimation to improve traffic monitoring and autonomous vehicle navigation systems, as well as applications in smart city frameworks.

CHALLENGES AND LIMITATIONS

The use of AI-based vehicle speed estimation systems faces a number of challenges and limitations that can affect their effectiveness and reliability. Key issues include:

1. Data Quality and Availability

Deep learning models require large, high-quality data records for training to effectively dismantle. However, recording extensive mark data on vehicle speed estimation is a challenge due to the complexity and cost of collecting more accurate speed measurements in real traffic conditions. This lack of data can hinder the development and accuracy of AI models in this field [10].

2. Environmental and Sensor Limitations

AI-based speed estimation systems are often based on visual data from cameras. In other words, they are sensitive to environmental factors such as lighting fluctuations, weather conditions, and blockages. These factors affect image quality and the accuracy of speed estimation. Additionally, sensor limitations, including calibration errors and hardware limitations, can introduce inaccuracies in data collection [11].

3. Model Complexity and Computational Requirements

Deep learning models, especially those that combine folding fish networks (CNNS) and repeating neural networks (RNNs), are mathematically intensive and can require considerable processing performance and storage. This complexity can interfere with actual time processing capabilities and limit the applicability of these models in scenarios. In this scenario, immediate speed estimation is extremely important [12].

4. Generalization and Robustness Trained on a Specific Data Record

KI models can be difficult to generalize to generalized environments or traffic conditions. Variations in vehicle type, street layout and traffic behavior in all regions can affect the robustness of the speed assessment system and reduce accuracy when used outside the training area [13].

5. Integration into existing infrastructure

Implementing AI-controlled speed estimates requires integration into current traffic management systems that may involve compatibility issues and critical infrastructure changes. Ensuring seamless integration and maintaining system reliability and performance is a key challenge [14].

To address these challenges, continuous research and development is required to improve data collection methods, improve resilience of environmental factors, optimize computational efficiency, and ensure adaptability in a variety of traffic scenarios.

FUTURE RESEARCH DIRECTIONS

Progress in AI-controlled vehicle estimation has opened up new methods for research to address existing challenges and improve system performance. Future research directions include:

1. Improved data quality and diversity

Developing large data records using high quality data records including a variety of traffic scenarios, environmental conditions and vehicle types is important. This diversity improves models and robustness models in a variety of real-world situations.

2. Integrating Multimodal Sensor Data

Combination of data from several sensors, such as cameras, LIDAR, radar, and GPS, can lead to more accurate and reliable speed estimates. Research should focus on effective sensor component technology to use the strength of all sensor cards.

3. Optimizing Arithmetic Efficiency

Developing optical AI models that maintain a high level of accuracy and simultaneously reduce arithmetic requirements is essentially important for real-time applications, especially in resource-related environments.

4. Including the described AI (XAI) approach

The implementation of the XAI method allows for transparency in the AI control speed estimation system, building trust and debugging and compliance with regulatory compliance.

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5. Fighting environmental change
Improved model resilience for environmental factors such as lighting, weather conditions, and changes in blockage is extremely important. This can be achieved through data scaling, robust characteristic extraction and domain tuning techniques.

6. Using Advanced Neuron Architectures
Architecture research such as transformers and hybrid models can improve the recording of temporal dependencies and spatial features, leading to more accurate velocity estimation.

7. Including traffic flow theory
The integration of traffic flow theories, such as motor wave theory in AI models, improves the ability to predict and estimate vehicle speeds, leading to more accurate and reliable systems. By ensuring ethical and data protection, acceptance of public acceptance and compliance with regulations is essentially important.

CONCLUSION

The use of Artificial Intelligence for estimating vehicle speed is a step further in the evolution of intelligent transportation systems. It has the capability of improving traffic management, increasing road safety and facilitating the automation of vehicles. These systems employ two of the deep learning techniques, Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs), to analyze and render real time vehicle speed estimation from huge volumes of visual and sensor data. However, some promises remain unfulfilled and there are issues with the data, variability in the environment, computational load, and system integration. For these issues, much work still needs to be done particularly in improving the diversity of data, computational efficiency, and the model's resistance to environmental factors. In addition to these suggestions, incorporating modern neural structures alongside explainable artificial intelligence components would generate clearer, more reliable systems that integrate multimodal sensor data. If these systems are easier to understand at a human level, they are less likely to be distrusted. Overcoming these problems will allow AI driven speed estimation systems to help make transportation networks safer, smarter and more efficient.

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PAIN - BRUISE OF FEMININE DESIRES IN POSSESSING THE SECRET OF JOY BY ALICE WALKER

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ABSTRACT
American writer of African ancestry always writes within two boundaries - oral tradition and literary tradition, African and American and male and female. Along with these boundaries they blend the themes of quest for self, status, identity and even power. Female writers like Toni Morrison, Zora Neale, Alice Walker, Gwendolyn Brooks, Paul Marshall, June Jordan and many more have contributed their thoughts to African American writings. They try to throw light about issues like race, gender and class. They also brought into light depicting the trauma of sexual exploitation, abuse, rape and seduction. Black women not only lead a life of black by race but also as a woman. Hence her life has double disadvantages in patriarchal society. She must struggle in between her gender and her race. Alice Walker was one of the great African American women writers focuses particularly on these women. Her writings explore the oppression of African people. Her novels, stories and even essays exhibit the untold influence on their culture, politics and especially on the Black Community. Slavery which is widely considered as one part of African ethnicity is also dealt with. Writers like Walker tried to bring out the slave narrative to describe dehumanized condition and their mean status as subhuman and the roots and rituals in it.

Alice Walker in her Possessing the Secret of Joy describes about female sexuality and the way how a woman's self-identity is exploited among African tribal women. Women in African who belong to tribal clan are considered as slaves. They are refused pleasure or happiness in their life. Many female kids in between the age of five and eleven is circumcised. The readers are shocked to note that many girls who undergo this task die since no hygienic measurements are taken and the girls who survive suffer with pain and infections. In later stages when they grow to women, the pain they experienced while the process is a never-ending thing all through their life.

Key words: *African American, slavery, women, pain, struggle*

INTRODUCTION
American writers of African ancestry always write within two boundaries one being the oral tradition and literary tradition, the other African and American and finally male and female. Many decades ago, African Americans simply talked about the themes of stereotypical and problems. Its culture expresses racial oppression and identities and started creating works in a dynamic way. Oral tradition always refers to old stories, sayings, proverbs and old songs. This was being passed from one generation to another generation orally. Tuwe (2016) in his article "*The African oral tradition paradigm of storytelling as a methodological framework: Employment experiences for African communities in New Zealand*" talks about the oral tradition and says

African people are rooted in oral cultures and traditions and as a result they have esteemed good stories and vibrant storytellers (Ngugi wa Thiong'o 1986, Vambe. 2001, Chinyowa 2004, Vambe 2004). Ancient writing traditions do exist on the African continent, but most Africans today, as in the past, are primarily oral peoples and their art forms and stories are oral rather than in written form (3)

For a long time this oral tradition preserved cultural heritage. Their values, tradition and histories were also transmitted orally. Realism was blended with magic and was exhibited in the story. Africans came to settle down in America they brought their backgrounds, specific words, languages and culture with them. They tried to create a boundary within their oral tradition developed literary tradition.

Along with these boundaries they try to have a quest for self, status, identity and even power. These writers try to explain about the African American ethnic culture, roots, rituals and characters. Female writers like Toni Morrison, Zora Neale, Alice Walker, Gwendolyn Brooks, Paul Marshall, June Jordan and many more have contributed their thoughts to African American writings. These writers not only write about themselves but also about other women. They try to throw light about issues like race, gender and class along with it depicting the trauma of sexual exploitation, abuse, rape and seduction. Black women not only lead a life of black but also a

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woman. Hence her life has double disadvantages in patriarchal society. Their identity becomes a big question. Shwaili and Adnan (2019) in their article describes about identity clearly.

Self-concept comprises two factors: personal and group identity. Personal identity refers to the personality characteristics, which are common across a given gender, originality, culture, and a particular class. On the other hand, group identity refers to the cultural norms and obligations that connect certain groups of people. (31)

Toni Morrison explored the black people's identity in America, especially black women. She was the first African American woman writer to win the Nobel Prize in 1993. She narrates the voices of African people especially women and children. She tries to combine the past with the present and tries to bring out the horrible matters such as rape, murder, alcoholism etc. She even describes identity, culture and belongingness. He female characters always undergo pain, tragic circumstances, quest for identity and search for their place in this wide world.

Zora Neale American author wrote about contemporary issues which are in the black community. She concentrates on racial conflicts which are happening in her society. Her works always reflected both African and American experiences and the struggles she faced as an African-American woman. He writings exhibited the practice of white men taking black African women as their concubines, merely for sex, and even leaving them to have children. She insisted in educating black students.

Gwendolyn Elizabeth Brooks played many roles in her life, as poet, teacher and author for many writings. She always represented her people's struggles in her community. Women and children of her community became the major concern of her novels and poetry. She even wrote about colour and men also. She vividly tried to visualize the growth of youth and adults and present it in her works. Her characters in her works exhibited emotions and feelings.

Paule Marshall displayed the human problem. She displayed identity crisis, issues related to race, imposing the importance of tradition etc. She reflects the troubled soul or individual or a community which raises question of its identity. She tries to connect the past, present and future keeping her black community in mind.

June Jordan is very familiar for her political and autobiographical verses. She expresses African-American culture. Her writing reflects self-identity, politics, individual and social responsibilities etc. She uses Black English vocabulary in her writings to create an informal way and more conversational style. She always tried to fix her frame between love, affection, politics and identity.

Africa has full of traditional rituals which each writer brings out in their writings. They not only wanted to bring out the positive side of its culture but also the negative side. Writers like Alice Walker argued that not each and every rituals in the culture to be accepted and honoured. The writers, especially female writers argued that African girls are victimized by this tradition and rituals, sometimes they even tend to leave their life or circumstances make them to die. Many rituals are done in the tribal groups in Africa which are not exhibited outside to the world.

Alice Walker was one of the great African American women writer whose focus in on African Americans, particularly women, who are struggling due to race and sex. Her writings explore the oppression of African people. Her novels, stories and even essays exhibit the untold influence on their culture, politics and especially on the Black Community. She also explores the significance of growing up as a black female. Her works portrayed the violence against black women, their oppressive condition and slavery. The characters in her novels strive hard to raise their voice against this oppression and slavery. African people who live in America have different culture and tradition in African continent and they tend to live as a single community in America. In many circumstances and situations, they are exploited. Each time they have to struggle to prove their identity and individuality. African American women were aware of their status in white America. It is notable that these women always struggle to keep their black family united in the alienated country. They showed great strength to fight for their rights and worked hard to come out of their depression.

Black women writers took a new step in literature to bring awareness about the status of black women the society. They wanted to eradicate the myths and wrong rituals of black women. They just wanted to exhibit the female as good thinkers as well as good human beings rather than slaves. This difference mainly happens due to their colour and race. Since American people live inbetween African and American culture they find it very difficult to adjust. Because they couldn't forget their African culture and couldn't adopt American culture on the whole.

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Initially these writers wrote in the form of autobiography to express the ill about patriarchal society and family. Later they started to explain about slavery. Slavery can be considered of two forms – one black women being slaves to white master and two black women being slaves to their own black men. They brought out the exploitation of race, sex and even class.

Slavery is considered as one part of African ethnicity. Writers like Walker tried to bring out the slave narrative to describe dehumanized condition and their mean status as subhuman. It explains about the rights of the black people and it throws light on the civil, human and social rights. Even though these people built a new network, love, family and religion, somewhere in some place they have racial discrimination till now.

Writers who belong to African American, tried to trace back the essential aspect of the blacks, their roots and their rituals. While black men fight against race and oppression, black women fight against discrimination and harassment of sex. Black women writers who very well know about their people's condition tend to bring out these things in their writings. They concentrate especially on physical violation and sexual violation. They insisted on powers which will enable each black woman to raise their voice against exploitation and repel against oppression and transform into a new womanhood. Writers like Alice Walker exhibited their protagonists as a rising power from nothingness to empowerment. They always fight for their self-identity and self-awareness through their rebellious character. Walker very well knows about the feminine sensibilities and male responsibilities. Her novels brought out the violence of black men.

Alice Walker in her *Possessing the Secret of Joy describes about female sexuality and the way how a woman's self-identity is exploited among tribal women. Each culture is bound with customs and tradition. Previously, women in African who belong to tribal clan are considered as slaves. They are refused to have pleasure or happiness in their life. They must not have any individual thoughts and wish. Even sexual pleasure is solely considered as the rights of men and not for women. The male always dominated in this matter. They think that it's their right to have sexual satisfaction and which is abandoned for women. Walker brings out the pathetic situation of a woman in the African society who has no control over her body or her bodily desires. Their body is used by others, especially men. Harris clearly states that*

Walker's approach in representing storytelling not only advances the way in which multiple women form connections and share their experiences with the protagonist, but also includes, more intimate forms of connections that probe the character's experiences. (29)

*This is the technique Walker uses to bring out the reality of the situation that happens in and around the society. She not only talks about the incidents that happens in the protagonist's life but also connects it with the other characters in the novel. Through many women in her novel she tries to bring out the pathetic situation of each and every female in the society. The writer brings out the horrible situation, in the name of tradition and culture, which happens to an African girl, Tashi in Possessing the Secret of Joy. Walker compares the position of women in every culture around the world and in African culture. There is no freedom for a girl in African culture and female circumcision happens frequently. Dunn in her article talks about female mutilation. She states that "*Female genital mutilation / cutting remains a widespread practice throughout Africa" (007). Even this horrible event happens not for the sake of the girl but for men alone, to seek sexual pleasure through it.

M'Lissa, the Olinkan woman is praised and celebrated all over the country for her great work as circumciser of females. She is appreciated for her act. People in her society even tend to praise her for her work. Many female kids inbetween the age of five and eleven is circumcised, because that will be the age where they cannot raise questions and just listen to their parents. This event is done with the permission of their parents. Even though Walker belongs to African society, she is against this barbaric act. SWW and Wardani in their article describes about this mutilation.

There are three reasons why female cutting still happen and take an important event for African woman. First is to construct femininity. The myth that clitoris is part of male organ become the trigger to trim the clitoris in order to be a fully woman. Second is stick the old woman and the young woman relationship. In this community the elder woman hold the strong influence to the younger's lives. By joining the same experience with the elder, the younger woman will gain respect and recognition from the peers also. The last is female cutting becomes a necessary part of their religious life. (300-301)

Through her powerful words and description about this act, the readers can feel the pain of the girls. Walker even considers it as an uncivilized performance which cannot be accepted by anybody. During this process the story's protagonist Tashi's dear and lovable sister Dura, dies. The readers are shocked to note that many girls who undergo this task die since no hygienic measurements are taken and the girls who survive suffer with pain

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and infections. Moreover she is not the only girl who dies. In later stages when they grow to women, the pain they experienced while the process is a never ending thing all through their life. Most of the women have urinary infections and have to suffer with great pain when they have intercourse with their male counterparts. This pain not only affects them physically but also mentally and emotionally. Sexual pleasure which is considered equal for both men and women becomes a question mark of them. They refuse having intercourse due to this great pain which leads their husbands to seek another partner for it or they force their wives to have anal intercourse. This bodily pleasure becomes a night mare for many girls. Ndasi and Asante clearly states that

Female genital mutilation/cutting (FGM/C) is a dangerous practice that predates all religions and perpetrated on children for various reasons in various cultural and global contexts, causing adverse lifelong health consequences including sexual, physical and psychological problems for the survivors. (232)

Few of them overcome all these hurdles and by chance get pregnant they will be having a painful, horrible delivery. Since their female genital is either cut or stitched together, it becomes very difficult for the baby to come out easily. Even the girl has a troublesome normal delivery, the baby's head will be out of shape or its brain will get damaged. Since the outlet is small and the baby couldn't be pushed outside it becomes very difficult for the baby to come out or even survive. Life becomes a terrible thing to lead for these women who underwent this ritual in the name of tradition and culture. Tashi couldn't understand why no one opposed this painful ritual even when this happened to her.

The same incident happens to Tashi when she was a child. After getting hurt mentally and physically she returns to her village with the help of Adam. The uneasy feeling during walking makes her to walk weirdly. Her friend Olivia observes her changes and most precisely her change in her walk. She makes fun of her walk saying that she has a classical walk, a typical Olinka women's walk, Olinka being their clan. She comments "classical walk in which the feet appear to slide forward and are rarely raised above the ground" (PSJ 63). Walker through this comment brings out the tragic situation of the women in the tribal group.

Same as when she becomes pregnant she is terribly upset because of the pain the delivery will cause her. When she gives birth to her son Benny, she faces a troublesome struggle. Due their genital cutting process the path narrows and Benny's head is stuck inbetween. Even the obstetrician finds difficult to make an opening. Due to this baby's head is badly ruptured. It becomes yellow and blue in color. Even Adam gets upset after seeing the baby. The medical students and nurses who stand beside her look at her in great pity. Tashi after seeing her child remarks "some small but vital part of his brain is crushed in the ordeal". (PSJ 58)

Tashi was very much affected due to this. Since she couldn't stop this horrible ritual she wanted to take revenge. She couldn't oppose her society or take revenge against them. Hating her society she feels to do something against it. So her hatred and anger turns towards the lady M'Lissa, who performs the rituals and has gained a special name and fame in this regard. She thinks that only M'Lissa is responsible for every cruelty which is happening to the girls in her society. She even had more vengeance towards M'Lissa because she killed her sister through her disgraceful act. This thought about their rituals, culture and the inability to do against it makes her insane. Walker even brings out the heavy psychological aspect which affects the protagonist and reflects in her whole life. Tashi tries hardly to recover from her loss but she couldn't. In due course she wanted to achieve two things, one she wanted to attain mental peace and another she wanted to stop this horrible, painful act and save many girls in her society. Through the victim who has been affected, the writer brings out about impact of the physical and mental destruction.

CONCLUSION

The pain she underwent when she was a child, and her haunting memory about it makes the protagonist finally to decide to kill M'Lissa so that she thinks that she can bring the world's attention towards the condition of African girls and women, who is affected by this unwanted, unhealthy and painful ritual. This murder will even bring her peace of mind. The writer does not indicate whether the killing of M'Lissa puts a stop to the ritual. Tashi psychologically thinks that through killing the bad lady, girls will be rescued. The writer wanted to bring this matter into light and she believed that may be on later stages this small step can bring awareness in the public and many voices can be raised against this painful circumcision. It will pave way to Tashi's followers or sisters, for whom she will be a role model, to raise their voice against this dangerous tradition.

The reader can very well not that the writer to indicate the intensity of the ritual, describes about many significant narratives to render how the ritual is performed, the particular instruments which is used, the painful and terror physical consequences on and after the ritual, and gynecological problems faced by the girls even after they grow to women and the pain which remains all through their lives. Walker, providing such detail

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descriptions wanted to insist the readers to know and understand about the severity of the ritual and its impact on human lives especially female.

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FUZZY OVERLAY-BASED SITE SELECTION FOR ASTRONOMICAL OBSERVATION IN LADAKH

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1. ABSTRACT
The research work represents a geospatial assessment of the Astronomical Observation (AO) site suitability in the Ladakh region using a fuzzy logic methodology within a GIS environment. Multi-temporal climatic, atmospheric, vegetative, and anthropogenic data were used from the year 2002 to 2022 to drive nine key parameters. The parameters are elevation (EL), Slope Angle (SA), Normalised Difference Vegetation Index (NDVI), Temperature (TEMP), Relative Humidity (RH), Precipitation (PR), Cloud Amount (CL), Aerosol Optical Depth (AOD), and Night-time Light (NTL). The factors were standardised using the fuzzy membership according to their relevance to AO. A fuzzy gamma (γ = 0.90) overlay analysis method has been taken into consideration with values ranging from 0 to 1. The output was further classified into six categories, ranging from not suitable to very highly suitable based on natural breaks. The resulting map identifies existing observation sites such as Hanle and reveals other high-potential zones for future development. This research work demonstrates the use of fuzzy logic in handling complex spatial variability in high-altitude, ecologically sensitive areas like Ladakh.

Keywords: *Site Suitability, Fuzzy logic, Ladakh, Astronomical observation*

2. INTRODUCTION
Astronomical observation (AO), which involves studying the universe, critically depends on the clarity of the night sky, along with the quality of the surrounding environment (Aksaker et al. 2020a). This research article aims to locate suitable areas for the establishment of AO sites in the Ladakh region (Aksaker et al. 2015). To find out optimal locations for AO development in a region like Ladakh is a complex process, which requires the integration of multi-sourced satellite data on topography, climatic conditions, atmospheric stability, and anthropogenic involvement (Aksaker et al. 2015; Collison and Poe 2013; García-Lorenzo et al. 2005; Koc-San et al. 2013; Najafabadi 2012; Uyan 2013). To conduct a stability analysis for the development of AO in Ladakh, a range of different parameters has been evaluated together with a multi-criteria decision analysis (MCDA) approach (Aksaker et al. 2015, 2020b, 2024). These parameters exhibit significant spatial and temporal variability across the study region due to its diverse landscapes, where a subtle variation in topographic shift can result in sharp environmental shifts, which conventional classification methods often fail to indicate (Bhutiyani 2015; Koc-San et al. 2013; Kuttippurath, Patel, and Sharma 2024; Negi et al. 2012). To address these complexities, the fuzzy logic method has been taken into consideration, which has the potential to provide a more realistic representation of the suitability conditions for AO in the Ladakh region (Duarte et al. 2016; Razzaque et al. 2024; Shamir and Nemiroff 2005; Yılmaz 2023). The study focuses on generating a potential site suitability map incorporating a total of nine 9 parameters, including EL, SL, NTL, TEMP, PR, RH, CL, NDVI, and AOD. Each parameter is standardised using a suitable fuzzy membership function and integrated with the help of fuzzy overlay analysis in a GIS environment (Özkan, Sarıçiçek, and Özceylan 2020; Vojteková and Vojtek 2019). The final map aims to identify optimal locations throughout the Ladakh region to strategically develop AO sites, supporting future initiatives such as space observatories (SO's), dark-sky reserves (DSR), and astronomical tourism (AT) development.

3. STUDY AREA
The study location for this research work concentrates on the Ladakh region (Figure 1), which is situated at a high altitude, north of the Greater Himalayan range and the southern part of the Karakoram Mountain range. Ladakh comprises two primary urban centres, Kargil and Leh (Chevuturi, Dimri, and Thayyen 2018). It lies between an area covering almost 60,000km² from **32° 15′ N to 35° 37′ N latitude; 75° 15′ E to 80° 15′ E longitude. The average elevation of this region is roughly 3500 meters above mean sea level, with arid climatic conditions with low precipitation and extreme temperature variation due to its high altitude and the rain shadow effect caused by the Himalayan Mountain range. (Singh and Bhatla 2024).**

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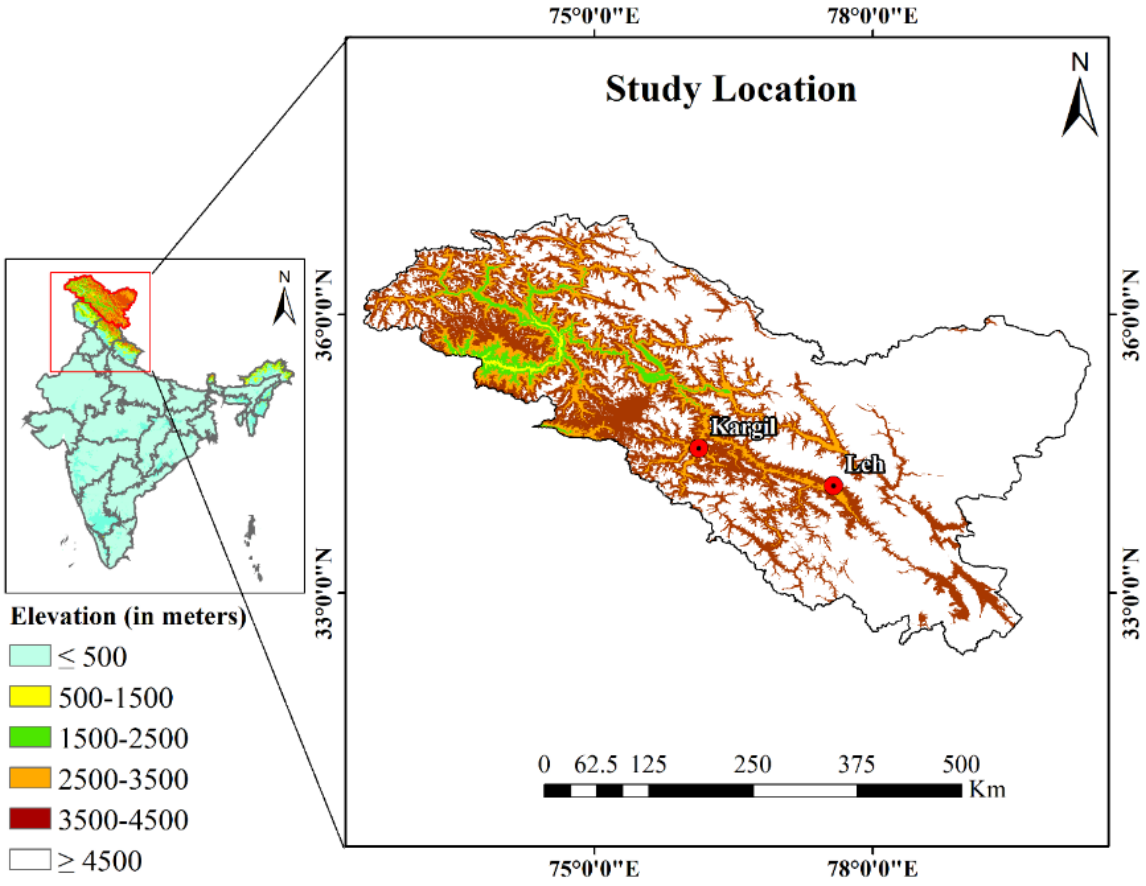

Figure 2 Study Location

4. DATA PREPARATION

For identifying optimal locations for the development of AO sites, a comprehensive geospatial dataset was compiled by integrating a total of nine parameters, focusing on topographic, climatic, and anthropogenic factors derived from multiple satellite data sources. The data set has been further processed in ArcGIS software to ensure a consistent spatial resolution, coverage, and projection to prepare the data sets for the fuzzy overlay model with the help of a fuzzy membership standardisation process.

4.1. Terrain and Ecological Determinants

The assessment of optimal site suitability study incorporates topographic parameters, specifically elevation (EL) and slope angle (SA). The data were obtained from the USGS Earth Explorer (USGS-EE) platform using the Shuttle Radar Topographic Mission (SRTM-1) dataset to incorporate elevation surface data (Figure 2-A). The slope has been generated from the EL dataset by using the standard terrain analysis tool in ArcGIS (Figure 2-B). Both layers were further categorised into six classes based on equal intervals (Conforti and Ietto 2019; Dewitt, Warner, and Conley 2015; He et al. 2023; Magesh, Chandrasekar, and Kaliraj 2012). NDVI has an important role in controlling the brightness of the sky, limited vegetation cover often corresponds with darker skies. From 2002 to 2022, NDVI data were collected from the NASA-LAADS satellite data portal by utilising the MOD13-Q1 dataset. Composites were averaged to create annual mean values by aggregating a total of 252 layers (21 years × 12 months) [equation i]. the NDVI values, ranging from -1 to +1, were further divided into 6 classes, where the higher value represents the higher density of natural vegetation (Daramola and Balogun 2019; Luan and Wan 2020; Series and Science 2020) (Figure 2-C).

$$ndvi_{Ln} \times 0.0001 \ldots\ldots\ldots (i)$$

Where, "Ln" represents individual layers. The value ranges between (-1 to +1).

Twelve monthly NDVI layers were averaged to produce a yearly mean NDVI, which was further averaged to create a single composite raster representing the mean NDVI of 21 years [equation ii].

$$\mathrm{s}NDVI_{Ag} = \frac{1}{t \times n} \sum_{n=1}^{t} \sum_{m=1}^{n} NDVI_{mn} \ldots\ldots\ldots (ii)$$

Where, $'NDVI_{Ag}'$ represents long-term average NDVI values, 'n' stands for the number of months, 't' represents the total number of years, and $'NDVI_{mn}'$ indicated NDVI for month 'm' in year 'n'.

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4.2. Climatological and Atmospheric Determinants

Climatic and atmospheric factors exert a cumulative influence on the sky clarity and transparency of the atmosphere. Here, for four climatic variables, TMP, RH, PR, and CLA, 100 station points were selected across the study area using a mixed sampling technique (random and purposive sampling) from the NASA POWER data access viewer portal for 21 years. The resulting dataset, extracted in CSV format, comprised 400 records (100×4 parameters), amounting to a total of 8400 data points from 2002 to 2022 (Kadhim Tayyeh and Mohammed 2023; Karmel and Jain 1987; Rapti 2000). The data points were imported into a GIS geodatabase on ArcGIS using OID values and merged with a spatial station point layer to perform the Inverse Distance Weighting (IDW) interpolation technique to create monthly and then annual mean raster layers for all four climatic parameters. All the factors were classified into six classes. To evaluate long-term trends in climate, monthly and yearly values were calculated for all variables and a standardised equation [equation iii] was applied to ensure analytical consistency (Figure 2- D, E, F, G).

$$CL = \frac{1}{y \times m} \sum_{J=1}^{y} \sum_{I=1}^{m} CL_{ij} \ \dots \dots \dots \ (iii)$$

Where, 'CL' represents a long-term average of all individual climatic parameters, 'm' indicates the total number of months per year, 'y' indicates the total number of years, and 'CL_{IJ}' stands for raster value for the month 'I' of year 'J'.

AOD values negatively impact the observational quality by increasing the absorption and scattering of the light. The data was sourced annually from 2002 to 2022 through the NASA Giovanni Earth Data Portal by extracting the MOD08-M3 dataset (Marco Andrés Guevara Luna, Fredy Alejandro Guevara Luna 2018). The extracted raster was further converted into a point dataset in the ArcGIS environment with pixel values extracted for each cell. With the implementation of IDW interpolation, annual layers were represented with the spatial distribution of AOD. The final layer was classified into six classes (Figure 2-H).

4.3. Human-Induced Determinant

NTL, which is an anthropogenic factor, has a significant effect on the night sky visibility. Artificial NTL creates the effect of artificial light pollution (ALP), which significantly reduces the visibility. So the regions with the minimum impact of NTL are deemed to be highly preferable for the establishment of AO sites (Changruenngam et al. 2023; Nisar et al. 2022). For 2002 to 2013 Defence Meteorological Satellite Program's Operational Linescan System (DMSP-OLS) with a spatial resolution of 1km, and from 2014 to 2022, the Visible Infrared Imaging Radiometer Suite Day/Night Band (VIIRS DNB) on NOAA-20 with a spatial resolution of 500 meters were utilised (Butt 2012; Chalkias et al. 2006; Dou et al. 2017; Kumar et al. 2017, 2019; Levin and Zhang 2017; Li and Zhou 2017; Shi et al. 2014; Zhang et al. 2019; Zhang, Schaaf, and Seto 2013). Due to varying spatial resolution, VIIRS data were resampled to match the 1km resolution of the DMSP dataset for consistency. The data computed the mean values (Digital Numbers-DN) [equation iv] throughout the time, resulting composite average NTL layer, which was further classified into six classes based on pixel intensity (Figure 2- I).

$$NTL = \frac{1}{Y} \sum_{e=1}^{y} NTL_e \ \dots \dots \dots \ (iv)$$

Where, NTL represents long-term NTL intensity, 'y' indicates the total number of years, and 'NTL_e' stands for yearly mean NTL value for year 'e'.

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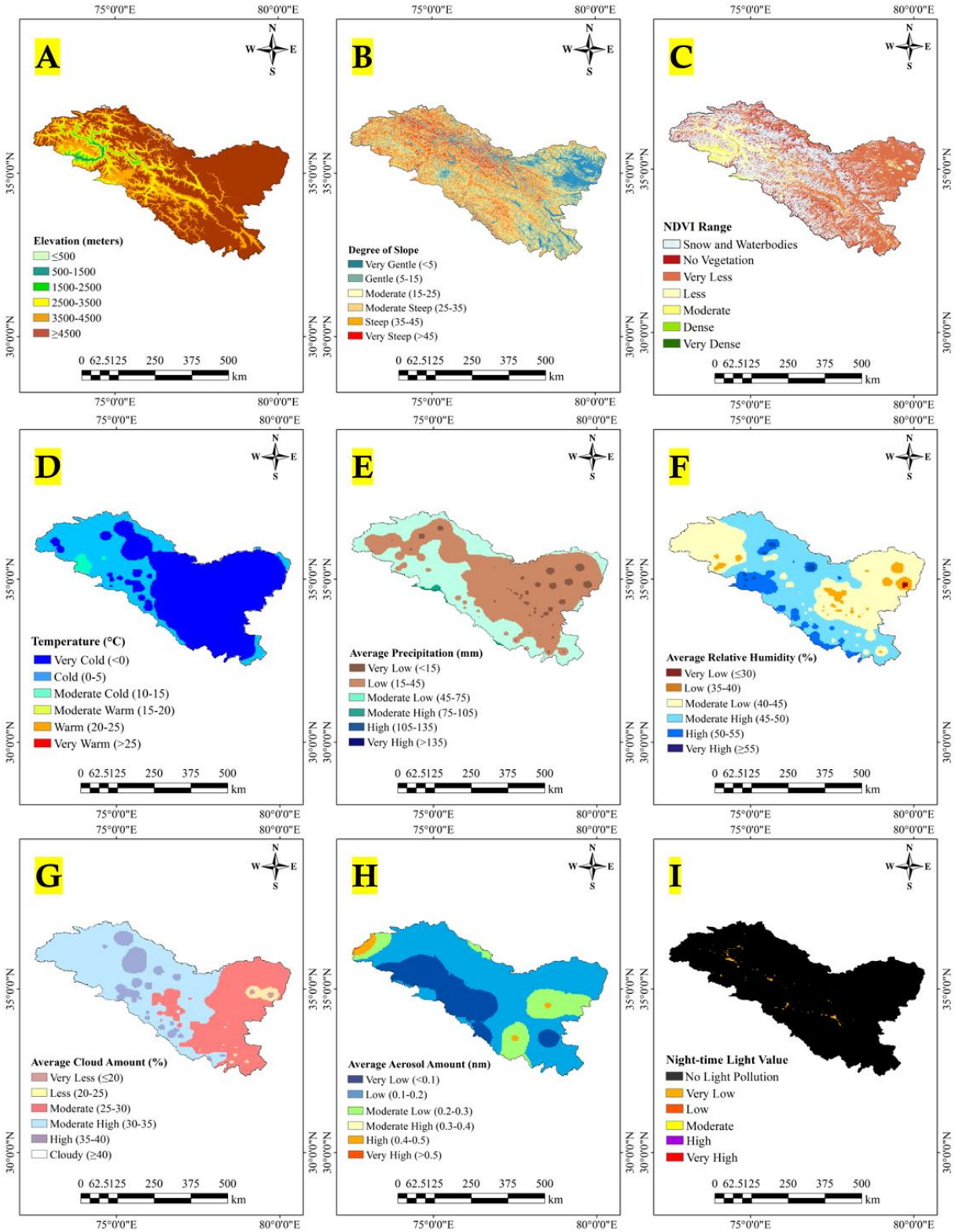

Figure 2 Selected Parameters: A) EL; B) SLP; C) NDVI; D) TEMP; E) PR; F) RH; G) CLA; H) AOD; I) NTL

5. METHODOLOGY

5.1. Fuzzy-Overlay Analysis

The fuzzy set theory was originally introduced by (Zadeh 2004), is a strong mathematical framework designed to model uncertain and dynamic information, making it particularly suitable for representing complex and gradual natural occurrences. Fuzzy logic allows the elements to process a varying degree of membership within a set ranging from 0 to 1, where the membership value of 0 denotes not suitable, while 1 indicates optimally suitable sites (Rouvray 1996). The characteristic enables fuzzy logic to effectively identify the detailed transition from poor to optimal conditions. In this study the fuzzy logic has been implemented in a GIS

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environment to evaluate the relative suitability of diverse geospatial factors to identify suitable locations for the development of AO sites. The mathematical representation of fuzzy logic can be expressed as:

$$Fu = [i, \mu S(i)],\ i \in \mathrm{U} \ldots \ldots \ldots (v)$$

Where '*Fu'* represents the class suitability of the fuzzy set, $'i'$ indicates the element from the universal set '*U'*, and $'\mu S(i)$', represents the membership function, which assigns a suitability score to each *'z'* in the range [0,1].

5.2. Fuzzy Implementation

This research work aims to identify optimal locations for AO sites with the help of fuzzy logic-based spatial analysis conducted within a GIS environment (Yousefi, Hafeznia, and Yousefi-Sahzabi 2018). The methodology is structured into four key stages, where the first stage represents the selection and collection of relevant satellite data. The data set corresponding to the selected factors was identified, acquired, and standardised to balance the spatial uniformity and compatibility within the GIS influence. The second stage consists of creating thematic layers which serve as the foundational inputs for fuzzy overlay analysis. The third stage is focused on the application of fuzzy logic, which was implemented to normalise the data set values and denote the degree of suitability on a continuous scale to inherent spatial variability in the study location. The fourth and final stage, the fuzzy-transformed layers were integrated using a weighted overlay approach with the fuzzy-overlay method, to aggregate the spatial information from all the selected parameters, based on their relevance to AO suitability. the final suitability map shows the optimal sites for AO locations in the Ladakh region (Figure 3). The selected factors were transformed into fuzzy membership values using a Gamma (γ) value of 0.9, and a composite suitability map was generated using the fuzzy overlay technique (Figure 3). This approach gives a flexible and robust framework for decision making approach which is suitable for a geographically and climatologically complex area such as the Ladakh region. The fuzzy function can create a relative importance and interaction among the factors. It adjusted the combined membership values based on the selected gamma (γ = 0.90) values to manage uncertainty. The range of "γ" values is between 0 to 1, where 0.9 is identified as optimal.

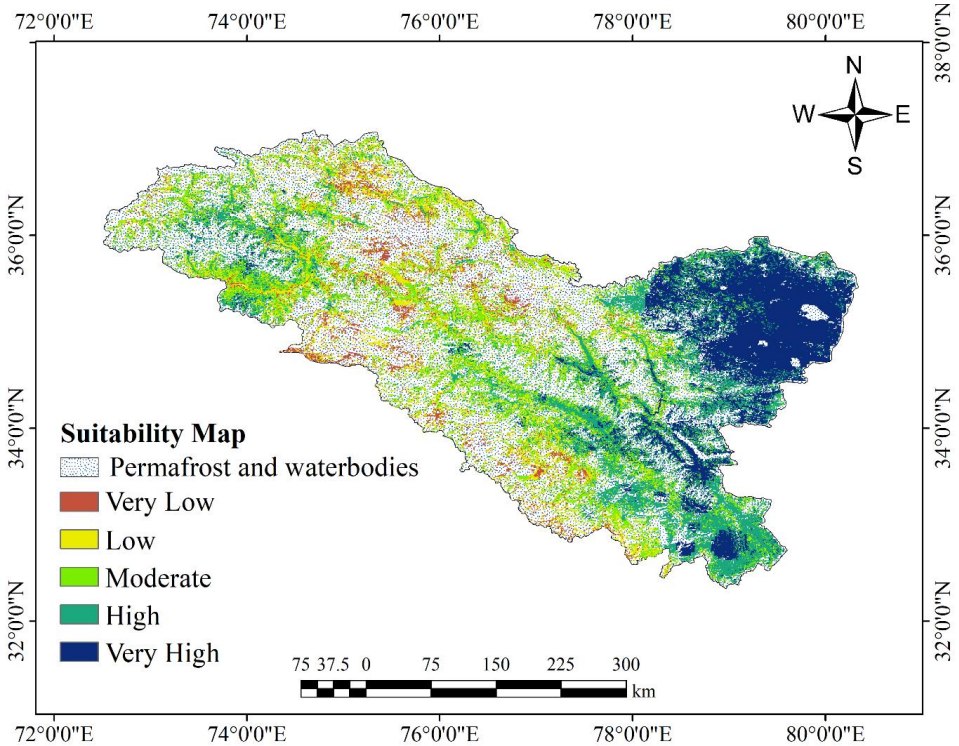

Figure 3: AO Site Suitability Map

6. RESULTS AND DISCUSSION

The final suitability map (Figure 3) provides a detailed spatial representation of potential locations for the development of AO sites across the Ladakh region. Suitability values derived from the fuzzy gamma operation (γ = 0.90) range from 0 to 1.

The suitability map (Figure 3) illustrates that the spatial suitability is not uniform, with distinct zones of high and low potential areas emerging across the study location. The areas which are low in suitability values between (0.0 - ≤ 0.3) are depicted in brown shades, concentrated largely in areas that consist of steep slopes,

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near settlement areas, more cloud cover, higher AOD amount and lower elevations. These are not suitable for AO site development. Regions with moderate suitability (0.4-0.6) are represented by yellow and light green, and can be stated as the transitional zones. While these areas exhibit relatively better conditions, they have some limitations as optimal sites. In contrast to both, the most suitable regions (0.7 -> 0.9) depicted in dark green to dark blue hues are predominantly situated in the eastern part of the study location in high-altitude, sparsely populated regions. These areas can be characterised by clear skies, minimal range of ALP, less climatic and atmospheric obstructions, and due to the existence of the plateau, these locations are topographically accessible and consist of wavy lands and widespread river valleys. Their consistently high fuzzy membership values across all parameters indicate this region as an optimal zone for establishing or expanding infrastructures related to the development of AO. The final map not only provides a robust foundation for scientific foundation for developing astronomical observatories or installations of research facilities, but also serves as a valuable planning tool for stakeholders aiming to develop sustainable tourism and local area development-related infrastructures in Ladakh.

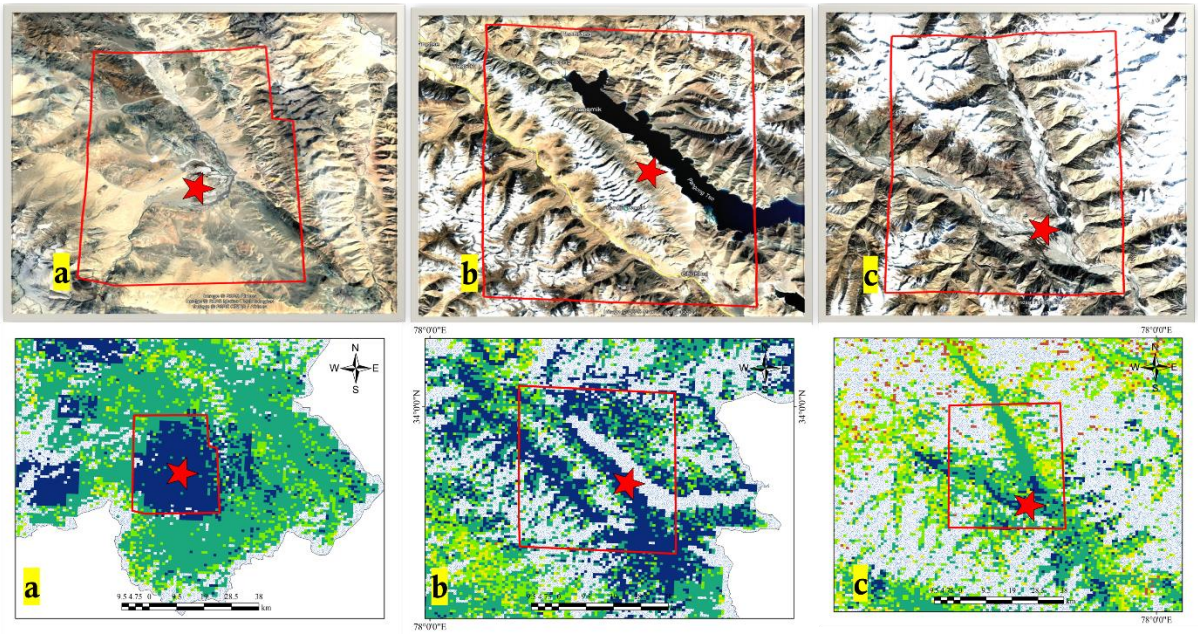

Figure 4: Existing AO locations: a) Hanle - Indian Astronomical Observatory; b) Pangong Lake - Astro Stays; c) Nubra Valley - Astro-tourism

7. CONCLUSION

The research work represents a comprehensive geospatial assessment of suitability analysis for the development of AO sites in the Ladakh region by leveraging fuzzy-logic-based spatial analysis within a GIS framework. By the integration of nine critical factors, consisting of topographic, vegetative, climatic, atmospheric, and human-induced factors, it successfully models a gradual and complex variability inherent in the real-world environment. The application of fuzzy membership function and the fuzzy gamma overlay method creates a flexible and realistic representation of the Earth's surface, offering high to low potential areas in a continuous manner. The final map indicates that, eastern parts of Ladakh, including Hanle, Pangong lake area, and Nubra Valley, along with Changthang plateau, hold the highest potential for AO sites due to their optimal conditions represented by all nine individual parameters. The methodology of the study not only validates the effectiveness of the fuzzy technique but also represents a scalable and modifiable model for future site selection studies in a high-altitude, ecologically and climatically fragile region like Ladakh. To validate the results, three locations, which are already performing AO-based activities, have been identified, and they perfectly coincide with the optimal location according to the final suitability map (Figure 4). Further, the finding contributes to promoting sustainable development and guiding policy decisions on the overall development in alignment with ecological preservation and community engagement in this region.

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ROLE OF PERFORMANCE MANAGEMENT ON EMPLOYEE PRODUCTIVITY

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ABSTRACT
Performance of employees are greatly influenced by Human Resource Management Practices in any Organization. The role of employees therefore is vital in the management and success of an organization. Maintaining and attracting talented energetic workforce who support the strategies of the organization becomes essential for organization that wish to outperform others. This process of Performance Management helps to examine and evaluate the effectiveness and efficiency of Employees based on their performance in the scheduled period. This paper attempts to know the role of Performance Management in improving Employee Productivity in Organization. It sheds insight on the Top Performance Management Tools used by leading organizations

Keywords: *Performance Management, Employee Productivity*

INTRODUCTION
Business Workforce is one of the biggest assets. The way organizations operate after Covid 19 Pandemic has seen a dramatic shift compared to 20th Century. Organizations are doing away with the traditional annual performance appraisal as the focus is shifting towards expecting high quality performance on daily basis. The goal of business organizations have shifted from short run profits to maintaining a sustainable competitive advantage and role of Performance Management cannot be overlooked.

Performance Management is a systematic process used by organizations to know and improve the performance of employees within the organization. It begins with setting clear and measurable goals known as objectives for every member and teams in the organization. Organizations must become aware that certain factors still matter to the employees like enlisting their cooperation and commitment towards meeting the organizational goals, negligence of such factors can hinder the workers from performing to their full abilities. An effective Performance Management will ensure that whatever employees contribute align with important organizational goals.

EFFECTIVENESS OF PERFORMANCE MANAGEMENT ON EMPLOYEES' PRODUCTIVITY
The term Performance Management was widely used in the HR field in the early 1990. Goal Setting, Employee Appraisal, and performance-based pay was becoming common prior to that period. It was only in the late 1980 that the organizations were concerned with the management of Individual Performance in a holistic way.

Employee productivity can be assessed by checking the efficiency of a worker or a group of workers. It can be evaluated in terms of the output of an employee in a given time. Performance Management portrays the message that the organization is interested in developing the personal skills, knowledge and abilities of its employees. Employees find it easier to accept constructive feedback when they are provided with it at the right time. Employees respond to managers who positively try to develop and improve them.

LITERATURE REVIEW

Gaba Monisha (2017) Performance Management is a system of managing Employee Performance for driving the individuals and organizations towards desired performance and results. **Chandhana.K and David. E (2015)** Every employee in an organization increases the productivity and Goodwill of every company. Appraisal as a tool should be used in a constructive way for the betterment of the organization. **Rinku.S And Sanjeev.S (2014)** Good appraisal system can be a significant contributor towards involvement and motivation. HR Professionals must realize that Employee engagement and Commitment is directly proportional to performance appraisal system.

Armstrong and Baron (1998) define performance management as a strategic and integrated process aimed at achieving organizational success by enhancing team and individual performance and capabilities.

Atkinson and Shaw (2006) argue that long-term organizational success depends on aligning organizational strategy, performance management practices, and human resource development for both individual employees and groups.

Rohan Singh, Madhumita Mohanty and Mohanty A.K. (2013) concluded that conducting periodical review of workforce performance by organizations has become a fundamental requirement which will help to shrink the gap between employee performance and successful attainment of its objectives

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Pushpa Hongal (2020) Competitive environment calls for retention of talented workforce which is a major task for HR managers along with acquisition. performance management is a very complex and critical task. Right Talent acquisition makes organization strategy stronger.

RESEARCH OBJECTIVES

1. To examine the how Performance Management improves Employee Productivity in the Organization.
2. To identify the Top Performance Management Tools used by leading organizations

SIGNIFICANCE OF PERFORMANCE MANAGEMENT

If Organizations must have a continuous improvement so that all the employees can achieve their goals it is important that organizations must have Performance Management Process in place. Some of the benefits of Performance management are as follows

1.It increases Retention

By keeping Performance Management in place organizations can reduce turnover rates. Performance Management gives the employees the support they need where employees take ownership of their work. Since it keeps the employees aligned with the companies' mission and vision, the employees can identify with the goals set by the company for them, therefore they tend to give their best performance and help in realizing the company's goals.

2. Boosting employee morale and engagement

Monitoring employee's performance, providing regular feedback and recognition boosts their morale and engagement. They are quick to adapt to changes brought in by the management. They can sail through challenging times with a good attitude because of their positive outlook

3.Identifying Training needs

Managers are in a better position to assess the training needs and requirements of their employees. It helps them to provide the right kind of raining needed for their organizations. It helps the organizations to conduct mentoring workshops and conferences which are aligned with their goals.

4. Defining Career Paths

Performance Management creates clarity and provides employees with a clear understanding of what is expected in their current role and what they must do to forge a clear career path for their growth in the organization. Because of this the employees continue to serve the organization and make concrete goals for achieving their aspirations

5. Setting and tracking clear goals

Performance Management can help the organizations to provide a framework for defining Specific, Measurable, Achievable, Relevant and Timebound goals. These kind of goal systems ensure that the objectives are properly aligned with company's objectives.

6. Reduce Micromanagement

Micromanagement is time consuming and can lead to low employee engagement and increased employee turnover. This fosters an environment of autonomy which creates more trust between managers and employees.

7.Build autonomy and accountability

Performance management can create a culture of autonomy and accountability where employees feel empowered to take ownership of their tasks and take independent decisions. By making employees accountable for their decisions the organizations train their employees.

8.Increase Organizational Performance

Performance management helps organization align their employees, resources and processes to meet their strategic goals and objectives.

9. Foster manager- employee Relationships

Performance Management System helps in establishing open and honest communication between managers and employees, which leads to better working relationships.

10. Improve the bottom line

The more employees have positive experience it is seen that it improves employee engagement, productivity and retention rates.

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TOP 10 BEST PERFORMANCE MANAGEMENT TOOLS

1. 9 Box Grid
A 9-box grid distinguishes the employee's performance according to their skills and accomplishments. It assesses the potential growth of everyone. This model segregates the workforce into nine groups according to current performance and future potential. It monitors potential and builds a culture of leadership among the workforces.

2. 360 Degree Feedback
Organizations use 360-degree performance software to provide quality feedback. Employees receive feedback not only from managers but from everyone around them.

3. Continuous Feedback
It improves employee morale and provides insights in real time. It also minimizes the time taken on task completion and ultimately creates an employee's centric and growth driven process. It helps acquire uninterrupted sessions with employees to review performance, it creates the opportunity for employers to get to know their employees on a personal level and make them feel valued. It develops team loyalty and creates a sense of security.

5. SMART Goals
SMART Goals set employees for success by making goals specific, measurable, achievable, realistic and timely. Goals also help create a sense of accountability and allowed individuals to assess the progress being made.

6. 5A's Test
Future driven organizations are believed to set objectives that are Assessable, Aspirational, Aligned, Accountable and Agile

7. Personal Development Plans
The PDP tool assists people in identifying areas of improvement setting goals by measuring progress and outlining a strategy to achieve the set objectives.

8. Pulse Surveys
They are brief and regular set of digital questions sent to employees as engagement surveys. They are related to job roles, communication, relationships within the workforce. The term is used to signify the continuity of these surveys to gain employee insights.

9. Performance Review
Employees get to know about their strengths and weaknesses and can work on them accordingly. Performance reviews ensure that constructive feedback is shared with the employees' time to time.

10. Performance Appraisal
Performance Appraisal provides adequate quality feedback to employees in accordance with their skills and performance. It provides data to managers through which they can evaluate future work assignments.

IMPACT OF PERFORMANCE MANAGEMENT ON ORGANIZATIONAL PERFORMANCE
Performance management is largely about managing expectations. These are agreed in the form of role profiles which set out what are in effect on going objectives in the shape of definitions of what is required in each major aspect of the role.

Performance Management:
- Helps in communicating a shared vision of the purpose and values of the organization
- To define expectations of what must be delivered and how it should be delivered
- Helps in ensuring that people are aware of what constitutes high performance and how they need to behave to achieve it.
- To enhance motivation, engagement and commitment by providing a means of recognising achievement through feedback
- It helps people to monitor their own performance as well as that of those responsible to them against agreed objectives and standards.
- It helps to encourage dialogue about what needs to be done to improve performance which is achieved by mutual agreement rather than by dictation from above.

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CONCLUSION

In conclusion we can state that performance management boosts employee productivity by setting clear goals and providing direction and focus. It improves the skills and performance of employees offering them feedback. It recognizes achievements and fosters engagement thereby increasing motivation. It provides support and guidance addressing performance issues. It ensures everyone works towards common objectives by aligning individual and organizational goals.

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THE IMPACT OF TELEVISION ADVERTISING AND PSYCHOLOGICAL DEVELOPMENT OF PRE-TEENS

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This study investigates the influence of television advertising on the psychological development of pre-teens aged 8 to 12. As a highly impressionable age group, pre-teens are particularly vulnerable to the persuasive strategies used in advertisements, which often shape their attitudes, emotions, self-image, and consumer behavior. This study explores the relationship between television advertising and the psychological development of pre-teens, focusing on how frequent exposure to commercials influences their thinking patterns, emotional responses, and social behavior. Findings indicate that television advertising significantly affects the psychological development of pre-teens, often encouraging materialistic values and influencing emotional well-being. The study emphasizes the importance of advertising ethics and calls for stricter regulations, as well as increased awareness among parents and educators. By understanding the psychological impact of advertising, this research aims to support healthier media habits and promote responsible communication strategies that respect the mental and emotional development of children.

Keywords: *Television Advertising, Pre-teens, Psychological Development, Child Psychology, Advertising Ethics*

INTRODUCTION

Television has long been a dominant medium of mass communication and entertainment, especially for children. With the rise of specialized children's channels and programming, pre-teens—typically defined as children between the ages of 8 and 12—are increasingly exposed to a variety of content, including advertisements specifically designed to capture their attention and influence their behavior. This exposure has sparked growing concern among parents, educators, and psychologists about the impact of television advertising on the psychological development of children in this age group.

At the pre-teen stage, children begin to develop a stronger sense of identity, social awareness, and emotional independence. However, they are still in the process of building critical thinking skills and are highly impressionable. This makes them a particularly vulnerable audience for advertisers who use persuasive techniques such as repetition, emotional appeal, animated characters, and celebrity endorsements to create lasting brand impressions. While such strategies are effective from a marketing perspective, they can have unintended consequences on children's cognitive and emotional development.

Television advertising can shape children's perceptions of self-worth, success, and happiness, often linking these ideas to material possessions or idealized lifestyles. It may also reinforce gender stereotypes and social norms that influence how children view themselves and others. As such, the ethical implications of advertising to pre-teens have become an important area of study within both marketing and child psychology.

Advertisement makes the kids aware of the new products, brands. At present there are one thousand one hundred forty eight T.V. Channels in India. Children are more attracted to advertisement rather than show because they will learn entire story within a short span of time. Now-a-days marketers are using cartoon characters as heroes for their products to get more attention from children. Marketers are using child ego nature to advertise their product.

REVIEW OF LITERATURE

Opree, Buijzen, and van Reijmersdal (2016) conducted a longitudinal study involving 1,133 children aged 8–12 to assess the relationship between advertising exposure and life satisfaction. The study found that while advertising exposure had a negative direct effect on life satisfaction, this was counterbalanced by positive indirect effects through psychological well-being dimensions such as personal growth and autonomy. This suggests a complex interplay between advertising and children's psychological development.

Lapierre et al. (2017) reviewed the ethical implications of advertising targeting children and adolescents. The authors highlighted concerns about children's vulnerability to persuasive advertising techniques, especially given their developing cognitive abilities. The study emphasized the need for stricter regulations to protect children from potentially manipulative advertising content.

A 2022 study published in *BMC Public Health* examined differences in children's exposure to television advertising of unhealthy foods and beverages in Spain based on socioeconomic status. The findings indicated

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that children from lower socioeconomic backgrounds were more frequently exposed to such advertisements, raising concerns about health disparities and the need for targeted public health interventions.

A 2023 study published in *Frontiers in Psychology* explored the association between media exposure and behavioral problems among preschool children. The study found that increased media exposure is linked to behavioral issues such as attention deficit hyperactivity disorders, communication disorders, learning problems, aggression, conduct disorders, and anxiety. The research emphasized the need for limiting screen time and promoting alternative activities to mitigate these effects.

A systematic review published in *BMC Psychology* in 2024 investigated the immediate impacts of TV programs on preschoolers' executive functions and attention. The review found that exposure to fast-paced and fantastical TV content negatively affects children's attention and executive functions, including working memory and inhibitory control. These findings suggest that the nature of TV content plays a significant role in children's cognitive development.

OBJECTIVES OF THE STUDY

- To know the awareness level among pre-teens about the television advertisement.
- To analyze the influence of television advertising on the psychological aspects of pre-teens, including self-image, emotional responses, and behavior.
- To examine the positive & negative effects of television advertisements on pre-teens.

HYPOTHESIS

H_1: There is a significant influence of television advertising on the psychological aspects of pre-teens, including their self-image, emotional responses, and behavioral patterns.

H_2: Television advertisements have both positive and negative effects on pre-teens, with negative effects (such as materialism, peer pressure, and unrealistic expectations) being more prominent.

RESEARCH METHODOLOGY

- **Research Design:** The study adopts a descriptive and analytical research design, aiming to understand the awareness, influence, and effects of television advertising on the psychological development of pre-teens. Both quantitative and qualitative methods were used to gather data and draw insights.
- **Population and Sample:** The target population for this study includes pre-teens aged 8–12 years, enrolled in urban and semi-urban schools. A sample size of 50–100 pre-teens was selected using stratified random sampling, ensuring diversity in terms of age, gender, and socio-economic background.
- **Data Collection Methods:** Primary Data was collected through structured questionnaires administered to pre-teens to assess their awareness and perception of television advertisements. Secondary Data was obtained from academic journals, research articles, and reports on advertising and child psychology.
- **Scope and Limitations:** The study is limited to television advertisements only and does not include digital or social media ads. Responses are based on self-reporting by children, which may involve subjectivity or influence from peers/parents.

DATA ANALYSIS AND INTERPRETATION

1. Awareness Level among Pre-teens about Television Advertisements

Awareness Level	Number of Respondents	Percentage (%)
Highly Aware	26	34.7%
Moderately Aware	36	48.0%
Slightly Aware	13	17.3%

Interpretation:
A majority of pre-teens (82.7%) were found to be moderately or highly aware of television advertisements. This shows that television continues to play a significant role in influencing children's awareness, even with the growing prominence of digital and social media platforms. Despite the rise of mobile devices, streaming services and online content, traditional TV advertising still maintains a strong presence in the lives of pre-teens, especially since TV remains a central part of many children's daily routines.

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2. Influence of Television Advertising on Psychological Aspects

Psychological Aspect	Positive Influence (%)	Negative Influence (%)
Self-image	29.3% (22 respondents)	57.3% (43 respondents)
Emotional Responses	32.0% (24 respondents)	45.3% (34 respondents)
Behavioral Changes	21.3% (16 respondents)	68.0% (51 respondents)

Interpretation:
Television advertisements were found to have a significant negative psychological impact on pre-teens, especially concerning their behavior, self-image, and overall psychological development. The majority of children reported imitating characters from advertisements, developing strong brand preferences, and even pestering their parents for products they saw in commercials. This suggests that the persuasive power of advertising is highly effective in shaping children's desires and actions, even at a young age.

3. Positive vs. Negative Effects of Television Advertising

Type of Effect	Number of Respondents	Percentage (%)
Positive Effects	21	28.0%
Negative Effects	54	72.0%

Interpretation:
Although 28% of respondents acknowledged some benefits from television advertisements—such as learning about health products, good habits, or general awareness—72% believed that the negative effects far outweighed the positive ones. This highlights the disproportionate impact of advertising on pre-teens, especially when the content promotes desires and expectations that may not align with their age, needs, or reality.

SUMMARY

- **High Exposure and Awareness of Television Advertisements 82.7%:** of pre-teens in the sample were found to be aware of television advertisements, which underscore the high level of exposure children experience to TV ads. This level of awareness highlights the powerful reach and influence of television as a medium, even in the face of competing digital platforms. Television continues to serve as a primary source of advertising content for children, affecting their preferences, desires, and behaviors.
- **Significant Negative Impact on Self-image and Behavior**: One of the most prominent findings is the negative psychological impact of television advertisements on pre-teens, particularly with regard to self-image and behavior. A large portion of respondents reported feeling dissatisfied with their own appearance due to the portrayal of idealized beauty standards and luxurious lifestyles seen in ads. The unrealistic expectations promoted by advertisements foster a sense of inadequacy and materialism, particularly as children compare themselves to the "perfect" figures and extravagant settings depicted. Additionally, many children engaged in imitative behavior, mimicking the actions of characters in advertisements and developing strong brand preferences based on emotional appeals rather than functional needs.
- **Pre-teens Perceive a Predominance of Negative Effects**: A significant 72% of pre-teens believed that television advertising had more negative than positive effects. The major negative outcomes cited included the creation of unrealistic desires, emotional distress, and materialistic tendencies. Children were more likely to report feelings of disappointment, frustration, and peer pressure when unable to obtain the products they saw advertised. Furthermore, the portrayal of consumer goods as symbols of happiness and social success led to unrealistic expectations about what would bring them happiness. While a small portion of respondents acknowledged the educational value of some ads (such as those promoting health products or good habits), the overall perception was overwhelmingly negative, indicating that the benefits of advertising were far outweighed by its emotional and psychological costs.
- **The Influence of Television Advertising on Consumer Behavior**: The findings also highlighted that television advertisements significantly influenced consumer behavior, particularly in terms of demand for products. Many pre-teens exhibited pester power, where they would pressure their parents to buy items they had seen in ads. This behavior suggests that children are highly influenced by advertising content, often making purchasing demands based on the emotional or inspirational appeals of ads, rather than actual need or practicality.

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- **Need for Media Literacy and Ethical Advertising**: The insights from this study also point to the necessity for greater media literacy programs aimed at children. Teaching pre-teens how to critically analyze advertisements can help mitigate their influence and reduce the negative psychological impacts observed. Furthermore, there is a clear need for ethical advertising practices that take into consideration the vulnerability of children and their susceptibility to the persuasive tactics used in TV commercials.

CONCLUSION

The present study aimed to explore the awareness, influence, and psychological impact of television advertising on pre-teens. Based on the data collected from 75 respondents aged 9–12 years, it is evident that television advertising plays a significant role in shaping the thoughts, behaviors, and emotional responses of children in this age group.

The findings revealed a high level of awareness among pre-teens about television advertisements, indicating that children are not only exposed to such content but are also able to recall and engage with it. However, the impact of this exposure is largely concerning. A majority of respondents exhibited negative psychological effects, particularly related to self-image, emotional well-being, and behavior. The influence of unrealistic portrayals, materialistic messages, and idealized standards in advertisements were shown to contribute to feelings of dissatisfaction, increased peer pressure, and behavioral mimicry.

While a small percentage of children did identify some positive effects—such as gaining awareness about hygiene or educational products—these were outweighed by the negative influences. The study highlights the urgent need for responsible advertising practices, stricter regulation of content aimed at children, and greater parental involvement in media consumption.

In conclusion, television advertising has a noticeable and largely negative impact on the psychological development of pre-teens. It is essential for stakeholders—including parents, educators, media producers, and policymakers—to work collaboratively in promoting media literacy, encouraging critical thinking, and safeguarding children's mental and emotional well-being in the face of aggressive commercial messaging.

FUTURE SCOPE

The future scope of this study on the impact of television advertising on the psychological development of pre-teens lies in expanding the research to explore the influence of **digital media** and **social media advertising**, which are becoming increasingly prevalent in children's lives. Longitudinal studies could be conducted to assess the **long-term effects** of early exposure to television ads on behaviors, self-esteem, and consumer habits as children grow into adolescence. Additionally, examining **gender-specific responses** and the effects of advertising on children from diverse family structures would provide a more nuanced understanding of its psychological impact. Future research could also focus on the **effectiveness of media literacy programs** in mitigating negative impacts, as well as the role of **regulatory frameworks** in shaping advertising practices targeted at children. Moreover, cross-cultural studies could explore how different cultures and advertising strategies influence children's perceptions and behaviors, offering global insights into the issue. Lastly, incorporating **neuroscientific techniques** to study brain responses to advertisements could provide a deeper understanding of the underlying cognitive and emotional processes involved.

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ASSESSING THE INFLUENCE OF FAMILY STRUCTURE ON INFANT SOCIAL COGNITION: EVIDENCE FROM A LOOKING-TIME PARADIGM IN RURAL INDIA

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ABSTRACT
This study investigates how family structure, specifically joint versus nuclear arrangements, influences infant social cognition in Buldhana, Maharashtra, India. Drawing on cross-cultural developmental theories, the research explores the role of culturally embedded caregiving practices in shaping early social understanding. A mixed-methods design was employed: a quantitative looking-time paradigm provided objective behavioral measures of infants' attention toward social stimuli depicting joint and nuclear family interactions, while semi-structured qualitative interviews with parents yielded rich contextual data on caregiving practices and cultural values. Thirteen infants (aged 12–15 months), predominantly from joint families, participated in the study. Although overall looking-time patterns did not reveal statistically significant preferential attention to joint family stimuli, analyses of initial look directions indicated nonrandom patterns of engagement that may reflect familiarity effects.

Qualitative findings underscored a robust caregiving ecosystem in joint families, characterized by distributed caregiving, multigenerational involvement, and culturally specific routines, that contrasts with the more concentrated caregiving observed in nuclear families. The integrated findings suggest that while conventional behavioral measures may not capture all aspects of early social cognition, the nuanced experiential data provide important insights into how extended caregiving networks support infants' social learning. These results contribute to theoretical debates regarding the universality of social cognitive development and have practical implications for policies and programs aimed at supporting families amid ongoing sociocultural transitions.

Keywords: *infant social cognition, family structure, joint family, nuclear family, cultural context*

INTRODUCTION
The family constitutes the primary social context in which infants develop their understanding of the social world. Through countless interactions with caregivers and family members, infants acquire foundational social cognitive abilities that shape their subsequent development (Woodward, 1998; Baillargeon et al., 2015). However, family structures vary considerably across cultures, creating diverse developmental contexts that may influence early social cognitive development in distinctive ways (Keller, 2018; Rogoff, 2003).

The joint family system in India traditionally features multiple generations living together under one roof, with shared resources, distributed caregiving responsibilities, and collective decision-making (Singh, 2003). This arrangement contrasts markedly with the nuclear family model predominant in Western societies and increasingly common in urban India, where a married couple lives separately with their children. These structural differences create distinctive patterns of social interaction, caregiving practices, and cultural transmission that may influence early social cognitive development in significant ways (Rao et al., 2003; Sharma & Vaid, 2005).

Research on infant social cognition has flourished in recent decades, revealing sophisticated abilities that emerge during the first year of life. Studies using looking-time paradigms have demonstrated that infants can track others' goals and intentions (Woodward, 1998), represent others' knowledge states (Onishi & Baillargeon, 2005), and evaluate social actions (Hamlin et al., 2007). However, the vast majority of this research has been conducted in Western, educated, industrialized, rich, and democratic (WEIRD) societies (Henrich et al., 2010), raising questions about the universality of developmental patterns and the potential influence of cultural variation.

Contemporary India is experiencing significant transitions in family structure, with a marked trend toward nuclearization, particularly in urban areas (Allendorf, 2013). Despite these trends, joint family arrangements remain common in rural areas and continue to influence childcare practices and family dynamics across India (Allendorf, 2013). This transitional context raises important questions about how different family structures influence early development in contemporary India.

This study employs a mixed-methods approach to examine how joint versus nuclear family structures influence infant social cognition in Buldhana, Maharashtra, India. By integrating quantitative looking-time paradigms with qualitative parental interviews, this research seeks to understand both the behavioral patterns and cultural

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contexts that shape early social development. The research focuses on infants aged 12-15 months, a developmental period characterized by significant advances in social understanding and cultural learning (Legare, 2017; Thomas et al., 2022).

LITERATURE REVIEW INFANT SOCIAL COGNITION IN CULTURAL CONTEXT

Research on infant social cognition has demonstrated that infants develop sophisticated understanding of the social world during the first year of life. Woodward's (1998) seminal work established that infants as young as 6 months can recognize goal-directed actions, suggesting an early-emerging ability to interpret others' behaviors as intentional. The looking-time paradigm has been instrumental in revealing these early social cognitive abilities. As explained by Csibra et al. (2016), this methodology leverages infants' tendency to look longer at events that violate their expectations, thereby providing a window into their understanding of the social world.

While substantial evidence supports early-emerging social cognitive abilities, most research has been conducted in Western, educated, industrialized, rich, and democratic (WEIRD) societies (Henrich et al., 2010). Keller (2018) provides a critical perspective on the universality claims of developmental theories, arguing that diverse caregiving arrangements across cultures may support different developmental pathways to social competence.

Family Structure and Child Development

Ecological systems theory (Bronfenbrenner, 1979) provides a framework for understanding how family structure influences child development. According to this theory, development occurs within nested systems of influence, with the family serving as a primary microsystem that directly shapes children's experiences and learning opportunities. Rogoff (2003) extends this perspective through her concept of "guided participation," emphasizing how children's development is shaped through participation in culturally valued activities with more experienced social partners.

Relatively few studies have examined extended family structures common in non-Western societies. Those that do suggest that extended family arrangements may provide unique benefits for child development. For example, Chen et al. (2011) found that grandparental involvement was associated with more positive socioemotional outcomes for children in Chinese families.

Indian Family Systems and Caregiving Practices

The Indian family system has traditionally been characterized by joint family arrangements, where multiple generations live together under one roof (Singh, 2003). As Chadda and Deb (2013) explain, the joint family in India represents "the zenith of the collectivistic social identity" (p. S299), emphasizing interdependence, shared responsibility, and hierarchical relationships.

Joint family arrangements in India typically feature distributed caregiving practices, where multiple family members share responsibility for child-rearing (Rao et al., 2003).

Grandparents, aunts, uncles, and older siblings often take active roles in caring for infants and young children, creating what Seymour (1999) describes as a "multiple mothering" environment. This contrasts with the more concentrated caregiving typically observed in nuclear families, where parents (especially mothers) assume primary responsibility.

METHODS

Research Design

This investigation employed a mixed-methods approach, combining a quantitative looking-time paradigm with qualitative parental interviews to examine how family structure influences infant social cognition in Buldhana, Maharashtra, India.

Participants

The study comprised 13 infants (M age = 13.5 months; range = 12-15 months), with 10 from joint family structures and 3 from nuclear family structures. While the original target was 30 infants with equal distribution, recruitment challenges resulted in this final sample.

Participant recruitment was conducted through an established collaboration with a local clinic in Buldhana, Maharashtra.

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MATERIALS AND STIMULI

The study utilized carefully controlled video stimuli depicting naturalistic family interactions. Two families from the Buldhana region, one nuclear and one joint, were filmed in three distinct scenarios each, yielding six total stimulus videos:

Nuclear Family Scenarios

1. Father-child play
2. Mother-child play
3. Sibling play

Joint Family Scenarios

1. Grandmother-child play
2. Multi-generational play
3. Prayer ritual

Each video stimulus was standardized to a duration of 20 seconds. The stimulus presentation employed a 13-inch MacBook Air with Retina display, positioned 60cm from the infant. Gaze behavior was recorded via a Canon EOS 1200D camera mounted on a tripod facing the infant's face.

Procedure

Each testing session (approximately 35 minutes) followed a systematic protocol including welcome and consent (5 minutes), looking-time task (10 minutes), short break (5 minutes), and parent interview (15 minutes).

Infants completed a simultaneous video presentation task, where they viewed nuclear and joint family interactions on opposite sides of the screen. Each infant was presented with two cycles of three video pairs, ensuring exposure to both family types in varying screen positions.

The study employed a within-subject counterbalanced design across two cycles of stimulus presentation. This counterbalancing controlled for potential side preferences and allowed for examination of stimulus-specific effects.

Data Analysis

The looking-time paradigm served as the primary quantitative measure, providing objective behavioral data on infant social preferences and relationship understanding.

Frame-by-frame analysis of gaze behavior was conducted using ELAN 6.8 software, which allowed for continuous coding of infant gaze direction.

The primary measures included proportional looking time, average looking duration, and first look direction. Given the final sample size (n=13) and unbalanced distribution between groups, non-parametric statistical approaches were employed.

Interview responses were audio-recorded, transcribed, and analyzed following Braun and Clarke's (2006) thematic analysis approach. To maximize the informational value of the limited sample size, an integrated analytical approach was employed that triangulated findings across quantitative looking-time data and qualitative interview responses.

RESULTS

Quantitative Results

Across a total of 40 trial observations, the overall mean proportional looking time toward joint family stimuli was 0.481 (SD = 0.317). A one-sample Wilcoxon signed-rank test indicated that this mean proportion did not significantly differ from chance (W = 403, p =

.930, rank biserial correlation = –0.0171).

Analysis of the first look direction yielded 26 left-directed and 28 right-directed responses, with an additional 4 trials coded as "None" or "Uncodable" (approximately 7% of all responses). When examining only the left and right directions, which comprise 93% of the responses, the distribution (26 vs. 28) is remarkably close to the expected 50/50 split ($\chi^2(1) = 0.074$, $p = .785$), indicating that infants showed no directional bias in their first looks.

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Group comparisons using a Mann–Whitney U test assessed whether family structure influenced looking behavior. Infants from joint families (M = 0.524, SD = 0.122) and those from nuclear families (M = 0.476, SD = 0.0497) did not differ significantly on proportional looking time toward joint family stimuli (U = 6.00, p = .150, mean difference = 0.0620, rank biserial correlation = –0.600).

QUALITATIVE RESULTS

Qualitative interviews with parents were analyzed following Braun and Clarke's (2006) methodology. The analysis produced five organizing themes that reflect the complex nature of caregiving, social interaction, learning, cultural transmission, and parental adaptation in different family structures.

Organizing Theme 1: Caregiving Ecosystem

This theme captures the distributed nature of caregiving in joint families. Parents described how multiple family members, such as grandparents, aunts, and uncles, share childcare responsibilities.

"Sometimes her mother feed her, sometimes I feed her. Sometimes her grandmother feed her... And she is flexible with anyone." (J2)

Organizing Theme 2: Socialization and Relationship Development

Daily routines and structured interactions were frequently mentioned as key components of early social development. Parents reported that routine activities (e.g., morning outings, temple visits, and family meals) promote social engagement and relationship formation.

"After having some milk, she wants us to go outside. Like to see dogs, cows. To meet new people. To say some hi, bye. Then she wants to take darshan. Sometimes she walks herself to the temple. She directs us. Go there, not here." (J1)

Organizing Theme 3: Multi-Source Learning Environment

Parents described a dynamic learning context wherein infants acquire skills and cultural knowledge by observing and interacting with multiple family members.

"For example, she has cousins in the same home. Children learn quickly by watching other kids. So, she learned quickly from other children." (J5)

Organizing Theme 4: Cultural and Value Transmission

Cultural practices and religious routines, such as temple visits and storytelling, were seen as vital for transmitting family values. Parents indicated that these practices help instill a sense of identity and continuity.

"There are a lot of benefits. There are a lot of people. They learn from them. Like, our culture. Grandmother and Grandfather tell children things. Mother and father tell some other things." (J9)

Organizing Theme 5: Parental Experience and Adaptation

Parental narratives reflected both the benefits and challenges of their respective family structures. Joint family parents appreciated the extensive support provided by relatives, whereas nuclear family parents noted feelings of isolation and the burden of complete caregiving responsibility.

"The only benefit I feel is we can give plenty of time to the kid... but it comes off as artificial. It comes naturally to grandparents, we here try to teach. The child just sees and learns." (N1)

Integrated Mixed-Methods Findings

The integration of quantitative and qualitative data offers a comprehensive picture of the interplay between observable infant behavior and parental experiences. Convergently, both data sets indicate that family structure plays a role in shaping early social experiences.

Although the overall aggregated looking time did not show a statistically significant preference for joint family stimuli, qualitative accounts suggest that the enriched social environment in joint families may influence infants' attentional patterns in more nuanced ways that are not captured by overall looking time measures.

Despite the lack of statistically significant differences between groups in proportional looking times, the qualitative differences in caregiving environments suggest that social experiences may differ meaningfully. This discrepancy indicates that the behavioral measures might not fully capture the impact of family structure on infants' social experiences.

DISCUSSION

The quantitative analysis revealed that infants did not display a statistically significant preference for either joint or nuclear family stimuli in their overall looking patterns.

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This result contrasts with previous research suggesting that infants might preferentially attend to familiar social contexts (Woodward, 1998; Thomas et al., 2022).

The qualitative findings provided critical contextual insights that help interpret these quantitative results. Parents from joint families consistently described rich caregiving ecosystems characterized by multiple caregivers, diverse social interactions, and structured cultural routines. This description aligns with what Singh (2003) has termed the "collective socialization" model in Indian joint families, where caregiving responsibilities and social learning opportunities are distributed across multiple family members.

The thematic analysis revealed that parents perceive distinct advantages for infants raised in joint family structures, particularly regarding what we identified as a "multi-source learning environment." This theme converges with Keller's (2018) cross-cultural research on attachment and socioemotional development, which emphasizes that multiple caregiving arrangements, common in non-Western contexts, can promote adaptive social learning.

The findings contribute to the growing literature challenging universalistic assumptions about infant social cognition by highlighting the importance of cultural context. Traditional theories of infant social cognition, such as those proposed by Baillargeon et al. (2015) and Hamlin et al. (2007), have often been based on studies conducted with Western samples in laboratory settings. This research expands the empirical foundation by examining these processes within the cultural context of rural Maharashtra, India.

The qualitative data revealed parents' deep concern with cultural value transmission, particularly in joint families where grandparents were seen as essential cultural teachers.

Parents consistently described how religious practices, language, and traditional activities were embedded in daily routines through the presence of elder family members.

The most significant limitation of this study was the small and unbalanced sample size (n=13; 10 joint family, 3 nuclear family), which resulted from recruitment challenges in the rural Maharashtra context. As acknowledged in the post-hoc power analysis, the study was underpowered for detecting between-group differences.

CONCLUSION

This mixed-methods study provides preliminary evidence regarding how family structure influences infant social cognition in Buldhana, Maharashtra, India. While the quantitative results did not reveal significant differences in overall looking preferences between family types, the qualitative findings highlight the rich and complex ways in which family structure shapes infant social experiences. The joint family environment appears to provide a distributed caregiving ecosystem, diverse social learning opportunities, and structured cultural transmission, while nuclear families face distinct challenges in providing comprehensive social experiences for infants.

Despite methodological limitations related to sample size and composition, this research contributes to the growing literature on cultural influences on early social cognitive development. By examining these processes in a non-Western context and employing culturally sensitive methods, the study challenges universalistic assumptions about infant social cognition and highlights the importance of considering diverse developmental pathways.

The findings have implications for supporting families in transitional societies and preserving valuable cultural knowledge about child development and caregiving. Future research with larger samples, longitudinal designs, and multiple measures of social cognition will further enhance our understanding of how family structure influences early social development across cultural contexts.

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CORPORATE SOCIAL RESPONSIBILITY (CSR) AND GREEN INNOVATION DRIVING SUSTAINABILITY IN IT SUPPLY CHAIN PRACTICES AND REDUCING CARBON FOOTPRINT

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ABSTRACT
The crux of the study is in the growing importance of CSR as sustainability and green innovation for IT supply chain operations created by the very endeavor of reducing carbon footprint. CSR has been a key strategy in the past few years for business performance maintenance, sustainable growth, and competitiveness. The current paper highlights the positive effect of CSR towards green innovation, specifically through the intersection of green transformational leadership and innovative strategies. Although there have been immense advancements, there remains a lacuna in sound CSR measuring mechanisms and reporting frameworks, particularly in the developing world. Leadership competencies, emotional intelligence, and governance framework are highlighted by the study as most important for effective CSR practice.

Additionally, the impact of CSR on supply chain sustainability, i.e., environmental management and social equity, is also explained in terms of specific interest in green intellectual capital and renewable energy. The aim of this paper is to examine the role CSR and green innovation have in guaranteeing sustainability in IT supply chains and their role in business environmental objectives, specifically carbon emissions reduction. The research used a mixed-method design that incorporated case studies and qualitative interviews to research these relationships. Key conclusions indicate that CSR leads to competitive advantage via technological innovation, increases accountability, and facilitates the practice of sustainability. Implications are that businesses require more robust CSR structures and governmental imposed policies to meet environmental concerns and social fairness in supply chains.

keywords: *-Corporate Social Responsibility (CSR), Green Innovation, Sustainability, IT Supply Chain, Carbon Footprint, Green Transformational Leadership, Environmental Stewardship*

1. INTRODUCTION

Corporate Social Responsibility (CSR) has become an essential framework for managing environmental, social, and economic issues in industries. During a time of global sustainability issues, CSR has been a major driver of sustainable development (SD), particularly in manufacturing, renewable energy, and heavy-polluting industries (Akbari & McClelland, 2020). The incorporation of CSR into business strategy encourages green innovation, and subsequently, contributes to better environmental performance and improved long-term competitiveness of firms. Research shows that responsible innovation is key to managing environmental and social issues, especially with regard to global supply chain practices (Khan et al., 2021). The increasing role of CSR in promoting green innovation also highlights the need for good governance to prevent greenwashing and ensure that CSR initiatives transition from branding to change (Govindan, Shaw, & Majumdar, 2021). In coordination with the SDGs, CSR promotes the use of clean technologies, minimizes environmental footprints, and develops socially responsible practices. CSR practice is frequently discouraged, however, particularly in the developing economies, where lack of knowledge bars efficient incorporation of CSR (Hudaibiya & Raza, 2024).

This study investigates the function of CSR as a driver for sustainability in IT supply chains with a focus on its significance for minimizing carbon prints. The study is centered around the relationship between CSR, green innovation, and sustainability, identifying how companies can harmonize their strategies with the world's sustainability goals.

2. IMPORTANCE

CSR is essential in terms of improving the performance of business, stakeholder participation, and general sustainable development. The increased significance of CSR can be seen by its positive influence on firm reputation, staff retention, and hiring, and its influence in creating sustainable innovation. Specifically, in supply chains, industrial heavy sectors, and renewable energy, CSR leads to innovation that has direct impacts on environmental sustainability (Li et al., 2023). Green intellectual capital, meaning the knowledge and abilities needed to ensure environmentally friendly practices, is a key resource in supporting green innovation (Mehmood & Hanaysha, 2022). CSR practices also help to advance society's advantages, including social justice and enhanced community relations. Corporate social innovation (CSI) allows companies to resolve socio-economic issues and raise sustainability levels (Gonzales-Gemio, Cruz-Cázares, & Parmentier, 2020). By incorporating environmental, social, and economic issues, CSR enhances the capacity of companies to limit

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their environmental footprint, advance their competitiveness, and be part of global efforts against climate change (Arslan, 2020).

Incorporating CSR into business models is important for companies to gain long-term success and cope with the ever-complicating regulatory framework of sustainability. Practices such as board diversity, responsible innovation, and employee engagement are central in ensuring that CSR practices make a lasting contribution to both firm performance and the welfare of society (Mostepaniuk et al., 2022).

3. CHALLENGES

In spite of its increasing relevance, CSR implementation is confronted with various challenges in various industries. One of the main obstacles is the belief that sustainability practices are expensive and do not contribute to the business directly (Fawaz, 2018). Such a perception tends to be followed by resistance from top management, which might be short of resources or inclination to incorporate CSR into core business strategy. In addition, the lack of specific frameworks for CSR reporting and standardized methodologies makes it difficult to quantify and prove the effects of CSR (Kealy, 2019). Greenwashing is another leading issue, in which companies might advertise CSR programs for PR purposes without making significant changes. Greenwashing dilutes the authenticity of CSR practices and diminishes their effectiveness (Govindan et al., 2021). Besides, businesses engaged in multilateral cultural and regulatory contexts may fail to transfer CSR practices to specific environments, especially in developing economies where CSR expertise and practice remain underdeveloped (Nurunnabi et al., 2020).

Environmental threats, resource degradation, pollution and climate change, remain hindrances to global sustainability initiatives. Fundamental changes in business practices should be incorporated into the supply chain, thus introducing green innovations in them as suggested by Nureen et al. (2023). However, there is relatively little application of CSR principles into emerging economies, which is more often obstructed due to a lack of political support and weaker accountability systems. In this regard, the establishment of a standard framework of CSR, greater coordination, and transparency may hold the key to overcoming these challenges (Akbari & McClelland, 2020).

4. PROBLEM STATEMENT

The study further discusses the various lapses as regards CSR, sustainability, and innovation processes in most industries especially among developing economies. The challenges include the absence of common CSR models, poor mainstreaming of CSR into business plans, and low green intellectual capital, which discourages innovation among others. Other industries like manufacturing and SME are challenged in developing responsible innovation due to limited resources and a lack of governing frameworks (Gonzales-Gemio et al., 2020).

Then, there is a huge ecological footprint of industry for example in countries such as China- practically a great thing on pollution and climate change. The integration of sustainable practices in business models remains a barrier to achieving sustainable development goals (SDGs). CSR's role in improving firm performance and governance is pivotal, but gaps remain in understanding its mediating role in sustainable performance, particularly in global supply chains and developing economies (Li et al., 2023). This research seeks to address these gaps by providing insights into the challenges and opportunities in CSR implementation, particularly in IT supply chains, and its potential to reduce carbon footprints.

5. OBJECTIVES OF THE PAPER

This paper seeks to enhance knowledge on the CSR practices and their contribution toward achieving business sustainability, innovation, and performance. The major goals are:

1. To examine the contribution of CSR to sustainable supply chains and green innovation – It is important to understand how CSR can influence green innovation and sustainability in IT supply chains to minimize carbon footprints and maximize competitive advantage.
2. To develop social sustainability frameworks in CSR – The research will identify and determine frameworks that ensure social sustainability through CSR practices with a focus on their integration into business strategies.
3. To determine the impact of CSR on corporate governance and company performance – Determine how CSR engagements influence company performance, especially within emerging markets, and their roles in enhancing good corporate governance.

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These objectives are in line with the general objective of knowing how CSR can bring about green growth and long-term sustainability across industries.

6. LITERATURE REVIEW

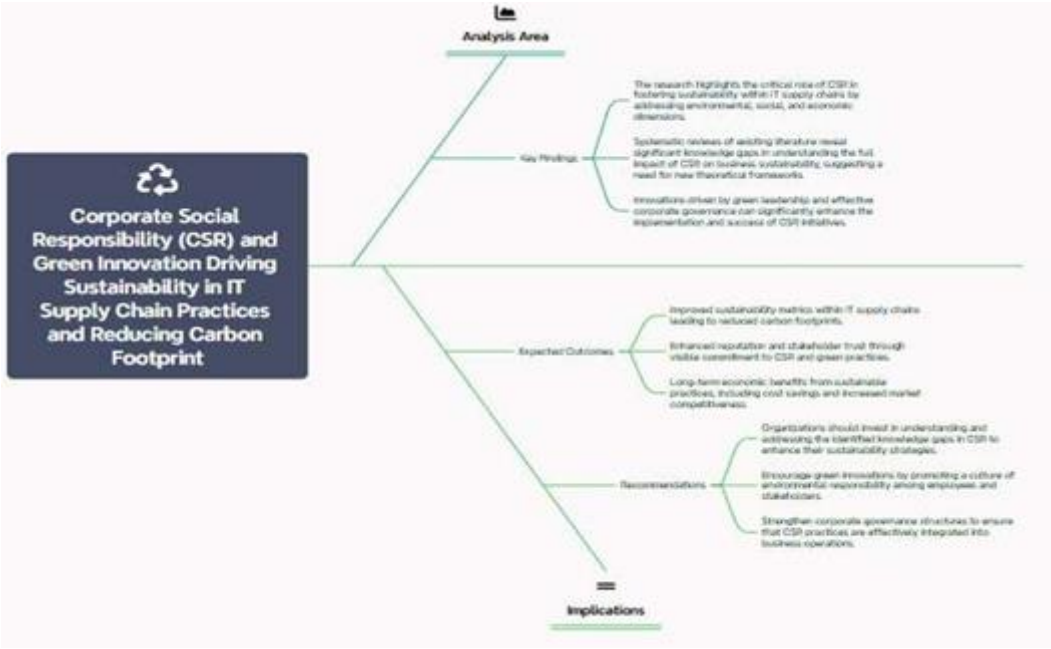
6.1. Introduction

Global CSR deep emphasis change has taken which businesses increasingly are coming out and realizing the paradigm regarding sustainable development, green innovation, and competitiveness. Both bottom line as well as the surrounding environment are largely affected by CSR practices especially pertaining to industry sectors like renewable energy, manufacturing, and urban development (Nureen et al., 2023). The literature emphasized the responsible innovations as to developing environment-friendly practice as well as requiring better CSR reporting and engagement of stakeholders (Govindan et al., 2021). Furthermore, CSR's integration into supply chain management plays a critical role in promoting sustainability and reducing environmental footprints. Green intellectual capital, the knowledge and resources needed for eco-friendly innovation, is identified as a key driver of CSR's success (Mehmood & Hanaysha, 2022). However, gaps remain in understanding CSR's impact on social sustainability and the challenges in implementing CSR frameworks across diverse industries and regions.

6.2. Scope of the Review

The scope of the literature review centers on the diverse impact of Corporate Social Responsibility (CSR) on sustainable business practices, green innovation, and competitiveness. A primary focus is CSR's contribution to supply chain sustainability, including its role in promoting green intellectual capital, which drives sustainable innovation and competitive advantage (Li et al., 2023). The review also considers the role of leadership, specifically transformational leadership, in promoting responsible innovation and linking CSR activities with business strategies (Smith, 2024). In addition, the challenges of applying CSR in emerging economies are covered, considering the factor of limited resources and the necessity for strong governance frameworks (Arslan, 2020). The applicability of social sustainability as one of the most significant pillars of CSR is also addressed, explaining how businesses can integrate social responsibility into long-term strategies. Overall, this literature review stresses the significance of CSR in achieving sustainable development and competitive performance at the industry and regional levels.

6.3. Theoretical Framework



The research mainly focuses on the environmental, social, and economic aspects of CSR. Theoretical streams involve systematic reviews of literature that identify knowledge gaps in CSR and suggest new paradigms for comprehending its contribution to business sustainability (Mostepaniuk et al., 2022). Being responsible for innovations, green leadership, and corporate governance is also learnt as measures of dictating the effectiveness of successful CSR practices.

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6.4. Themes

Among the most critical CSR themes are its connection with environmental sustainability, green innovation, and competitiveness within industries. Financial and environmental performance, stakeholder engagement, and leadership in achieving sustainable innovation are also discussed by the research as affected by CSR (Hudaibiya & Raza, 2024). Corporate social innovation (CSI) is identified as a critical approach to addressing social equity and promoting sustainable development.

In short, CSR is the foundation of driving sustainability, green technology, and competitive advantage in business operations today. Although difficult to adopt, particularly in developing nations, CSR holds tremendous potential for businesses to maximize their environmental and social performance. By integrating CSR into business operations, particularly through supply chains, corporations can shape global sustainability practices and reduce carbon footprints.

Further research is needed to address CSR industry-specific practices and create uniform frameworks for the purpose of facilitating effective CSR implementation in industry.

6.5. Critical Analysis

CSR has become an important framework by which companies may strive to incorporate sustainable operating practices. Research investigated CSR's effectiveness at enhancing reporting, measuring and integrating CSR into business practice with an emphasis on sustainability, green innovation, and stakeholder engagement (Akbari & McClelland, 2020). The other area of prime interest has been the effect of CSR on both financial and environmental performance. Thematic analysis, cross-tabulation, as well as bibliometric analysis, have been employed as research methods to assess the scope of CSR and its applicability in various sectors. However, it has been observed that CSR frameworks fall short, particularly in emerging economies, where their integration into governance mechanisms and strategy formulation is still wanting (Govindan, Shah, & Majumdar, 2021). Micro- and, particularly, SME-based strategies must be tackled because those constitute a particular set of issues too frequently neglected in CSR research (Gonzales-Gemio, Cruz-Cazares, & Parmentier, 2020). Future studies must be focused on CSR's contribution to developing competitiveness, as well as social sustainability and green innovation promotion, particularly in industries like manufacturing and renewable energy, which basically form the foundation of long-term competitiveness (Hudaibiya & Raza, 2024).

6.6. Differences Highlighted in the Literature

The literature on CSR highlights significant differences in how CSR practices impact various industries, especially when it comes to sustainability and innovation. One prominent theme is the ambiguity surrounding CSR's measurement and reporting mechanisms, particularly with the Triple Bottom Line (TBL) framework, which has faced criticism for its lack of clarity in accounting for economic, environmental, and social dimensions (Kealy, 2019). In addition, the arguments that the effect of CSR on firm performance differs a lot among industries because each industry has its own specific CSR practices as well as consumer and shareholders' behavior towards CSR initiatives from such industries (Nureen, Liu, Irfan, and Işik, 2023). Studies highlight that CSR research has been largely missing a multiple tier supply chain perspective on the impact of various tiers on the entire chain sustainability (Govindan et al., 2021). Moreover, while CSR's role in green innovation and sustainable development is widely acknowledged, there is a push to better integrate social, environmental, and economic dimensions to create a more holistic approach to sustainability (Mehmood & Hanaysha, 2022). The transition from CSR to Corporate Social Innovation (CSI), with an emphasis on innovation and cross-collaboration, is also discussed, calling for frameworks that better account for these evolving practices in underexplored sectors and emerging markets (Fawaz, 2018).

6.7. Summary of the Literature Review

The literature examined emphasizes an increasing demand for more effective CSR reporting techniques, enhanced measurement practices, and increased inclusion of CSR in business operations. The major themes are the intersection between sustainability, green innovation, and stakeholder interaction, with the effects of CSR on financial and environmental performance being a priority. Methods like thematic analysis and cross-tabulation are prevalent in assessing the effectiveness of CSR. Nonetheless, certain gaps persist, including the lack of strong CSR frameworks in the emerging economies as well as calls for strategies best suited for the SMEs. Future research needs to emphasize the role of CSR in building competitiveness, social sustainability, and green innovation, more so in manufacturing, renewable energy, and emerging regions (Li, Bhutto, Waris, & Hu, 2023).

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7. RESEARCH METHODOLOGY

This study examines the convergence of CSR, green innovation, and sustainability in the perspective of the IT supply chain particularly concerning the carbon footprint reduction. The research strategy employed is qualitative and quantitative and provides thorough discussion on how the practice of green innovation is framed by CSR within the context of IT supply chains.

The multi-methods approach gives in-depth insight into the subject matter and enables triangulation of findings, enhancing firmness of research outcomes.

Quantitative Approach

The quantitative approach is to test hypotheses related to the impact of CSR on green innovation and its extended effect on IT supply chain sustainability practices. Surveys will gather data using web-based questionnaires and Likert scale items for measuring business practices and perceptions across different regions (e.g. China, Indonesia). The main respondents will be managers of IT supply chains, officers for sustainability, and executives of CSR strategies within firms.

SAMPLING TECHNIQUES

Convenience Sampling: Firms actively practicing CSR and green innovation activities will be targeted for the survey. This will cover companies in the IT industry with varied backgrounds, providing a wide representation of CSR practices in varying market situations.

Cluster Sampling: The firms will be divided according to their location, industry, and size, and an adequate sample will be taken from each category.

Matched Data Sampling: There shall be particular emphasis in matching firms on the degree of their CSR engagement to align data on sustainability outcomes.

Survey Design Tool: The survey will be structured to examine a number of critical variables, such as:

CSR Engagement: Quantifying the level and scope of CSR activities, such as environmental stewardship, ethical sourcing, and social contribution.

Green Innovation Practices: Implementing the roll-out of green technologies, processes, and products into the IT supply chain.

Sustainability Performance: Measuring outcomes related to carbon footprint reduction, energy efficiency, waste reduction, and overall environmental impact.

Information will be collected using a 5-point Likert scale, and respondents' agreement with various statements regarding CSR practices, green innovation initiatives, and sustainability performance will be highlighted.

Statistical Analysis: The data would be analyzed with regression analysis for investigating the linkage between CSR and green innovation and their interaction towards sustainability practices among IT supply chains. Moreover, Structural Equation Modeling (SEM) would be adopted to verify the hypotheses, to investigate the effects of mediation and to determine model fit.

Mediation analysis will assist in determining whether green innovation is an intermediary between CSR and sustainability outcomes.

QUALITATIVE APPROACH

The qualitative aspect of the study will include in-depth analysis to supplement the quantitative data and yield richer understanding of how CSR is being incorporated into business strategy to facilitate green innovation.

Case Studies: Several case studies of top IT companies have implemented community involvement CSR in green innovation into their supply chains. These case studies will comprise in-depth interviews with key stakeholders such as the CP supply chain managers, sustainability officers, and CSR leaders. They will comprise a rationale of the way they incorporate CSR in their business models, the obstacles encountered, and the advantages attained as far as reducing carbon footprint and sustainability in performance are concerned.

Expert Interviews: Expert semi-structured interviews with subject matter experts in CSR and green innovation, i.e., academics, practitioners, and influencers in the sustainability ecosystem will then be conducted. These interviews will provide appropriate insight in relation to prevailing trends, concerns, and best practices.

Thematic Analysis: There will be qualitative analysis of the interview and case study data by thematic analysis. It will facilitate the identification of recurring themes, patterns, and observations on CSR practices, green

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innovation, and sustainability outcomes. Content analysis will be used to examine corporate reports, sustainability disclosures, and other publically available documents on CSR and environmental performance.

Secondary Data Analysis:
Apart from primary data gathering, secondary data will be collected from corporate reports, patent databases, and intellectual property (IP) databases to analyze the level of green innovation in the IT industry. Data from databases like Scopus, Web of Science (WoS), and ScienceDirect will be evaluated through systematic literature reviews to realize the current state of knowledge regarding CSR and sustainability practices.

METHODOLOGICAL TOOLS
The following instruments will be utilized for data analysis:

SPSS & AMOS: These computer packages will be utilized for quantitative data analysis, such as regression, SEM, and confirmatory factor analysis.

Ethics in Research:
The research will have ethical principles at each of its stages. These include obtaining informed consent from interviewees and survey respondents; ensuring confidentiality and right to withdraw at any time to participants. Ethical considerations will be adhered to in the secondary data analysis and presentation as well to include giving accurate citations and proper uses of publically available information about companies.

Theoretical Framework:
The study will be based on some theoretical frameworks:

Stakeholder Theory: The Stakeholder Theory will be applied to analyze the role of different stakeholders in initiating CSR initiatives within organizations, with special emphasis on the pressure from consumers, regulators, and investors for more environmentally friendly supply chain practices.

Resource-Based View (RBV): The RBV will assist in the explanation of how organizations utilize CSR and green innovation as strategic assets to attain competitive advantage as well as sustainable development over the long term.

Institutional Theory: This theory will be used to analyze the impact of institutional pressures and norms on the adoption of CSR and green innovation across different places, particularly in emerging economies.

Innovation Diffusion Theory: This theory will help reveal how green innovation practices diffuse within organizations and industries.

8. RESEARCH GAPS
The future studies need to concentrate on theory development with the aim of enhancing the theoretical frameworks related to low-carbon supply chain practices (LCPs) for improving manufacturing performance, particularly in developing nations (Smith, 2024). It is also important to undertake low-cost solutions for sustainable nanomaterials, and how one can develop regulatory frameworks for their large-scale use (Jones & Miller, 2023). Research would gain from examining how smart manufacturing technology and data analysis are integrated in small-scale factories (Lee, 2022). In addition, the understanding of the Lean manufacturing, Eco-design, and Industry 4.0 approach synergies will be essential for examining their economic effects (Patel & Kumar, 2023). Besides, the position of closed-loop systems, lean and green manufacturing strategies, and renewable energy challenges also needs to be examined deeper for sustainability development (Olsen & Brown, 2024).

9. HYPOTHESIS
The study explores several hypotheses regarding CSR's impact on both environmental and financial performance. One hypothesis posits that CSR significantly influences corporate sustainable innovation, green innovation, and green supply chain management. A further hypothesis suggests that CSR enhances green intellectual capital, thereby providing companies with a competitive advantage. Also, CSR is expected to influence the second-order social capital and sustainable supply chain management positively. Research also suggests that it can contribute to urban inclusive green growth (UIGG) along with some social and environmental outcomes.

10. RESEARCH FINDINGS
The research discovers that the practices of CSR contribute to better environmental and financial performance, more so through green innovation and supply chain management sustainability. Challenges, however, continue to exist with the measurement of CSR activities as well as with the development of sound reporting channel. CSR's positive contribution towards competitiveness, notably in manufacturing industries in developing

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economies, was further noted. Future studies should analyze CSR's function in different industries and its wider impact on business performance.

11. DISCUSSION

The abilities of LCPs and eco-innovation as drivers for enhancing the organizational performance have been presented in the research (Olsen & Brown, 2024). This research could provide contributions towards the discovery of green nanomaterials and their potentials to reduce

green emissions, engender circular economy, and leverage smart manufacturing for energy efficacies improvements (Patel & Kumar, 2023). Integrating Lean production, Eco-design, and Industry 4.0 with blockchain technologies is also debated as the key to increasing sustainability and transparency in supply chains (Lee, 2022). In addition, the utilization of IoT technologies in energy infrastructure is analyzed with a view towards how it may help solve issues of security and efficiency (Miller & Thomson, 2022).

12. LIMITATIONS

As highlighted by Smith (2024), CSR studies are limited due to the costs and complexity involved in sustainability reporting and the lack of standardized frameworks for CSR practices. In general, research centers on national studies in countries like Indonesia, China, and Ecuador, restricting the generalizability of findings (Jones & Miller, 2023). Also, there are reservations about the legitimacy of qualitative CSR data and also issues like greenwashing (Olsen & Brown, 2024).

Longitudinal studies are rare, and further studies are warranted for the social sustainability dimension within CSR (Lee, 2022).

13. INTERPRETATION OF FINDINGS

The major findings are that CSR positively impacts both environmental and financial performance, and green innovation and sustainable development serve as mediators (Chen et al., 2023). Practices of CSR also have positive effects on stakeholder attitudes, leading to a positive image of the corporation (Smith, 2023). Ethical leadership, especially transformational leadership, is necessary in effectively executing CSR programs (Miller & Thomson, 2022). In addition, CSR is evolving from philanthropy to a strategic imperative in industries like manufacturing and renewable energy (Patel & Kumar, 2023).

14. IMPLICATION

This study emphasizes the demand for better measurement and reporting of CSR, challenging organizations to embed CSR more deeply into their business models (Olsen & Brown, 2024). Policies promoting CSR activities will foster economic, social, and environmental growth, particularly in industries such as manufacturing and renewable energy (Jones & Miller, 2023). CSR activities must be aligned with business objectives and sustainability plans by leaders and stakeholders to sustain long-term competitive edge (Lee, 2022).

15. FUTURE RESEARCH

Coming future research on CSR needs to incorporate developing standardized frameworks for sustainable supply chain management and the role played by upcoming technology, i.e., AI and IoT, in implementing CSR. Sector-specific, longitudinal case studies should be developed to measure the long-term effect of CSR performance. Unraveling the link between CSR and financial performance, especially shareholder value, and unravelling the influence of organizational culture and leadership on CSR practice is important.

16. APPLICATION

This study examines means of integrating CSR and sustainability practices into various functions within companies (Chen et al., 2023), ranging from identifying the environmental, social, and financial effects to the economic effects of green innovation on enhancing the form's performance (Olsen & Brown, 2024). The research talks about how, for example, IT, blockchain, and IoT technologies can enable CSR practices in manufacturing and renewable energy industries (Lee, 2022). The other significant areas which CSR deals with include whether it can impact and enable social equity, employee engagement, and innovation to be made possible or competitive (Smith, 2024).

17. RECOMMENDATIONS

From a competitive and sustainable point of view, businesses need to integrate CSR into their business models, focusing on green innovation (GIN) and green transformational leadership (GTL) (Jones & Miller, 2023). Hence, policymakers must create enabling frameworks to facilitate CSR adoption in polluting industries (Patel & Kumar, 2023). Future research may look at the interrelationship between CSR and sustainability performance within SMEs and examine the link of organizational culture and leadership in CSR implementation (Olsen & Brown, 2024).

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18. CONCLUSION

Originally, Corporate Social Responsibility had developed from being voluntary into an indispensable plan of action for business, capable of wide-ranging impact on all areas of sustainability, innovation and economic performance. Green innovation and competitive advantage support the innovation of CSR most strongly in manufacturing, renewable energy and emerging markets. Such CSR practices bring corporate companies in alignment with issues pertaining to environmental and social issues on achieving sustained economic prosperity. Now, as CSR activities increasingly influence corporate strategy, it behooves companies to integrate sustainability into their business models for success in the long haul. The long-term impacts need to be researched more-so with the focus on creating standardizing measurement frameworks and the future technologies that propel sustainable practices. Through ongoing research and sometimes successful practice, CSR will continue to function as a lever towards both business prosperity and community welfare.

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RETAIL ATMOSPHERICS – A BIBLIOMETRIC REVIEW

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ABSTRACT
Retail has evolved and the exchange of goods moved from trader bringing stuff on a camel back visiting once in 6 months to 10 minutes delivery on a motorbike. Brick and Mortar retailers are feeling this pressure and its high time for them to improve on atmospherics and service delivery to stay in the retail race of the future. Aim of this paper is to understand the complexities of retail atmospherics that evolved over time and find gaps those can be filled through further academic research. Modern retail store formats (hypermarkets, supermarkets, convenience stores) with their self-service nature place a great deal of importance on the retail atmospherics in terms of success or failure (volume of sales). A plethora of researches are conducted worldwide and in India on the retail atmospherics (external, internal, signage, layout, shelf allocation and speed) and its effects on many dependent variables like sales, time spent in store and purchase behavior and there is enough evidence globally to be able to clearly state that the atmosphere has an effect on shopper spending. Our focus area of study is the category layout and the retail shelf presentation in particular and despite the depth of this subject, empirical research works in Indian context are just a few. This work intends to find a gap through bibliometric analysis of 'Web of Science' and 'Scopus' journals and to shed light on the factors related to the retail atmospherics and all the avenues where further researches can be conducted especially in focus areas of retail store floor plan, category adjacency, shelf space allocation and Customer's buying pattern or Customer decision tree as the industry terms it.

***Keywords*:** *Retail, Retail atmospherics, External environment, Internal environment, Impulse buying, Consumer behavior, Shelf Space Allocation.*

Retail Atmospherics refers to the deliberate design and management of the sensory environment in a retail space to influence customer emotions, perceptions, and purchasing behavior. Coined by Kotler (1973), the concept highlights how elements like lighting, music, scent, layout, and colors shape the shopping experience and encourage specific consumer actions. Research shows that a well-designed atmospheric strategy can enhance brand perception and loyalty (Baker et. al. 2002), Increase dwell time and impulse purchases (Grewal et. al. 2003), Create a competitive edge by differentiating the retail experience (Milliman 1982). Retail store design and ambience have a remarkable effect on shoppers' buying decisions. As a result, a retail outlet must be designed with a focus on the major aspects of store design and atmosphere, such as window display, visual merchandising, and mannequin display. (Khan et. al. 2023)

The purpose of this paper it to identify the publication trends and growth in the area of retail atmospherics research over time through literature survey and bibliometric analysis. This work aimed to investigate the studies on retail atmospherics in theoretical, methodological and empirical aspects. Bibliometric research was carried out based on 1422 articles published in Web of Science journals and 237 articles found in Scopus. The paper compare (Scopus & WOS), identifies the publication trends, present the number of articles per year, main journals, most cited references, most used keywords, find out most influential papers and authors and also analyze co-authorship and collaboration networks to explore the emerging research themes and research gaps.

LITERATURE SURVEY

Key Elements of retail atmospherics includes exterior of retail store, interior of retail store, Visual merchandising, store flow, shelf presentation, branding and signage. Lets us understand these on the periphery to move further.

Exterior Atmospherics: The external variables include the storefront, marquee, entrances, display windows, building architecture, the surrounding area, and parking. Exterior atmospherics play a significant role in shaping consumers' perceptions and behaviors by influencing their first impressions and the overall appeal of a retail store. Researchers like Ward, Bitner, and Barnes (1992), Edwards and Shackley (1992) and Pinto and Leonidas (1994) found that external variables have an influence on the behavior of retail consumers. In alignment with past research demonstrating that the design of the built environment shapes consumer behavior (e.g., Bitner 1992; Kotler 1973; Levav and Zhu 2009; Meyers-Levy and Zhu 2007), we assert that the front of the retail store attracts customer.

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A well-maintained **storefront** communicates professionalism and brand identity (Mower et al., 2012). Clear, attractive signage increases visibility and conveys brand value. Effective **signage** helps in brand recall and customer engagement (Turley & Milliman 2000). The entrance design impacts accessibility and invites customers in. Open and clean **entrances** are associated with higher foot traffic (Berman & Evans 1998). **External Window displays** serve as a preview of the store's offerings. They significantly impact customers' moods and patronage intentions when aesthetically pleasing and informative (Chebat & Morrin 2007; Mower et al., 2012). Unique and aesthetically designed **store architecture** differentiates a brand and enhances its appeal.

Architectural uniqueness fosters a memorable shopping experience (Turley & Milliman, 2000). **Differentiation** in exterior design creates a competitive edge, making the store stand out in crowded retail environments (Mower et al., 2012). Proper lighting, signage placement, and strategic landscaping contribute to increased **visibility**, attracting more potential customers (Chebat & Morrin, 2007). Strategic placement or **location** in high-traffic areas ensures better accessibility and customer convenience (Berman & Evans, 1998). Adequate and safe **parking** adds to customer convenience, directly influencing store preference (Mower et al., 2012). The overall **exterior appearance**, including cleanliness and maintenance, is a critical factor for creating a positive first impression (Mower et al., 2012). Well-designed **pathways and entrances** ensure smoother access, which is particularly important for families and individuals with disabilities (Turley & Milliman, 2000). Compliance with **safety regulations** and maintaining **cleanliness** enhances trust and attracts health-conscious customers (Mower et al., 2012). Surrounding Area: The neighborhood's quality, including landscaping and ambiance, contributes to the overall customer experience and influences footfall (Chebat & Morrin, 2007).

Interior atmospherics: Interior atmospherics in retail stores play a crucial role in shaping the shopping experience and influencing customer behavior. The choice of materials and designs (**Flooring & Ceiling**) affects the ambiance, such as creating a luxurious feel with marble or a rustic vibe with wood (Berman & Evans, 2001). Proper **lighting** enhances product visibility and sets the mood, with studies showing its significant impact on consumer emotions and buying decisions (Kotler, 1973; Zhou & Wong, 2004). Retailers use ambient **scents** to evoke positive emotions and create memorable shopping experiences (Milliman & Turley, 2002). Well-placed and attractive **fixtures** facilitate easy browsing and contribute to the store's visual appeal (Sirgy et al., 2000). **Wall texture and finishes** can align with the store's theme and target audience preferences, impacting perceptions of quality and comfort. **Background music or soundscapes** influence the pace of shopping and create an emotional connection (Bell & Ternus, 2006). Warm or cool **colors** can evoke specific emotional responses and perceptions of product quality (McGoldrick 1990). Comfortable store **temperatures** ensure longer shopping durations and customer satisfaction (Berman & Evans, 2001). A **clean environment** is critical for positive customer perceptions and trust in the brand. Spacious, well-organized **aisles** improve navigation and reduce shopper stress. The **trial spaces** should be well-lit, clean, and comfortable to enhance the decision-making process. **Reducing unused or "dead"** spaces helps optimize the retail layout and increases customer engagement. **Properly displayed** products, arranged aesthetically, draw attention and simplify the shopping process (Bell & Ternus 2006). Informational and promotional **graphics** guide customers and create a cohesive brand identity.

Larger **stores sizes** allow for more variety and better experiences, but they must balance spaciousness with accessibility (Zhou et.al. 2004). Modern stores increasingly use **digital displays** to provide dynamic content, advertisements, or interactive tools that engage customers and enhance the shopping journey (Levy & Weitz, 2012). Clear **directional signs** ensure smooth navigation, improving customer satisfaction, especially in larger stores or malls (Bitner 1992). Incorporating **technologies** like augmented reality (AR) for virtual try-ons or smart mirrors in trial rooms enriches the customer experience. Areas where customers can customize or **personalize** products create an engaging and memorable shopping experience (Pine & Gilmore 1999).

Eco-friendly materials and **energy-efficient** lighting appeal to environmentally conscious shoppers enhancing brand loyalty (Harris 2010). Comfortable **seating zones** allow shoppers to relax, extending their time in the store and increasing the likelihood of purchases. Conveniently placed **service counters** ensure easy assistance and streamline checkout processes. **Themed interiors** create a cohesive narrative, reinforcing brand identity and creating an immersive environment (Berman & Evans, 2001). **Dynamic lighting** that changes based on time of day or seasons adds a layer of innovation and sophistication to the shopping experience. Incorporating natural scents or **indoor plants** not only improves air quality but also enhances the ambiance.

Visual merchandising: is an activity that coordinates effective merchandise selection with effective merchandise display (Walters & White 1987).

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VM is therefore concerned with both how the product/brand is 'visually communicated' to the customer and also whether this message is decoded 'appropriately' in this context affecting a positive psychological or behavioral outcome ultimately leads to purchase (Kerfoot et. at. 2017).

Visual merchandising includes arranging a variety of products in an appealing manner to maximize sales potential. **Assortments** should align with customer preferences and store objectives (Raghu 2013). Creating **themes for displays**, such as festive or seasonal settings, enhances customer engagement and emphasizes product relevance during specific periods (Sodhi & Kant 2013). Properly arranged **racks and shelves** facilitate ease of browsing and highlight the organization of merchandise, improving customer experience (Tshepo Tlapana 2021). Grouping items that complement one another, such as clothing **ensembles**, provides styling ideas to customers and increases basket size (Pegler 1983). Strategically placing **impulse-buy items near payment counters** can boost sales while customers wait (Chaudhary & Jadhav 2014). Effective **display** arrangements, such as tiered setups or categorized sections, allow for better visibility and product emphasis (Bailey & Baker 2014). A **planogram** outlines the placement of products by style, size, or type, ensuring uniformity across stores in retail chains (Raghu 2013). Using **props and mannequins** adds life to displays, especially in apparel stores, helping customers visualize product usage. (Law et. al. 2012) **Signage at points of sale** informs customers of offers, product highlights, or payment options, increasing purchase likelihood (Baek et al., 2015). Methods such as **window displays**, **cross-merchandising**, or **interactive setups** effectively catch customer attention and drive foot traffic into stores (Baek et al., 2015).These elements collectively contribute to creating an engaging and profitable retail environment.

In-Store signages: Informational and promotional **graphics** guide customers and create a cohesive brand identity. (Roopa & Ramesha 2019). Types of In store signages includes:

Category Signage: Signage that helps customers navigate product categories within the store (Quartier, Cleempoel, & De Marez 2009). Effective category signage can improve customer satisfaction and influence buying decision. A study involving over 3,000 shoppers revealed that 82% of purchase decisions were made in store, with 62% of shoppers making impulse buys during their shopping experience. Notably, 16% of unplanned purchases were driven by in- store promotions, highlighting the impact of effective signage in prompting spontaneous buying decisions. (The impact of in-store signage on consumer purchase decisions | Marketing Dive)

Promotional Signage: Used to highlight discounts, sales, or special promotions. Promotional signage can significantly boost product visibility and sales, particularly when paired with other marketing tactics (Anderson & Simester 2001). **Point-of-Sale Signage** are placed at checkout areas to promote last-minute purchases or advertise offers. Effective point-of-sale signage, such as for tobacco control, has shown measurable impacts on purchasing behavior (Cohen et al., 2011). **Digital Signage** are dynamic digital displays used for advertisements, customer engagement, or wayfinding. Digital signage improves customer engagement and sales by leveraging targeted and visually appealing content (Burke 2009) Benefits: Offers flexibility in content, interactivity, and real-time updates. **Directional Signage** guides customers through the store, pointing out restrooms, exits, or specific product sections. Large retail stores like IKEA or supermarkets often use directional signs to lead shoppers to popular sections like groceries or home goods. (Piippo 2024). **Informational Signage** provides details about product use, benefits, or availability (Bitner 1992). Electronics retailers may use signage to highlight product features or compare specifications. **Branding Signage** highlights the store's or a product's branding to reinforce identity and build customer loyalty. (Lindstrom 2008). High-end stores like Apple or Nike use sleek, branded signage to reflect their brand ethos. **Regulatory or Compliance Signage d**isplays mandatory information like safety warnings, legal age restrictions, or return policies. Signage stating "You must be 21 to purchase alcohol or tobacco" at checkout counters. (Armour, Gordon & Min 2020). **Interactive Signage:** Uses touchscreens or other technologies to allow customers to interact with content, such as checking inventory or customizing products. Beauty stores like Sephora use interactive screens to offer makeup tutorials or product recommendations (Gambetti 2010). **Window Signage are p**laced on store windows to attract passersby and showcase offers or products. Retailers often use bold, eye-catching window signage during seasonal sales or product launches. (Sachdeva & Goel 2003)

Floor Graphics: Adhesive signs or patterns placed on the floor to guide shoppers or highlight promotions. Arrows pointing to a clearance section or promotional offers displayed on the floor. (Crankshaw 2012). **Endcap Signage are** signage on display racks at the end of aisles, showcasing promotional or featured items. A supermarket endcap promoting pasta with matching sauces and utensils. (Blessa 2015). **Way finding Signage** is part of a broader category that includes maps or detailed guides for navigating large stores or complexes. Department stores with multiple floors may provide way finding kiosks or printed maps. (Blessa 2015).

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Sustainability or Eco-Friendly Signage highlights environmentally friendly practices, recycling options, or sustainability-focused products. Signs near reusable bags or products made with recycled materials. (Worakittikul, Saenwerm & Naruetharadhol 2024)

Retail Presentation: Well-designed store layouts are critical because they have a strong influence on in-store movement designs, shopping environment, shopping behavior, and operational productivity (Behera & Mishra 2017).

Idea Oriented Presentation is a visual merchandising strategy (VM) where products are displayed in a way that communicates a theme, concept, or lifestyle (Ebster & Garaus 2015). The focus is on inspiring customers by showcasing how products can be used together or fit into a specific context, encouraging purchases by creating a compelling narrative around the items.

This approach is particularly effective in industries such as fashion, home décor and lifestyle retail. Displaying furniture, home decor, or apparel in a room setting to inspire customers. (Merrilees & Miller 2001). **Item and Size Presentation** is a merchandising strategy focused on organizing products by item type and size. This method ensures a clear and logical layout, making it easy for customers to find the exact product they need in the desired size. It is particularly effective in fashion retail, footwear, and other industries where size variation is a critical factor in the buying decision. Simplifies shopping for customers and ensures a clean, organized look. (Levy, Weitz, & Grewal 2018). **Color Presentation** is a VM strategy that organizes products based on color, creating an aesthetically pleasing and cohesive display. (Bell & Ternus 2012). This approach leverages the psychological and emotional impact of colors to attract attention, convey a theme, and enhance the overall shopping experience. Attracts attention and makes the store aesthetically pleasing (Bellizzi & Hite 1992). Color presentation is widely used in fashion retail, home décor, and lifestyle stores, where visual appeal plays a crucial role in influencing customer behavior. **Price Lining** in VM refers to the strategic arrangement of products in retail spaces to highlight specific price points, making it easier for customers to compare options within a price range and encouraging purchases (Grewal, Roggeveen & Nordfält 2017). This technique not only simplifies the shopping experience but also maximizes perceived value and promotes upselling by emphasizing differences in quality or features at various price tiers. Helps customers quickly identify products within their budget and compare options. (Monroe 1973). Electronics stores, grocery retailers, or apparel brands highlighting budget, mid-range, and premium products.

Vertical Merchandising is a strategy that involves organizing products vertically on shelves or displays. This approach maximizes the use of vertical space and aligns with natural eye movement, making it easier for customers to browse and select products (Sorensen, H. 2009). It is widely used in retail environments like grocery stores, fashion outlets, and electronics shops to create visually appealing and customer-friendly layouts. Products are displayed vertically from top to bottom, typically on shelves, to allow customers to easily browse across different categories or sizes (Chandon, Bradlow & Young 2009).

Tonnage Merchandising is a retail strategy that focuses on presenting large quantities of a single product or product category in a visually impactful way. This approach emphasizes abundance and value, creating a perception of cost-effectiveness and urgency that can encourage customers to make bulk purchases or stock up on items. (Underhill 2009). It is particularly common in grocery stores, warehouse clubs, and discount retailers.

Frontal Presentation refers to the strategic display of products so that their most visually appealing or informative side faces the customer directly. (Pegler)This technique is widely used in retail and merchandising to capture customer attention, convey product value, and enhance overall sales. It emphasizes creating a visually engaging and accessible layout that encourages customers to engage with the displayed items (Kerfoot, Davies & Ward 2003).

Grid Presentation is a VM technique where products are arranged in a systematic, grid-like structure, creating a clean and organized display. (Levy et. al. 2018). This method is widely used in retail environments to maximize space efficiency, promote easy navigation, and allow customers to compare similar products side-by-side. (Baker et. al. 2002). It is especially effective in grocery stores, electronics outlets, and department stores.

Story Telling Display in VM involve creating immersive and thematic product presentations that tell a story, evoke emotions, or convey a lifestyle, inspiring customers to engage with the brand and its offerings. (Schmitt 1999). This technique goes beyond merely showcasing products—it creates a narrative that resonates with customers, helping them envision how the products can fit into their lives. (Bone & Ellen 1999). Fashion stores, gift shops, and high-end retailers during holidays or special events.

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Pyramid Display is a triangular composition, where products are arranged in layers, with the widest base at the bottom and items tapering toward a focal point at the top. (Ebster & Garaus 2015). This structure naturally draws the eye upward, emphasizing the most important or premium product. Products like vine bottles, books or boxes are stacked or arranged in a pyramid structure to create a visually appealing presentation.

Cross Merchandising Presentation is a strategic retail technique where complementary products from different categories are displayed together to encourage additional purchases. The goal is to inspire customers by showcasing how products can be used together, solving a need or creating a desirable lifestyle presentation. (Grewal et. al. 2017). Related products are grouped together to encourage cross-selling. (Doha et. al 2017). Example: pairing wine with cheese or chargers with electronic devices. Baked goods with coffee or tea. Tortilla chips displayed alongside salsa and guacamole. A complete outfit display, pairing clothes with shoes and accessories.

Eye Level Merchandising is a visual merchandising strategy where products are displayed at the customer's eye level to maximize visibility and encourage purchases. This principle leverages consumer psychology, as items at eye level are more likely to catch attention and be perceived as more accessible or desirable. (Verhoef et. al. 2015) Products are displayed at eye level, as this is where customers tend to focus the most. (Chandon et. al. 2009). Used for high-margin products in grocery or department stores.

Interactive Displays in retail are innovative merchandising tools that engage customers through interactivity, blending technology, creativity, and customer experience. These displays are designed to capture attention, foster engagement, and provide personalized experiences, enhancing the overall shopping journey. (Pfiffelmann et. al. 2019). Displays where customers can touch, try, or interact with products encourages hands-on experience, increasing the likelihood of purchase.

Shelf Talkers are small, attention-grabbing displays or signs placed on retail shelves to highlight specific products, promotions, or features. These tools are commonly used in visual merchandising to influence purchasing decisions at the point of sale. (Bell et. al. 2011). Grocery stores and pharmacies use these to direct attention to specific products to boost product visibility and provides quick information to customers.

Mannequin Displays are a cornerstone of visual merchandising in the retail industry, used to showcase apparel, accessories, or lifestyle products in an engaging and life-like manner. (Kerfoot et. al. 2003). Provides styling inspiration and showcases products in a lifelike setting. They help customers visualize how products can be worn or used, influencing purchase decisions by creating aspirational or relatable narratives. Mannequins are used to showcase clothing, accessories, or themed outfits. (Fornari et. al. 2016).

Merchandising Rules (MR) for product display on shelves: Merchandising is a cornerstone of retail success, involving a spectrum of activities from strategic planning to in-store execution. (Marshall et. al. 2006). The merchandising rules set as the benchmark by retailers to be followed by the planogramer at the planning stage and to be maintained by the retail operators at the store location where the customer interact with the product displayed as per the rules and guidelines. MR for Merchandisers and Planners are different from MR for Retail Store Operators and Salespersons

based on the roles and responsibilities of the stakeholders involved. Understanding these distinct yet interconnected roles is critical for achieving operational efficiency and maximizing customer satisfaction. (Kotler et. al 2015).

Merchandisers and retail planners are Responsible for developing overarching merchandising strategies, analyzing market trends, and ensuring product availability at the right cost and time. **Effective assortment planning** is critical to meeting consumer demand and maximizing shelf efficiency. (Hübner et al. 2016). Merchandisers and retail planners optimize product mix to cater to customer preferences and **maximize category performance**. Use data analytics to **forecast demand** and ensure variety across price points. **Shelf-space allocation** directly impacts product visibility and profitability. (Kotzab and Madlberger 2001). Merchandisers and retail planners allocate shelf space based on sales potential, product turnover, and category importance. **Develop planograms** to guide store layouts. **Inventory synchronization** reduce operational inefficiencies (Raman et al. 2001). Merchandisers and retail planers maintain optimal inventory levels to prevent stockouts or overstocking. Leverage **just-in-time** (JIT) inventory techniques for cost efficiency. They also **Design promotional calendars** and ensure alignment with marketing strategies. Monitor the impact of promotions on sales performance (Buttle 1984).

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Retail store operators and ground sales staff are responsible for implementing merchandising plans, maintaining in-store displays, and interacting directly with customers. Accurate **planogram implementation** boosts sales by aligning displays with customer expectations. (Ehrenthal & Stolzle 2013). Store operators/ground staff ensure **adherence to store layouts** provided by planners. Regularly **update displays** to reflect seasonal themes or promotional activities. They conduct regular **shelf audits** to replenish stock and **ensure consistent availability**. Rotate products to prevent expiration (FIFO method). Salesperson expertise and **customer engagement** is directly linked with improved customer loyalty (Babin & Attaway 2000). Retail operators/ground staff **guide customers** toward high-margin or promotional products. **Provide product knowledge** to enhance customer satisfaction. Keep displays clean, organized, and visually appealing. **Use signage** to highlight promotions, best sellers, or new arrivals.

Merchandisers and planners operate as architects of retail strategies, while retail store operators and salespersons act as builders executing these blueprints. Recognizing their unique contributions and fostering collaboration can drive operational efficiency and improve customer satisfaction.

BIBLIOMETRIC ANALYSIS

Bibliometric analysis of literature available in Web of Science and Scopus indexed journals on the core topic of retail atmospherics is conducted and the findings are presented in this article. This paper tries to deep-dive into the following research questions through a bibliometric review and network visualization analysis:

1. The major trends in the research carried out in Retail Atmospherics wrt the publication of research papers/articles and citations.
2. The top contributors to knowledge generation in this domain in terms of top authors, countries, journals and organizations.
3. The underlying inter-relationships between the most frequently used author keywords that can provide direction toward unexplored avenues of research.
4. The cooperation relationships between the countries contributing to research in this domain.
5. The research gaps that can translate into potential avenues for research in the field of Retail Atmospherics, especially in the area of shelf space allocation, item hierarchies helping the customers to pick and choose, store layout and category adjacencies helping the customers navigate the store naturally?

The analysis shows that although retail atmospherics research is still emerging, it has promise for future studies because shops all over the world are quickly implementing the outcomes it to improve overall consumer experience and increase profitability through loyalty and repeated visits.

For better understanding of the two indexes, we have divided the study in two parts, part 1 covers the analysis of Web of Science and in part 2 covers Scopus findings and then we concluded the both combined.

PART 1: Web of Science Analysis

Data Source: We pulled the data from "Web of Science" with the **Search Query** "Retail Atmospherics" as our main topic under study with sub topics "Floor plans", "Planogram", "Customer Decision Tree", "Shelf Space Allocation", "Store Ambience", "Store Atmospherics" and "Atmospherics". Use used the time period of 35 years of modern retail development globally with the **Time Frame** from 1990 to 2025 and extracted the data on **02 April 2025**

Number of Publications: Total 1423 valid publications were found in Web of Science which were extracted by country, by type of publication, by authors, by keyword occurrence, by WOS category, by universities publishing these and by number of citations.

We observed the WOS categories picked up by our keywords (Table 1) and in the next stage we removed the unrelated categories to focus only on the relevant categories. Top category was business but there were some other works being pulled due to the use of our term "Atmospherics" that included work in the field of electromagnetic induction, radio waves and environment to name a few, we considered irrelevant for our work and manually removed few of these to pull the data again.

After removing these unrelated categories we again pulled the data to stay closer to the subject and maintain focus on business, economics architecture and management. See Table 2, after data cleaning the relevant global papers in the field of retail atmospherics drops down to 801.

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We still maintained the construction and building technology because the store layout are sometimes studied under the construction and civil engineering and filling the retail store happens at the later stage depending upon the received layout.

The categories finally selected are further studied for finding out the trend of publications and major contributing authors in the field. We found that 773 of these articles are published in English language, 11 in Spanish, 7 in French and 6 in German, rest are in other languages.

Types of Publications: the data is extracted from the year 1990 to 2025. The publications **I**ncluded the editorial, book review, meeting abstract news items and letters but primarily with 83.4% articles (Total 668) and 13.3% proceeding papers (total 107) covers 96.7% of the total web of science publications.

Index type: The papers are published mainly in the Social science index (SSCI) where 441 papers are published, the 210 papers are published in Science citation index Expanded (SCI-Expanded) chart 1 below lists all indexes of WOS where the authors published their work.

Year on Year trend: Retail atmospherics has always been a very niche subject and there are very few researches globally in this area, the Chart 2 below gives a glimpse of the YOY publication in Web of Science on Retail Atmospherics. The chart shows a clear rise in the number of publications over a period of 35 years and shows an upward trend. Year 2021 and 2024 has maximum number of publications overall and since year 2000 it was only in year 2006 that we saw a decline in the number of articles published.

Active Countries by number of articles: Major contribution in retail is from the USA with 235 articles is stands on the top of the chart, Chart 3 below showcases the countries and their contribution in terms of articles published in Web of Science on the topic of retail atmospherics. England comes distant second with 84 articles and China with 69 articles comes third. India on ninth rank has published 35 articles with major (13 articles) coming from IIM systems.

MOST CITED PAPER

The top contributing article in the field of retail store atmospherics is "Atmospheric effects on shopping behavior: A review of the experimental evidence" by Turley, LW and Milliman, RE (Journal of Business Research, Volume 49, Issue 2, Page 193-211 DOI: 10.1016/S0148- 2963(99)00010-7) this has received 1077 citations in Web of Science core collection and 1313 citations across all databases so far.

Second most influential article with 716 citations in WOS core collection and 824 citations across all databases is "Empirical testing of a model of online store atmospherics and shopper responses" by Eroglu, SA; Machleit, KA and Davis, LM (Psychology and Marketing, Volume 20, Issue 2, Page 139-150, DOI: 10.1002/mar.10064).

Third major contribution with 665 citations in WOS Core and 781 citations across all databases is by the article "Perceived quality, emotions, and behavioral intentions: Application of an extended Mehrabian-Russell model to restaurants" by Jang, SC and Namkung, Y, published in Journal of Business Research, Volume 62, Issue 4, Page 451-460 DOI: 10.1016/j.jbusres.2008.01.038.

Fourth most cited article is by Grewal, D; Roggeveen, AL and Nordfält, J, with title "Future of retailing, published in the Journal of retailing, Volume 93, Issue 1, Page 1-6, DOI: 10.1016/j.jretai.2016.12.008 has received 578 citations in WOS core and 686 citations across all databases till date.

Fifth most cited paper is "Customer Experience Management in Retailing: Understanding the Buying Process" by Puccinelli, NM, Goodstein, RC, Grewal, D, Price, R, Raghubir, P, and Stewart, D published in Journal of Retailing, Volume 85, Issue 1, page 15-30 in 2009 with DOI: 10.1016/j.jretai.2008.11.003. This has received 671 citations across all databases and 550 citations in WOS core circulations.

Authors & Affiliations: Major contributing authors are Jean Charles Chebat from HEC Montreal Technion Israel Institute of Technology, Montreal University, Canada with 13 articles and 1436 citations to these papers. Dhruv Grewal from Babson college, Wellesley, Massachusetts, USA is another most influential author in this field with 13 articles and 2841 citations to his work. Anne

L. Roggeveen (Ph.D. Columbia University) is the Charles Clarke Reynolds Professor of Retailing & Marketing at Babson College is another notable author and researcher with 9 articles and 1152 citations to her work.

Journals attracting these articles: Table 3 depicts the journals attracting maximum number of articles in the field of 'retail atmospherics'. Clearly the Journal of business research, Journal of retailing and consumer services, Journal of retailing, International journal of retail distribution management and European journal of marketing published more number of articles in Web of Science core collection.

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We can see the journals in buildings and architecture are also publishing articles in the field of retail atmospherics due to the fact that the engineers while designing the

retail store takes care of the civil structure, power supply, entry – exits, cash counter locations, changing rooms, store rooms, customer service areas and often these areas are fixed locations in the store and cannot be moved unless there is a major redesigning is planned at the retail store. Psychology and environmental enthusiasts also study retail store layout and atmospherics due to academic reasons and therefore we observe the usage of this term in these journals also.

Keywords with appearance: The top keywords with maximum number of appearance are listed in the table 3. Atmospherics is the most frequently used keyword among our fetched 801 papers with impact being the second in frequency with 160 appearances.

PART 2: SCOPUS ANALYSIS

Data Source: We pulled the data from "SCOPUS" with the **Search Query** "Retail Atmospherics" as our main topic under study. Use used the time period of 30 years of modern retail development globally with the **Time Frame** from 1994 to 2025 and extracted the data on **05 May 2025**

Number of Publications: Total 237 valid publications were found in Web of Science which were extracted by country, by type of publication, by authors, by keyword occurrence, by Scopus category, by universities publishing these and by number of citations.

We observed the Scopus categories picked up by our keywords (Table 1A) and in the next stage we removed the unrelated categories to focus only on the relevant categories. Top category was business but there were some other works being pulled due to the use of our term "Atmospherics" that included work in the field of Medicine and physics etc to name a few, we considered irrelevant for our work and manually removed few of these to pull the data again.

After removing these unrelated categories we again pulled the data to stay closer to the subject and maintain focus on business, economics architecture and management. See Table 2A, after data cleaning the relevant global papers in the field of retail atmospherics drops down to 231. We still maintained the engineering because the store layout are sometimes studied under the construction and civil engineering and filling the retail store happens at the later stage depending upon the received layout.

The categories finally selected are further studied for finding out the trend of publications and major contributing authors in the field. We found that most of these articles are published in English language.

Types of Publications: (Chart 1A) The data is extracted from the year 1994 to 2025. The publications **I**ncluded the editorial, book review, meeting abstract news items and letters but primarily with 80% articles (Total 185) and 4.7% proceeding papers (total 11) covers 85% of the total Scopus publications.

Year on Year trend: Retail atmospherics has always been a very niche subject and there are very few researches globally in this area, the **chart 2A** below gives a glimpse of the YOY publication in Scopus on Retail Atmospherics. The chart shows a clear rise in the number of publications over a period of 30 years and shows an upward trend. Year 2013, 2015 and 2022 has maximum number of publications overall and since year 2000 it was only in year 2020 that we saw a decline in the number of articles published.

Active Countries by number of articles: Major contribution in retail is from the USA with 92 articles is stands on the top of the chart, **Chart 3A** below showcases the countries and their contribution in terms of articles published in Web of Science on the topic of retail atmospherics. England comes distant second with 40 articles and India with 23 articles comes third. India on third rank with Amity, Kalinga, IMI Kolkata and Motilal (Prayagraj) has publiched 2 papers each.

MOST CITED PAPER

The top contributing article in the field of retail store atmospherics is "Customer Experience Management in Retailing: Understanding the Buying Process" by Puccinelli, N.M., Goodstein, R.C., Grewal, D., ... Raghubir, P., Stewart, D. (Journal of Retailing, 2009, 85(1), pp. 15–30, DOI: 10.1016/j.jretai.2008.11.003) this has received 656 citations in Scopus core collection and 305 cross references in PlumX Metrics.

Second most influential article with 516 citations in Scopus core collection is "Impact of ambient odors on mall shoppers' emotions, cognition, and spending: A test of competitive causal theories" by Chebat, J.-C., Michon, R. (Journal of Business Research, 2003, 56(7), pp. 529–539, DOI: 10.1016/S0148-2963(01)00247-8).

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Third major contribution with 477 citations in Scopus is "Cross-category effects of induced arousal and pleasure on the Internet shopping experience" by Menon, S., Kahn, B. (Journal of Retailing, 2002, 78(1), pp. 31–40, DOI: 10.1016/S0022-4359(01)00064-1)

Fourth most cited article is by Sirgy, M.J., Grewal, D., Mangleburg, T., with title "Retail environment, self-congruity, and retail patronage: An integrative model and a research agenda, published in Journal of Business Research, 2000, 49(2), pp. 127–138, DOI: 10.1016/S0148- 2963(99)00009-0, has received 433 citations in Scopus.

Fifth most cited paper is "Store atmospherics: A multisensory perspective" by Spence, C., Puccinelli, N.M., Grewal, D., Roggeveen, A.L., published in Psychology and Marketing, 2014, 31(7), pp. 472–488 with DOI: 10.1002/mar.20709. This has received 401 citations Scopus core circulations.

Authors & Affiliations: Major contributing authors are Jean Charles Chebat from HEC Montreal Technion Israel Institute of Technology, Montreal University, Canada with 9 articles. Dhruv Grewal from Babson college, Wellesley, Massachusetts, USA is another most influential author in this field with 8 articles are top contributors.

Subject Areas: Chart 4 depicts the keyword 'atmospherics' is attracting scientists from these subject areas to study its impact on/with various other (dependent/independent) variables. Clearly Business, Economics, Social Science and Humanities are areas attracted to atmospherics and its impact on overall consumer behavior. We can see the disciplines of engineering and decision science are also publishing articles in the field of retail atmospherics due to the fact that the engineers while designing the retail store takes care of the civil structure, power supply, entry – exits, cash counter locations, changing rooms, store rooms, customer service areas and often these areas are fixed locations in the store and cannot be moved unless there is a major redesigning is planned at the retail store. Psychology and environmental enthusiasts also study retail store layout and atmospherics due to academic reasons and therefore we observe the usage of this term in these journals also.

Keywords with appearance: The top keywords with maximum number of appearance are listed in the table 3A. Atmospherics is the most frequently used keyword (56 appearances) among our fetched papers with retailing being the second in frequency with 37 appearances.

VOSVIEWER ANALYSIS

VOSviewer is a software tool for **creating maps based on network** data and for **visualizing and exploring** these maps. We used VOSviewer version 1.6.20 for our analysis of data we downloaded from Web of Science indexed journals by using the keyword "Retail Atmospherics". After pulling this data we created the 'tab delimited' file in WOS to export this data and then retrieve this file in VOSviewer for further analysis. Network visualization analysis (Van Eck & Waltman, 2010) was conducted using co-authorship ties between nations conducting research in this area, citation links between journals publishing research literature in the subject of retail atmospherics, and keyword co-occurrences of the most cited author keywords.

We pulled the data into VOS viewer and created a map using bibliographic data, we had chosen bibliographic database files as data source, then we selected the files from 'Web of Science' downloaded data (801 publications) and Scopus downloaded data (231 publications) and then we had repeated the above steps to study co- authorship, co-occurrence, citation chose minimum threshold value for both Scopus and WoS separately.

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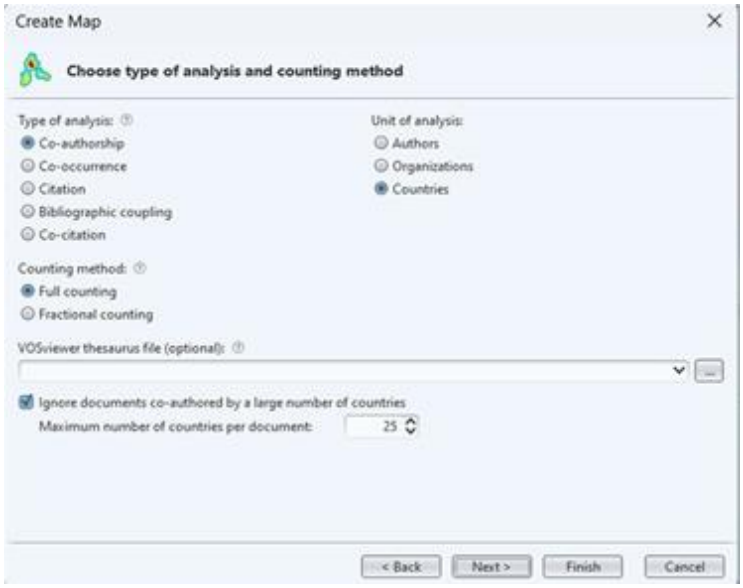

Co-Occurrence Analysis: We conducted Analysis of Keywords occurring together in research articles published in different parts of the world and indexed in WOS as well as Scopus separately for understanding more deeply on how these keywords are used and their significance.

Map 1 (WOS): is created with keywords (Total 211) that we pulled out from WOS and found that the major keyword with most occurrences and links was Atmospherics. We also checked the total links those exists among all these (211 keywords) to be 5432 means either of these 211 words are used this many times together in various research papers and articles. Link Strength means how many times these two terms are used together in the same published reference paper. Total links is shown by the size of the bubble in the map, 'atmospheric' 'impact' 'satisfaction' are large bubbles with more number of links.

Map 1A (Scopus): is created with keywords (Total 67) that we pulled out from Scopus and found that the major keyword with most occurrences and links was Retailing. We also checked the total links those exists among all these (67 keywords) to be 215 means either of these 67 words are used this many times together in various research papers and articles. Keywords like Curiosity, Arousal, Lightening and Advertising context are clubbed separately and are not directly showing a linkage with word Retailing. We zoomed onto the keyword atmospherics that is showing a very small cluster and is linked with words like 'Retail' and 'Highstreet'.

Map 2 (WOS): Upon focusing on keyword 'Atmospherics' we found that the keyword is used 250 times with total 191 links and link strength of 1690. All these connecting lines in the map are the link strengths, selecting any curved line give us the strength, means how many times these two keywords appeared together. The map also shows many indirect links between keywords eg. Layout is not directly linked with atmospherics but layout is linked with design and design is linked with atmospherics.

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Map 2A (Scopus): Co-Occurrence analysis of keywords in scopus coming in the larger cluster and on focusing on keyword 'Retail Atmospherics' we found that the keyword is used 2 times with total 14 links. Keyword 'Retailing' is used most often and cited in Scopus with 25 links.

Map 3 (WOS): The keyword "Floor plan" shows indirect linkage with the keyword "Design" and another keyword "Architecture" that is part of engineering and design and lesser connected with customer perception, ease of shopping and behavior. However the keyword "Layout" (Refer Map 3) has more direct linkages with social science research subjects like "behavior", "emotional responses", "choice", "comfort", "servicescape", "environment" and "floorplan" apart from "atmospherics" and "impact". Keyword "Layout" has 32 links and total link strength of 49.

Map 4 (WOS): Another important keyword is "Cues" that has total 103 links and link strength of 274 with 39 occurrence, is directly linked with keyword "floorplan". This keyword "Cues" also referred to as "Silent Cues" showing co-occurrence with keywords like "Scent", "Music", "Sound", "Memory", "Loyalty", "Floor plan" and "Layout".

Customer loyalty is studied with environment and music. Sensory marketing shows links with behavior and consumption whereas the word floor plan does not show any links and thereby opens up a huge window for researchers to explore. Similarly the keyword 'planogram', that operators and planners claims to be the biggest tool to generate impulse purchase is missing in this map and is apparently a huge gap.

Co-Authorship Analysis: We also checked which all countries are participating and sharing knowledge in retail atmospherics domain and created separate map for the same. We selected only those countries where at-least 10 research papers are published in this area and VOSviewer gave us 21 such countries to study.

Map 5 (WOS): Density visualization of co-authorship by country clearly shows the contribution of the USA far ahead of the other countries. USA has in all 19 links and total link strength of 112, total 232 research papers and 13, 876 citations to its credit.

England is the second most influential country in terms of retail atmospherics publications with 17 links and 47 link strength, 82 documents and 2676 citations. France with total links 12 and link strength of 23 and 1113 citations stands at third position followed by Germany with 11 links, link strength of 18 and 699 citations. Netherlands, Canada and Spain with 10 links are also among the leading countries contributing in this research area.

Map 5 (WOS): Density visualization of co-authorship by country clearly shows the contribution of the UK far ahead of the other countries. UK has in all 4 documents, total link strength of 7 and 8 citations to its credit. USA is the second most influential country in terms of retail atmospherics publications with 4 documents, 7 link strength, 3 citations in scopus.

Map 6 (WOS): Indian researchers have co-authored with USA, Canada, England, China and Taiwan for retail atmospherics. India shows 5 links and total link strength of 10 and 34 documents published so far and have received 835 citations.

Map 6A (Scopus): There are very few co-authored works across borders, USA and UK authors are collaborating across borders and are showing maximum work co-authored, whereas other countries are showing very few linkages and link strength is also low.

Citations Analysis: We checked for citations by Institute and found that Babson College is the front runner with 11 documents and 2312 citations followed by Purdue University with 10 documents and 1664 citations and Alabama University with 6 documents and 938 citations at third most contributing institution. All the top contributing universities also have links for citation, co- authorship and co-occurrence.

Map 7 (WOS): shows citations by authors, for extracting this we selected only the authors with minimum 5 documents published and we find that Dhruv Greval is most cited author with 11 papers and 1941 citations with total strength of 107. His article "Future of Retailing" coauthored with Roggeveen, AL and Nordfalt, J is also at rank 4 among the most cited articles list.

Roggeveen Anee, L. with 9 documents and 1152 citations is the second most cited author and is the co-author of Future of Retailing as well. Spence Charles is third most influential author with 9 documents and 499 citations to his name.

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Map 7A (Scopus): Don't see any linkages between authors, all the works are showing independent exploration, this shows an opportunity to study the relationship between retail atmospherics with shopper behavior using other relevant parameters like the retail store layout and its impact on ease of shopping also the keyword space planning and shelf space is not shown as in WOS clusters.

CONCLUSION

This paper evaluated the global trends in research on retail atmospherics using bibliometric and network visualization analysis. Research on retail atmospherics has started with the modernization of retail but in the last six years the production of research articles in this field has seen a jump with more multi-authored articles being published in this subject.

We observed that WOS is way ahead of Scopus in all parameters viz. number of articles, Author collaborations and co-occurrence of keywords etc.

The study shows the stronghold of USA in retail atmospheric researches maximum number of publications coming from there globally, top researchers and universities are also from USA.

Other key findings includes

1. Floor plan and retail store layout though has remarkable impact on consumer purchase behavior and acts as silent cues, these are yet to be deeply studied from the customer point view and how the floor plan can help shopper enjoy his / her shopping trip, spend more time in store, finds everything naturally and easily and buys out of impulse.
2. More work is being done for designing the **floor plan** (or store layout) from engineers' viewpoint, as the keywords are more part of designing, architecture and algorithm studies and there is a lot of scope to study layout from customer behavior, ease of shopping and retail store environment view point.
3. Planogram is majorly an unexplored topic and studies around planogram designing, methodologies, strategies, customer decision tree, product hierarchies etc. are very few though heavily used terms in the industry.
4. Space Allocation Problem, the toughest retail dilemma is being studied only from algorithm and architecture viewpoint and have a huge scope to study it from customer perception and satisfaction angles.

IMPLICATIONS OF THE STUDY THEORETICAL IMPLICATIONS

A bibliometric study aims to offer a numerical evaluation of the research conducted over time in a certain sector of knowledge. Since the idea of retail atmospherics gained popularity, this paper has tried to give a brief overview of the major developments in the field. It sheds light on how the idea of retail atmospherics is worked by the academicians and researchers and the main perspective-based lenses that scholars have used to study this phenomenon. Researchers might use the study's insights into current author-country relationships as a guide for future academic collaborations. By offering a fundamental framework for their investigation into retail atmospherics, this study can also provide as a springboard for novice researchers in this area. Furthermore, the researchers in emerging economies can pick up the trend from this paper to investigate their market specific dynamics in the field of consumer behavior and ease of shopping.

Managerial Implications

The bibliometric analysis in the area of retail atmospherics has indicated that although the research in this area is not new, still there are certain elements of retail store planning and setup that due to various reasons consider only the architectural inputs while designing the retail store floor. Silent retail cues within the isle, shelves and checkouts are real game changers for increase in impulse purchase at the stores, this could be the natural flow of merchandise visibility through smartly done floor plan and this could also be the availability of the right item at the right place that can be done with smartly done shelf allocation. There are areas where more fundamental researches can help improve shopping experience and overall sales and profitability. Shelf space allocation problem, customer decision tree and product hierarchies, Store layout, category adjacencies, impulse cues through store design elements etc. are such problems those can be solved through more academic researches and industry should collaborate with researchers interested in finding solutions to real retail problems.

Societal Implications

In the digital era of online shopping, the customer walking in the retail store is for fun and ease, the days of shopping list are gone and the retailers designing the retail store smartly and in natural flow creates a proxy shopping list in the minds of the customer to shop. Moreover the focus will now shift to more customer service and customer delight thereby enhancing the overall retail experience.

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LIMITATIONS OF THE STUDY

A possible limitation of the study could be that citation and co-citation data and trends are typically dynamic in nature and are expected to change over a period of time.

SCOPE FOR FUTURE RESEARCH

The research domain on retail atmospherics is attracting significant interest from academicians and researchers. This study attempts to encapsulate the key trends in retail atmospherics research during the period 1990–2025. A detailed study of the sample set of 801 research articles has revealed potential avenues for future researches.

Research on retail atmospherics and silent cues has indicated that the world's most expensive real estate (Kaikati and Kaikati 2006) the retail shelves are to be organized in a way to fulfill multiple purposes. Future research could delve deeper into which specific aspects of retail atmospherics (customer decision tree, shelf space allocation problem, layout and floor plan) offer significant returns in terms of enhanced customer value.

Also used Web of Science publications only due to scope of the study but researchers can pull out the data from Scopus and other indexes to further enhance the results of this study.

DECLARATION

No funding or financial assistance of any kind is received in writing this article. We make sure that all the citations are duly credited and have not published this paper anywhere else except for this conference (International Conference: Innovative strategies of economics, commerce, finance and management for sustainable and inclusive global future, Poona college of arts, science and commerce, Camp Poona, 411001).

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Table 1: Web of Science Categories under scanner (First Cut – 1423 publications)

Table 1 (WOS Categories under scanner)		
Web of Science Categories	**Record Count**	**% of 1,423**
Business	318	22.347
Construction Building Technology	118	8.292
Management	115	8.082
Engineering Civil	113	7.941
Architecture	108	7.59
Engineering Electrical Electronic	90	6.325
Meteorology Atmospheric Sciences	84	5.903
Astronomy Astrophysics	71	4.989
Computer Science Information Systems	66	4.638

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Environmental Studies	66	4.638
Hospitality Leisure Sport Tourism	66	4.638
Geosciences Multidisciplinary	61	4.287
Computer Science Artificial Intelligence	54	3.795
Telecommunications	53	3.725
Geochemistry Geophysics	50	3.514
Computer Science Interdisciplinary Applications	47	3.303
Environmental Sciences	45	3.162
Computer Science Software Engineering	44	3.092
Engineering Multidisciplinary	33	2.319
Computer Science Theory Methods	29	2.038
Green Sustainable Science Technology	29	2.038
Physics Applied	29	2.038
Remote Sensing	29	2.038
Geography	28	1.968
Psychology Multidisciplinary	28	1.968

Source: All figures collected from Web of Science Analytics

Table 2: Web of Science Categories under scanner (After removing irrelevant categories)

Table 2 (WOS Categories under scanner after filtering)		
Web of Science Categories	**Record Count**	**% of 801**
Business	311	38.826
Management	109	13.608
Architecture	97	12.11
Construction Building Technology	96	11.985
Engineering Civil	90	11.236
Hospitality Leisure Sport Tourism	62	7.74
Computer Science Interdisciplinary Applications	28	3.496
Economics	25	3.121
Public Environmental Occupational Health	23	2.871
Computer Science Artificial Intelligence	21	2.622
Multidisciplinary Sciences	21	2.622
Psychology Applied	19	2.372
Information Science Library Science	18	2.247
Computer Science Information Systems	17	2.122
Psychology Multidisciplinary	17	2.122
Food Science Technology	14	1.748
Computer Science Theory Methods	12	1.498
Psychology Experimental	11	1.373
Social Sciences Interdisciplinary	10	1.248
Operations Research Management Science	9	1.124
Sociology	9	1.124
Cultural Studies	8	0.999
Engineering Multidisciplinary	8	0.999
Art	7	0.874
Business Finance	7	0.874
Showing 25 out of 74 entries		

Source: All figures collected from Web Of Science Analytics

Table 1A: Scopus Categories under scanner (First Cut – 354 publications –including duplicates)

Table 1A (Scopus Categories under scanner)	
Subject Area	**Publications**
Business, Management and Accounting	202
Economics, Econometrics and Finance	44
Social Sciences	28
Psychology	16

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Computer Science	14
Arts and Humanities	12
Engineering	8
Decision Sciences	7
Environmental Science	5
Agricultural and Biological Sciences	4
Materials Science	3
Mathematics	2
Earth and Planetary Sciences	2
Chemical Engineering	2
Physics and Astronomy	1
Nursing	1
Medicine	1
Energy	1
Chemistry	1

Source: All figures collected from Scopus Analytics

Table 2A: Scopus Categories under scanner 345 (After removing irrelevant categories)

Table 1A (Scopus Categories under scanner after filtering)		
Subject Area	**Publications**	**% age of 345**
Business, Management and Accounting	202	59%
Economics, Econometrics and Finance	44	13%
Social Sciences	28	8%
Psychology	16	5%
Computer Science	14	4%
Arts and Humanities	12	3%
Engineering	8	2%
Decision Sciences	7	2%
Environmental Science	5	1%
Agricultural and Biological Sciences	4	1%
Materials Science	3	1%
Mathematics	2	1%

Source: All figures collected from Scopus Analytics

Table 3: WOS Journals with maximum number of articles

Table 3: Journals with maximum number of articles	
Publication Titles	**Record Count**
Journal Of Business Research	51
Journal Of Retailing And Consumer Services	44
Automation In Construction	27
International Journal Of Retail Distribution Management	22
Journal Of Retailing	21
European Journal Of Marketing	20
Buildings	16
Journal Of Services Marketing	16
A U Architecture And Urbanism	15
Journal Of Asian Architecture And Building Engineering	14
Herd Health Environments Research Design Journal	13
Journal Of Building Engineering	13
Psychology Marketing	11
Frontiers In Psychology	9
International Journal Of Hospitality Management	9

Source: All figures collected from Web Of Science Analytics

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Table 3A: Scopus Journals with maximum number of articles

Table 3A: Journals with maximum number of articles	
Journals	**Documents**
Journal Of Business Research	25
International Journal Of Retail And Distribution Management	17
Developments In Marketing Science Proceedings Of The Academy Of Marketing Science	16
Journal Of Retailing And Consumer Services	15
Journal Of Retailing	11
International Review Of Retail Distribution And Consumer Research	10
Journal Of Marketing Management	6
Journal Of Global Fashion Marketing	5
Journal Of Services Marketing	5
European Journal Of Marketing	4

Source: All figures collected from Scopus Analytics

Table 4: WOS - Top keywords with maximum appearances

keyword	occurrences	keyword	occurrences
atmospherics	250	perceptions	42
impact	160	store environment	41
behavior	114	cues	39
model	91	store atmospherics	39
satisfaction	84	loyalty	37
environment	77	retail atmospherics	36
quality	68	servicescape	36
experience	57	customers	35
background music	55	responses	35
music	52	shopping behavior	34
consumption	50	ambient scent	33
emotions	50	customer satisfaction	33
design	49	information	30

Source: All figures collected from Web of Science Analytics

Table 4A: Scopus Top Keywords with maximum appearances

Table 4A: Top keywords with maximum appearances in Scopus Journals				
Keyword	**Appearance**		**Keyword**	**Appearance**
Atmospherics	60		Color	7
Retailing	39		Store Atmosphere	6
Store Atmospherics	37		Shopping Experience	6
Retail Atmospherics	28		Marketing	6
Retail	20		Atmospheric Electricity	6
Consumer Behavior	14		Visual Merchandising	5
Consumer Behaviour	13		Shopping Behavior	5
Consumption Behavior	11		Shopping Activity	5
Servicescape	10		Scent	5
Music	10		Sales	5
Customer Experience	10		Retail Stores	5
Sensory Marketing	9		Emotions	5
Emotion	9		Electronic Commerce	5
Retail Environment	7		E-commerce	5
Design	7		Digital Signage	5
			Aesthetics	5

Source: All figures collected from Scopus Analytics

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Table 5: WOS - Top 10 published articles with author and Journal publications.

Research Publication Title	Author	Journal
Atmospheric effects on shopping behavior: A review of the experimental evidence	Turley, LW and Milliman, RE	JOURNAL OF BUSINESS RESEARCHarrow_drop_down 49 (2) , pp.193-211
Empirical testing of a model of online store atmospherics and shopper responses	Eroglu, SA; Machleit, KA and Davis, LM	PSYCHOLOGY & MARKETINGarrow_drop_down 20 (2) , pp.139-150
Perceived quality, emotions, and behavioral intentions: Application of an extended Mehrabian-Russell model to restaurants	Jang, SC and Namkung, Y	JOURNAL OF BUSINESS RESEARCHarrow_drop_down 62 (4) , pp.451-460
The Future of Retailing	Grewal, D; Roggeveen, AL and Nordfält, J	JOURNAL OF RETAILINGarrow_drop_down 93 (1) , pp.1-6
Customer Experience Management in Retailing: Understanding the Buying Process	Puccinelli, NM; Goodstein, RC; (...); Stewart, D	JOURNAL OF RETAILINGarrow_drop_down 85 (1) , pp.15-30
AN EXPERIMENTAL APPROACH TO MAKING RETAIL STORE ENVIRONMENTAL DECISIONS	BAKER, J; LEVY, M and GREWAL, D	JOURNAL OF RETAILINGarrow_drop_down 68 (4) , pp.445-460
Impact of ambient odors on mall shoppers' emotions, cognition, and spending - A test of competitive causal theories	Chebat, JC and Michon, R	JOURNAL OF BUSINESS RESEARCHarrow_drop_down 56 (7) , pp.529-539
Cross-category effects of induced arousal and pleasure on the Internet shopping experience	Menon, S and Kahn, B	JOURNAL OF RETAILINGarrow_drop_down 78 (1) , pp.31-40
Retail environment, self-congruity, and retail patronage: An integrative model and a research agenda	Sirgy, MJ; Grewal, D and Mangleburg, T	JOURNAL OF BUSINESS RESEARCHarrow_drop_down 49 (2) , pp.127-138
An expanded servicescape perspective	Rosenbaum, MS and Massiah, C	JOURNAL OF SERVICE MANAGEMENTarrow_drop_down 22 (4) , pp.471-490

Source: All figures collected from Web Of Science Analytics

Table 5A: SCOPUS - Top 10 published articles with author and Journal publications.

Top 10 of 345 Publications		
Research publication title	**Author**	**Journal**
Customer Experience Management in Retailing: Understanding the Buying Process	Puccinelli, N.M., Goodstein, R.C., Grewal, D., ... Raghubir, P., Stewart, D.	Journal of Retailing, 2009, 85(1), pp. 15–30
Impact of ambient odors on mall shoppers' emotions, cognition, and spending: A test of competitive causal theories	Chebat, J.-C., Michon, R.	Journal of Business Research, 2003, 56(7), pp. 529–539
Cross-category effects of induced arousal and pleasure on the Internet shopping experience	Menon, S., Kahn, B.	Journal of Retailing, 2002, 78(1), pp. 31–40
Retail environment, self-congruity, and retail patronage: An integrative model and a research agenda	Sirgy, M.J., Grewal, D., Mangleburg, T.	Journal of Business Research, 2000, 49(2), pp. 127–138

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Store atmospherics: A multisensory perspective	Spence, C., Puccinelli, N.M., Grewal, D., Roggeveen, A.L.	Psychology and Marketing, 2014, 31(7), pp. 472–488
The interactional effects of atmospherics and perceptual curiosity on emotions and online shopping intention	Koo, D.-M., Ju, S.-H.	Computers in Human Behavior, 2010, 26(3), pp. 377–388
Mall atmospherics: The interaction effects of the mall environment on shopping behavior	Michon, R., Chebat, J.-C., Turley, L.W.	Journal of Business Research, 2005, 58(5), pp. 576–583
In-store music and aroma influences on shopper behavior and satisfaction	Morrison, M., Gan, S., Dubelaar, C., Oppewal, H.	Journal of Business Research, 2011, 64(6), pp. 558–564
Calibrating 30 Years of Experimental Research: A Meta-Analysis of the Atmospheric Effects of Music, Scent, and Color	Roschk, H., Loureiro, S.M.C., Breitsohl, J.	Journal of Retailing, 2017, 93(2), pp. 228–240
The DAST Framework for Retail Atmospherics: The Impact of In- and Out-of-Store Retail Journey Touchpoints on the Customer Experience	Roggeveen, A.L., Grewal, D., Schweiger, E.B.	Journal of Retailing, 2020, 96(1), pp. 128–137

Source: All figures collected from Scopus Analytics

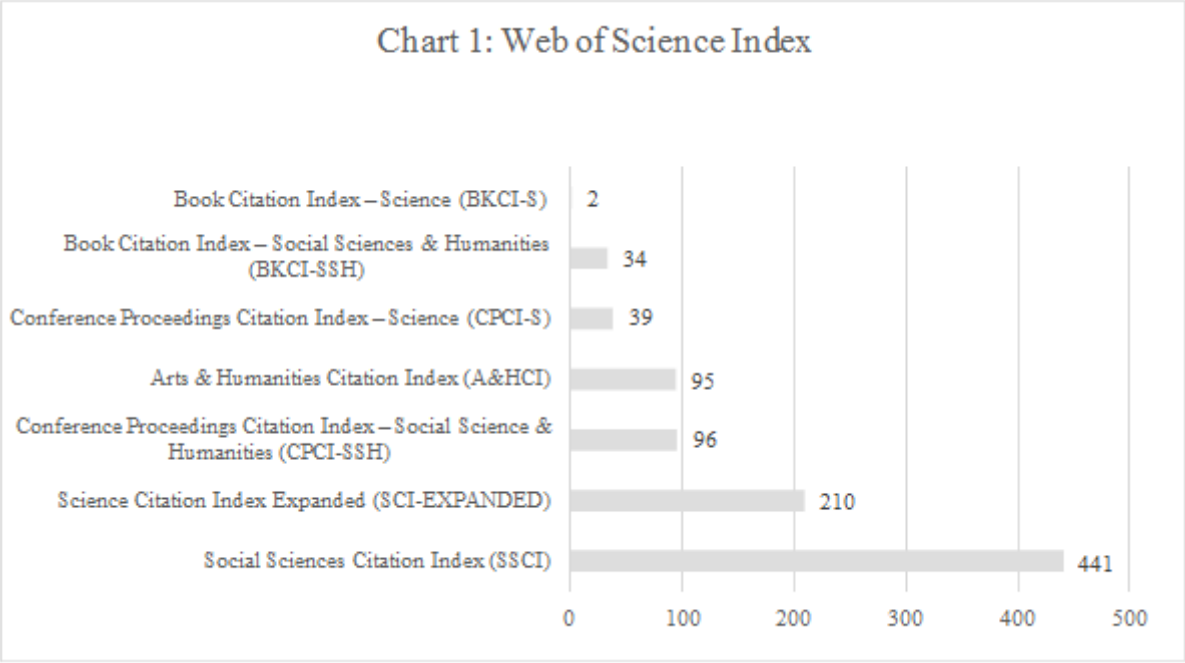

Chart 1: Top web of science index with maximum number of publications.

Source: All figures collected from Web Of Science Analytics

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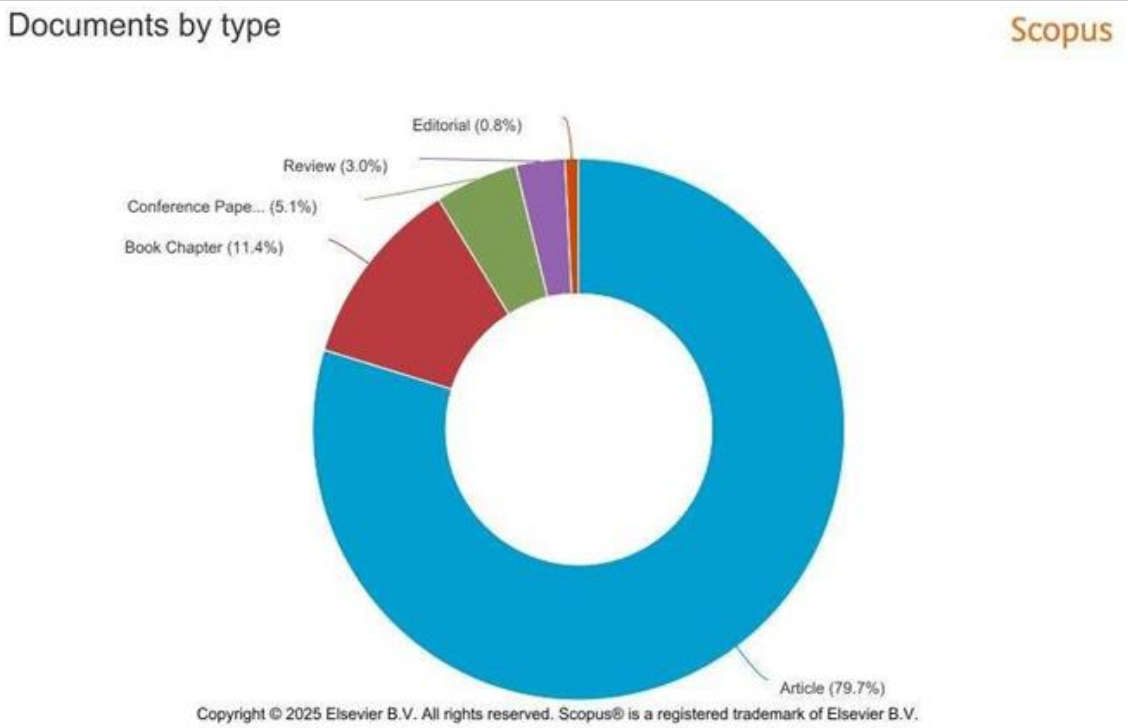

Chart 1A: Article types in Scopus Index.

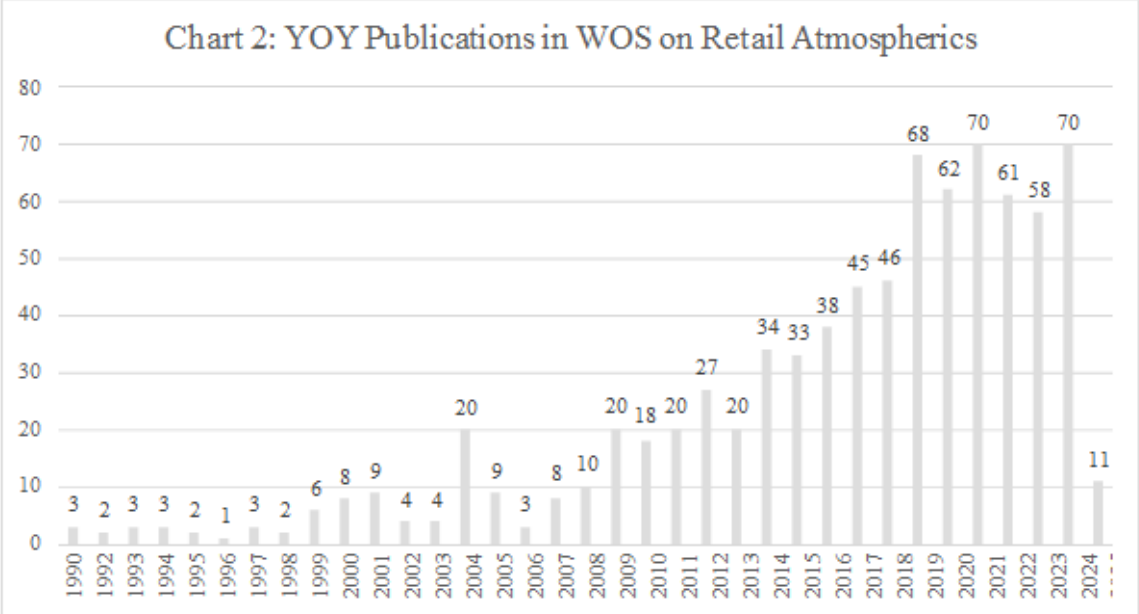

Chart 2: Year on year scientific publications in web of science on Retail Atmospherics

Source: All figures collected from Web Of Science Analytics

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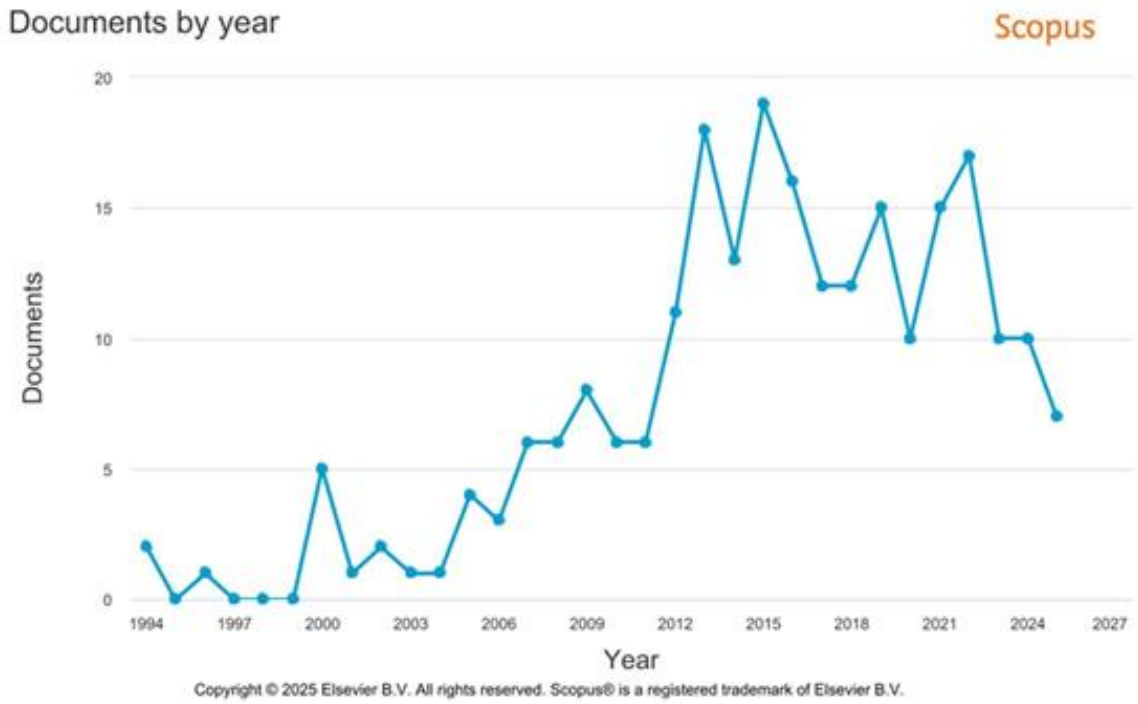

Chart 2A: Year on year scientific publications in Scopus on Retail Atmospherics

Source: All figures collected from Scopus Analytics

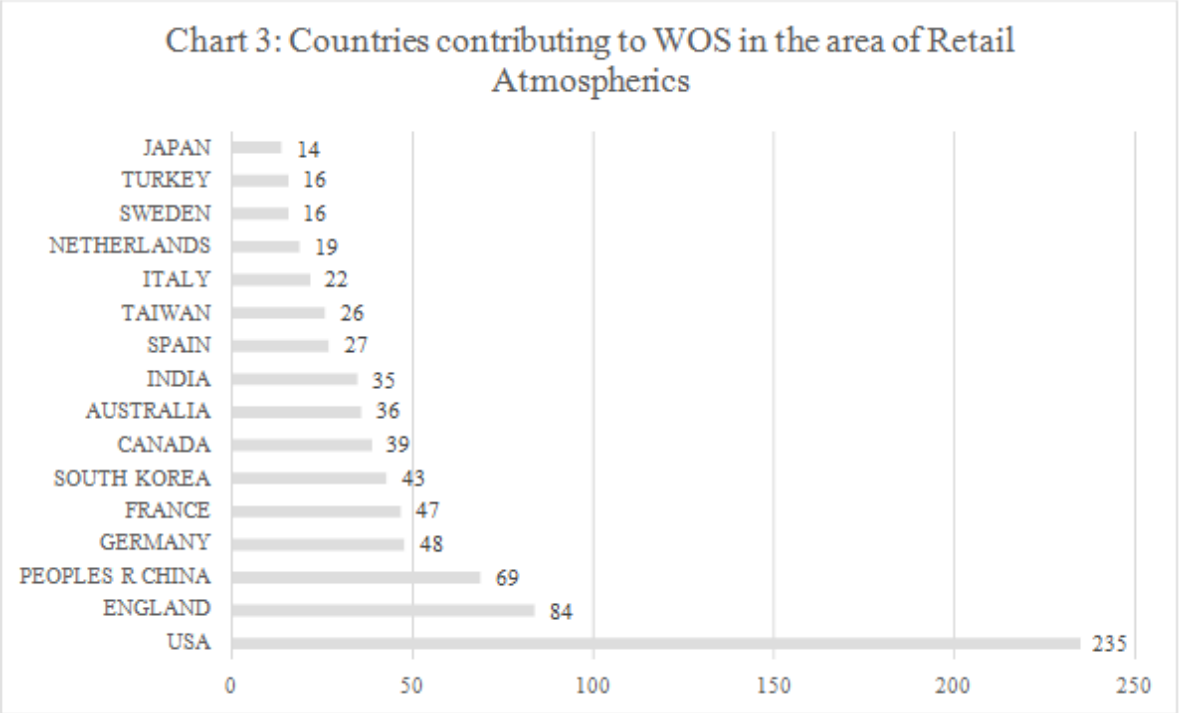

Chart 3: County-wise contribution in publications in WOS on retail atmospherics

Source: All figures collected from Web Of Science Analytics

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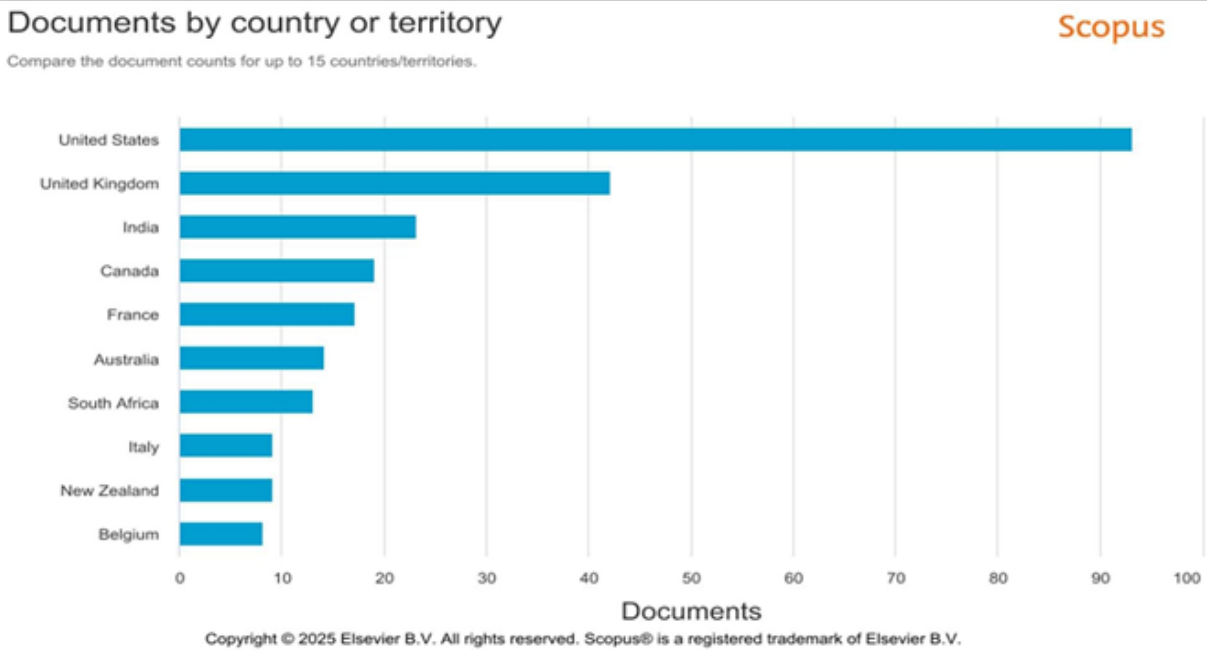

Chart 3A: County-wise contribution in publications in Scopus on retail atmospherics

Source: All figures collected from Scopus Analytics

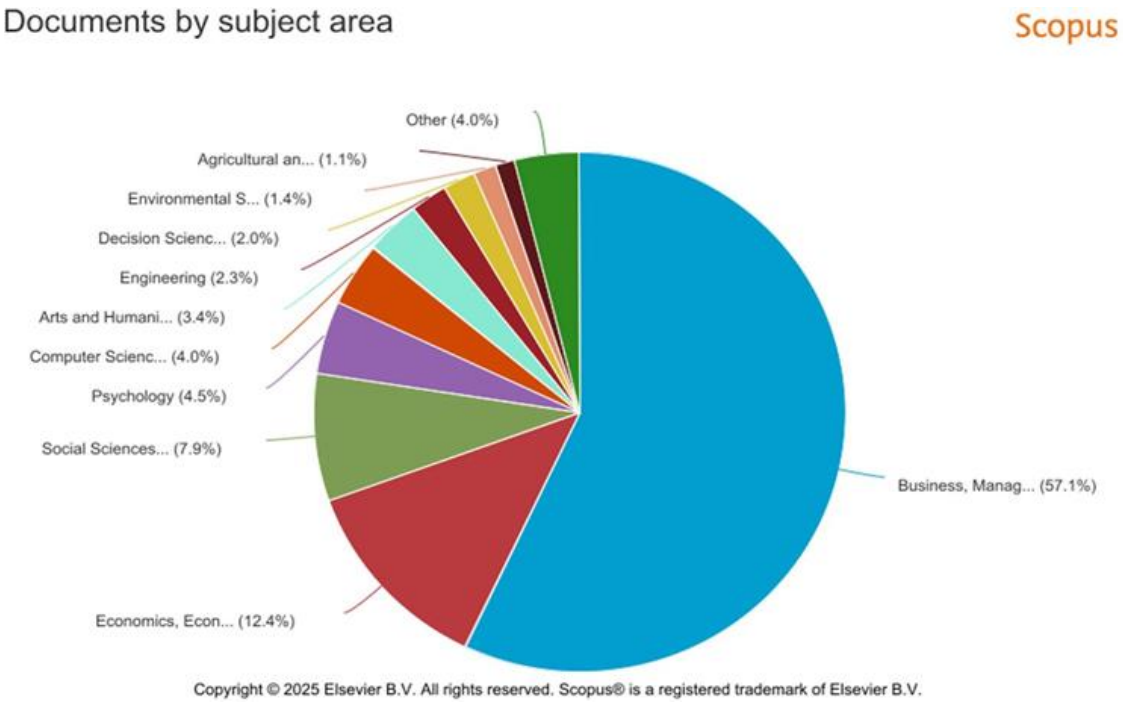

Chart 4: Subject Areas covered under Scopus Index by the keyword 'Retail Atmospherics'

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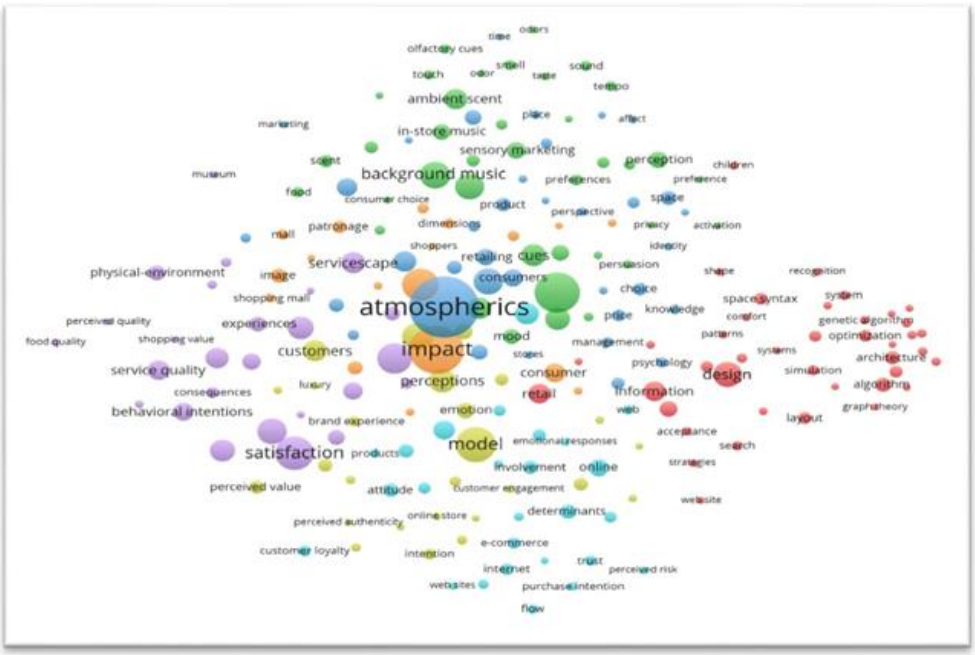
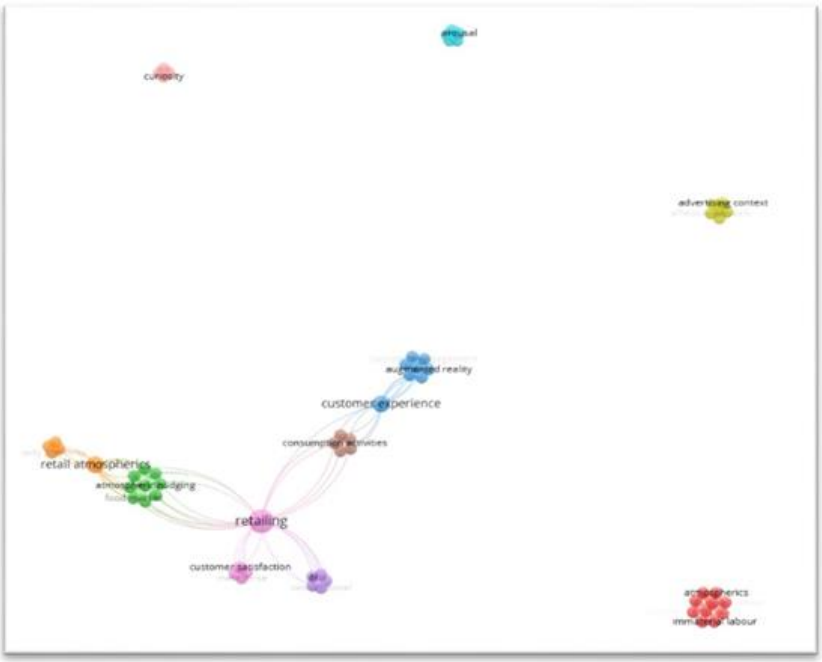


Map 1 (WOS): Co-Occurance Analysis of Keywords in WOS

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Web of Science.



Map 1A (Scopus): Co-Occurance Analysis of Keywords in Scopus

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Scopus.

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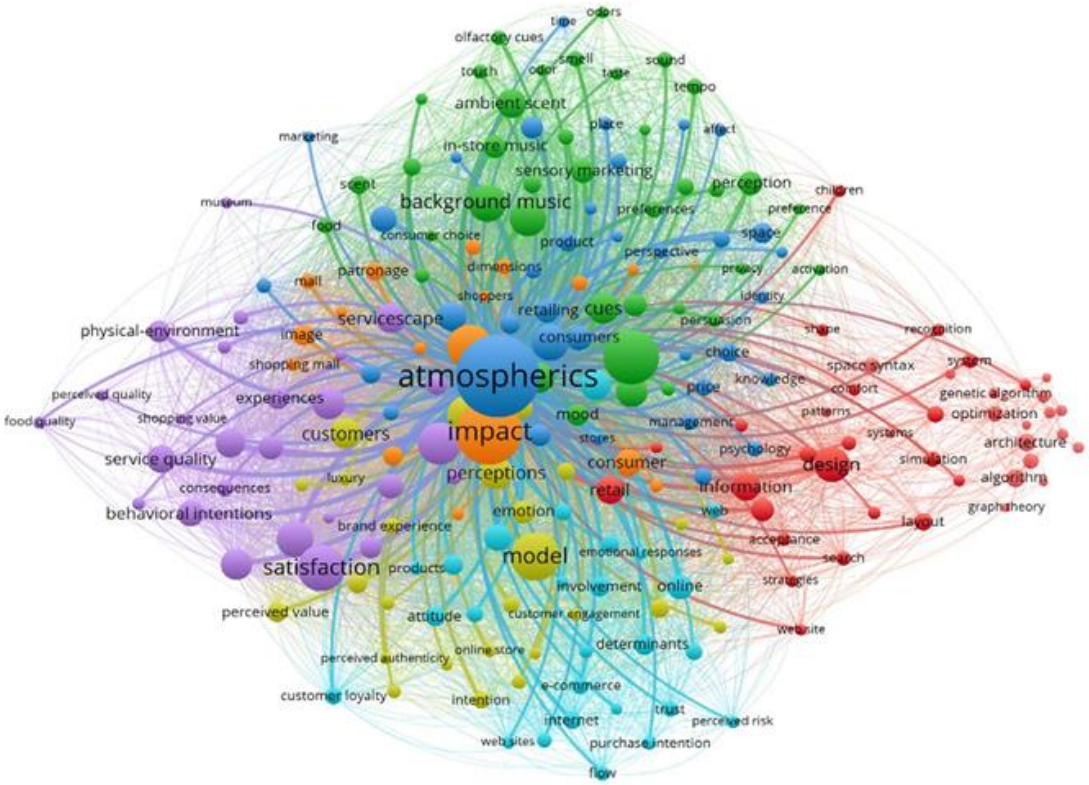
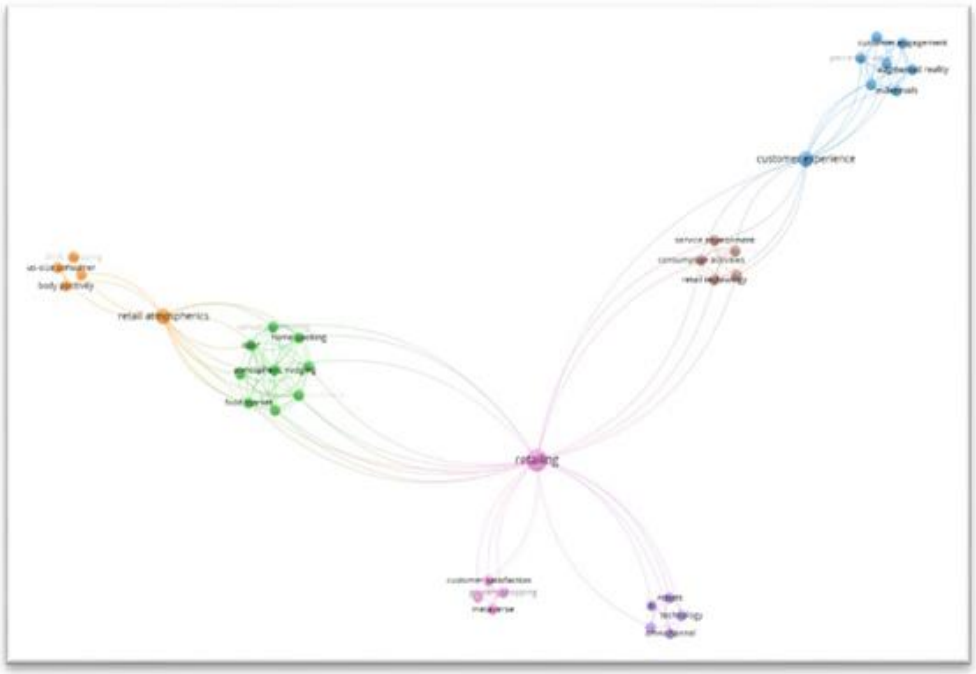


Map 2 (WOS): Co-Occurance Analysis of Keywords with Links in WOS

Source: version 1.6.20. All maps are created using the keywords data pulled from Web of Science.



Map 2A (Scopus): Co-Occurance Analysis of Keywords in Scopus zooming in the large cluster

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Scopus.

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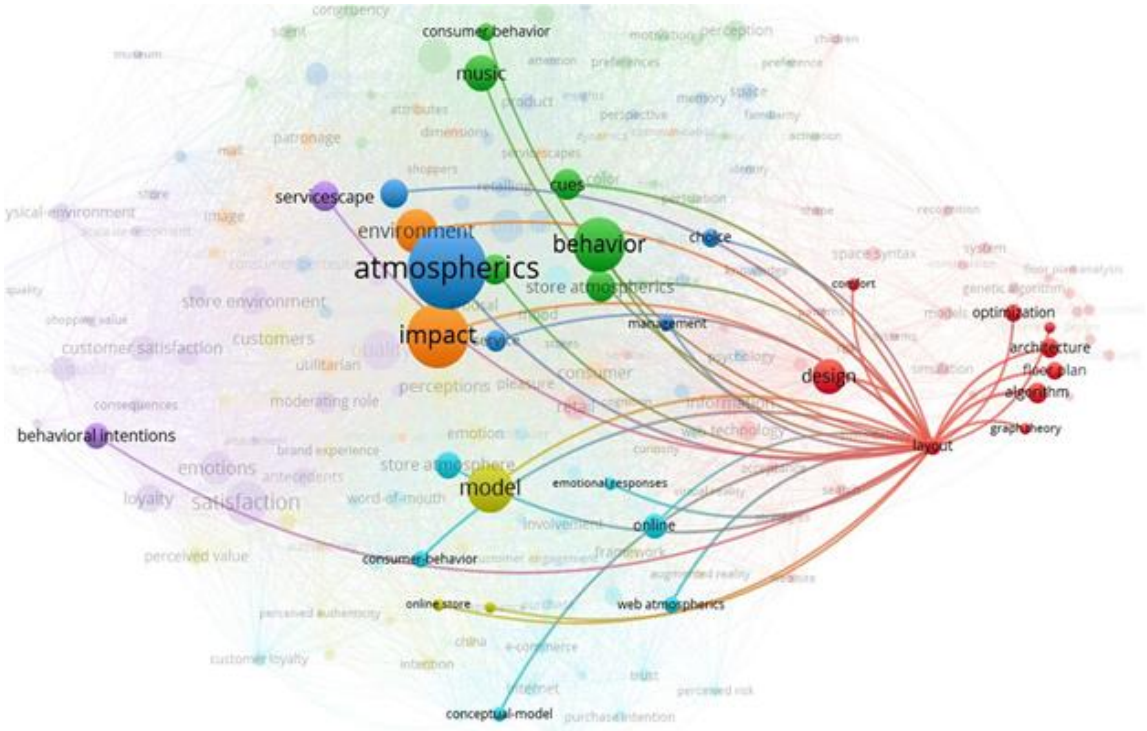
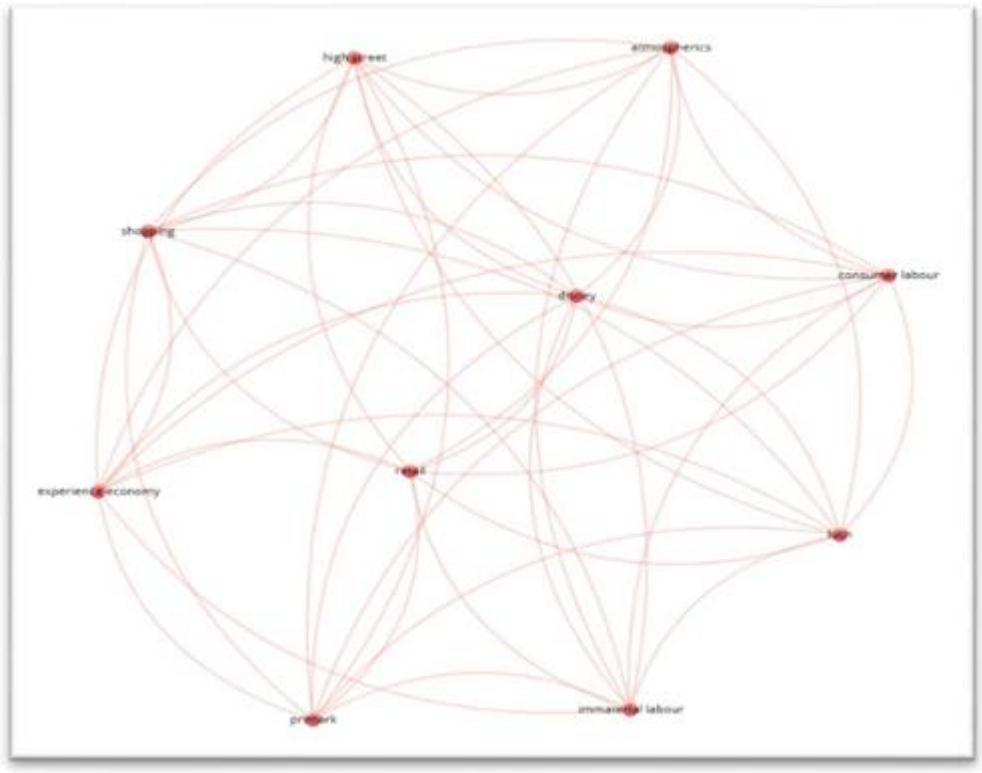


Map 3 (WOS): Co-Occurance Analysis of Keyword "Layout" in WOS

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from WoS.



Map 3A (Scopus): Co-Occurance Analysis of Keywords in Scopus zooming in the small cluster with keyword Atmospherics.

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Scopus.

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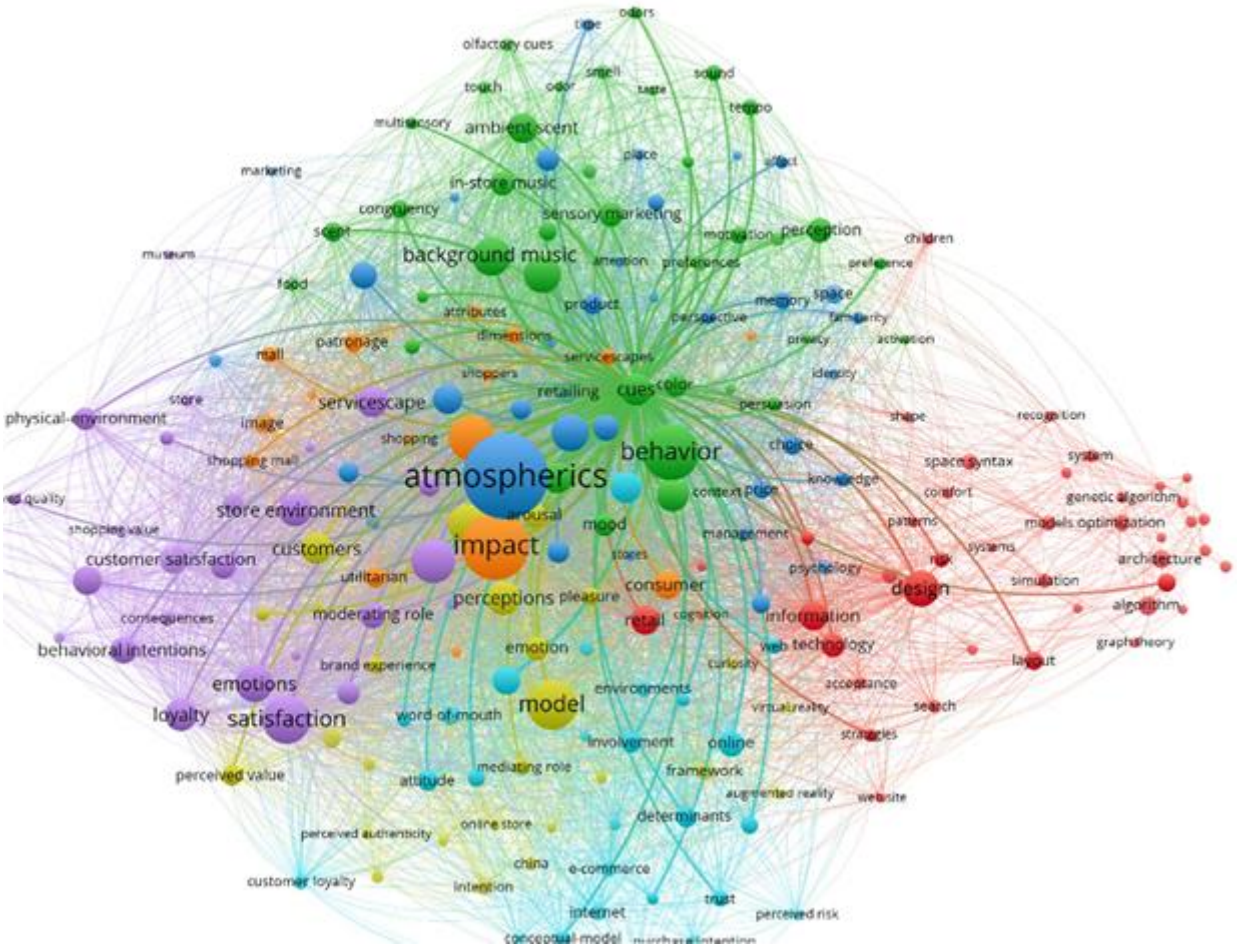
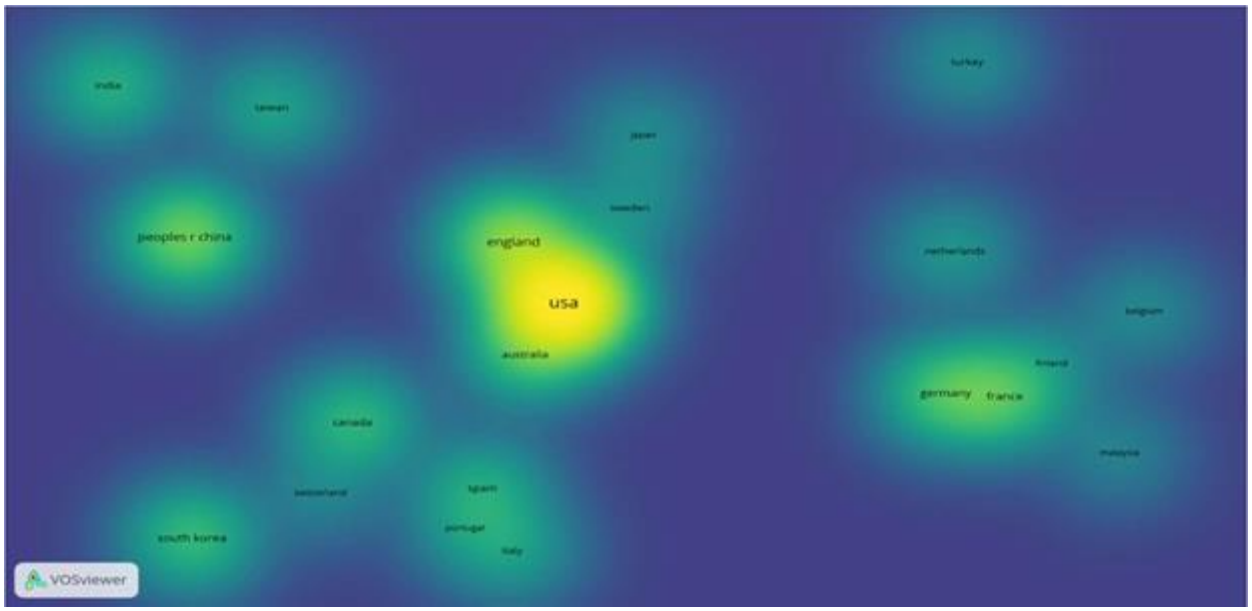


Map 4: Co-Occurance Analysis of Keyword "Cues" in WOS

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Web of Science.



Map 5: Co-Authorship Analysis of countries – Density Visualization Map in WOS

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Web of Science.

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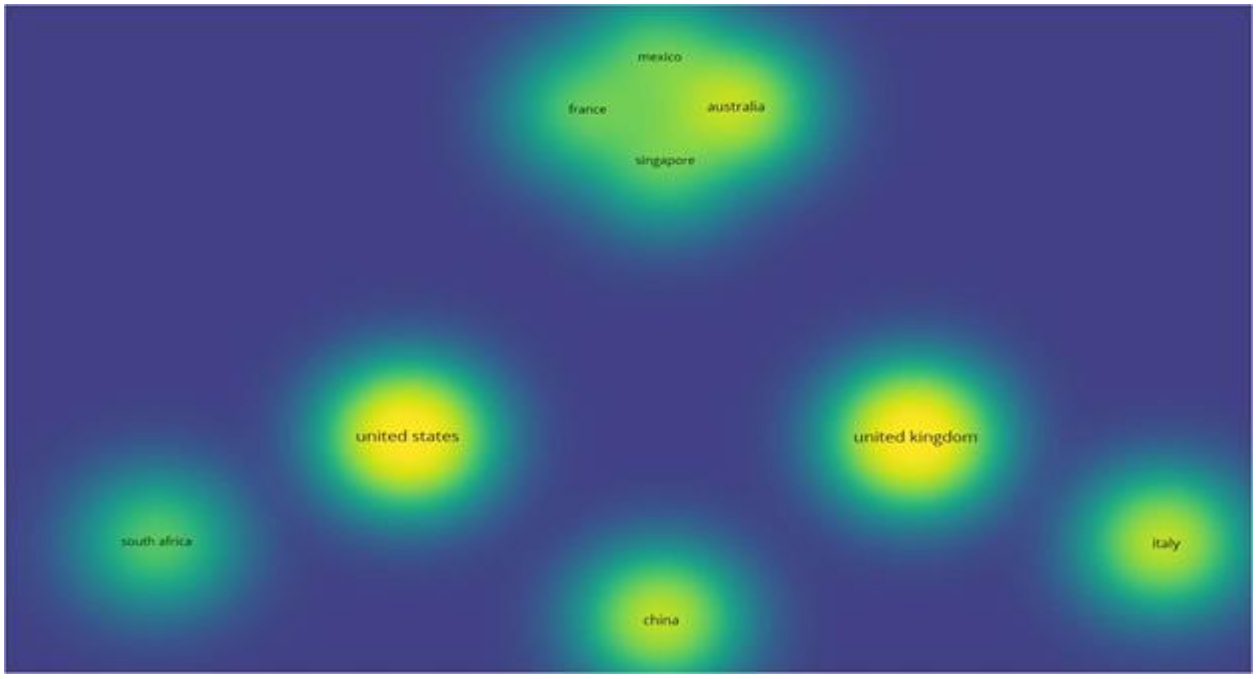
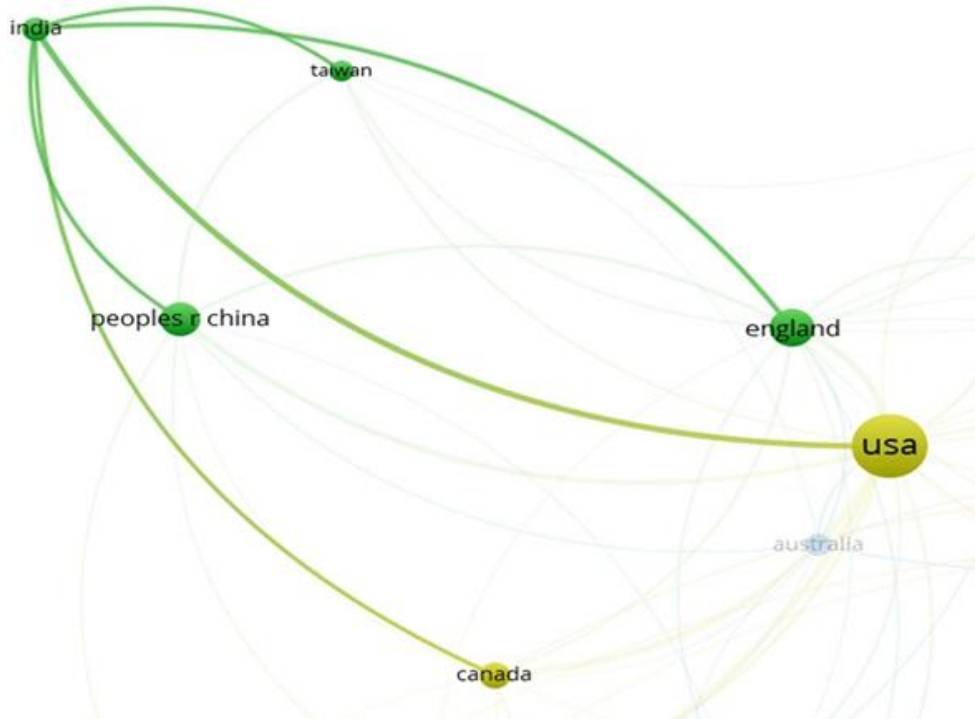


Map 5A: Co-Authorship Analysis of countries – Density Visualization Map in Scopus

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Scopus.



Map 6 (WOS): Co-Authorship Analysis of countries – Focus India in WOS

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Web of Science.

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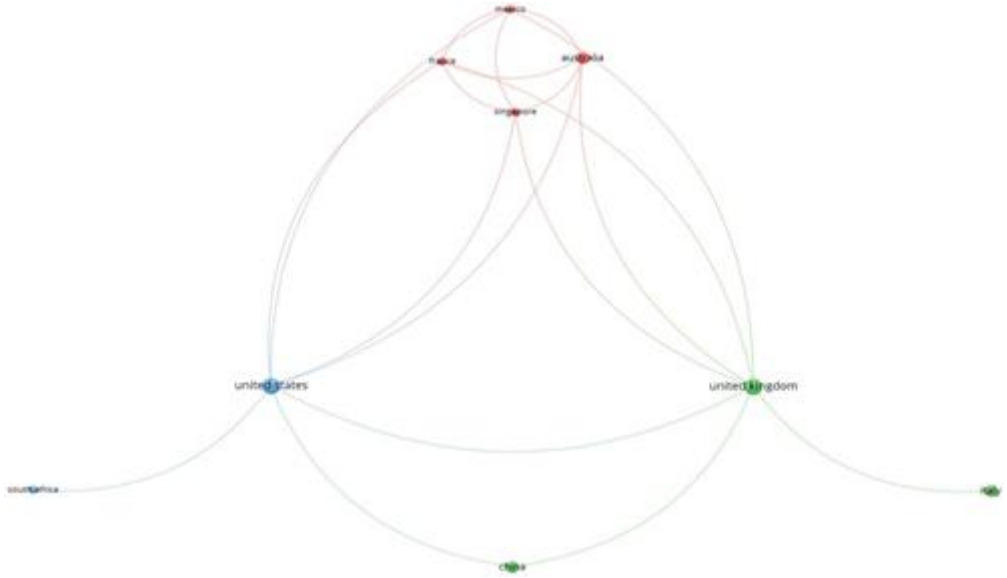
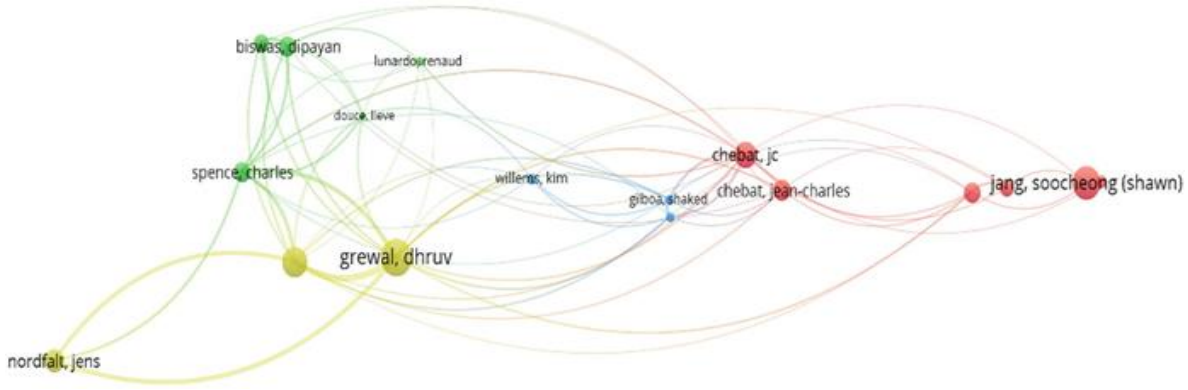


Map 6A (Scopus): Co-Authorship Analysis of countries – Scopus

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Scopus.



Map 7 (WOS): Citation Analysis of of Authors in WOS

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Web of Science.

Map 7A(Scopus): Citation Analysis of of Authors in Scopus

Source: VOSviewer version 1.6.20. All maps are created using the keywords data pulled from Scopus.

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TAILORING EXPERIENTIAL LEARNING PEDAGOGIES TO LEARNING STYLES: A STUDY AMONG MBA STUDENTS

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[1]Mba Student and [2]Associate Profesor, Scms School of Technoogy and Management

BACKGROUND AND RATIONALE

- Changing landscape of education: The demand for skill-based, application-oriented learning is increasing globally.
- Experiential learning (e.g., internships, case studies, simulations) is increasingly recognized as effective in bridging theory with real-world practice.
- OECD (2023) emphasizes that social-emotional skills (adaptability, collaboration, responsibility) are as critical as academic knowledge for success in today's workforce.
- GMAC (2024) survey shows 88% of employers seek MBA graduates with practical problem-solving and team collaboration skills—skills best developed through experiential learning

RESEARCH OBJECTIVES

- Identify dominant learning styles (VARK) among MBA students.
- Determine preferred experiential learning methods.
- Examine the relationship between learning styles and EL method preferences.
- Explore the impact of EL methods on perceived skill development in areas such as
- Communication, teamwork, problem-solving and strategic thinking.

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RESEARCH METHODOLOGY

Research Design

- Type of Study: Descriptive and analytical research
- Approach: Quantitative, survey-based method
- Purpose: To investigate the alignment between MBA students' learning styles and their experiential learning preferences, and the perceived skill development

Sample & Data Collection

- Population: MBA students
- Sampling Technique: Convenient sampling
- Sample Size: N = 100
- Mode of Data Collection: Online via Google Forms

Survey Instrument

The structured questionnaire included:

1. Demographic Details: Age, gender
2. Learning Style Assessment (VARK)
3. Experiential Learning Method Preference
4. Experiential Learning Evaluation
5. Skill Enhancement Perception

DATA ANALYSIS TOOLS

Descriptive Statistics – Frequencies, Percentages for learning styles and preferences

Cross-tabulation – To compare learning styles with method preferences

Chi-Square Test / Correlation Analysis – To examine relationships between categorical variables

Interpretation – Focused on patterns that show how learning styles align with experiential method choices and perceived skill gains

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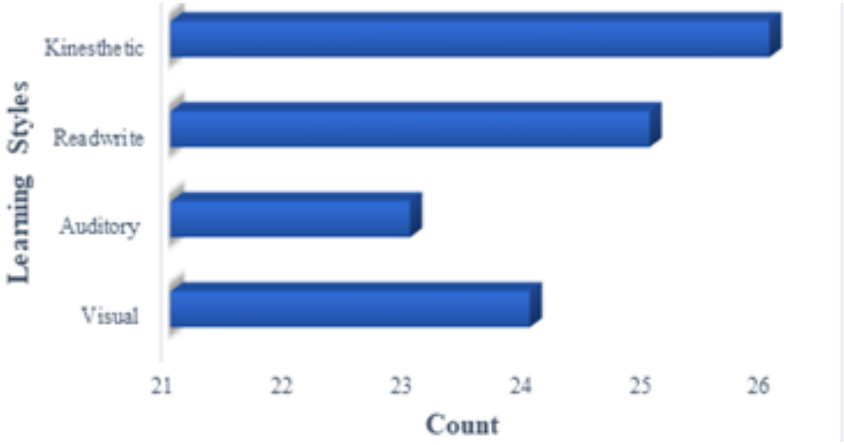
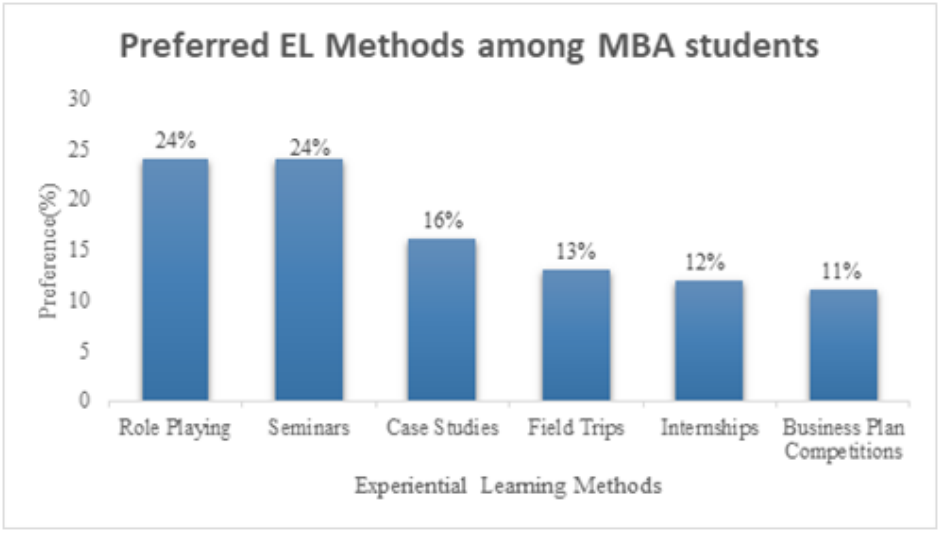
FINDINGS

1. Understanding the Dominant Learning Style



2. The preferred experiential learning method



FINDINGS

3. The relationship between identified learning styles and preferences for specific experiential learning methods.

Learning Style	Preferred Methods	Percentage
Visual	Role Playing	33%
	Internship	20%
	All other Methods put together	57%
Auditory	Seminars	69%
	All other Methods put together	21%
Read/Write	Case Studies	20%
	Role Playing	20%
	Internship	20%
	All other Methods put together	40%
Kinesthetic	Role Playing	34%
	Case Studies	19%
	All other Methods put together	57%

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4. Perceived skill development resulting from past experiential learning experiences

EL Method	Problem Solving	Communication	Strategic Thinking	Teamwork
Internship	28%	23%	18%	31%
Case Studies	20%	18%	28%	34%
Role Playing	28%	28%	18%	26%
Seminars	19%	27%	24%	30%
Field Trips	26%	28%	21%	25%
Business Plan Competitions	23%	28%	26%	23%

CONCLUSION

Key Takeaways

Learning-Centric Curriculum Design

- The study revealed that dominant learning styles influence the preference for certain experiential methods.
- Implication: MBA curricula should be flexible and diversified to incorporate a range of experiential formats matching diverse learning styles.

Enhanced Skill Alignment

- Respondents indicated that specific skills\were best developed through targeted experiential activities
- Implication: Mapping experiential methods to the most relevant skill sets can optimize student development.

Data-Driven Pedagogy

- The use of tools like the VARK framework can provide personalized learning pathways, improving student engagement and outcomes.
- Implication: Institutions can adopt psychometric tools to diagnose learning preferences at the start of programs.

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RECOMMENDATIONS FOR EDUCATORS AND INSTITUTIONS

- Customize Experiential Learning Based on VARK Profiles
- Integrate Experiential Methods with Skill Goals
- Periodic assessment

Final Thought: A one-size-fits-all pedagogy no longer fits today's MBA classroom. Tailoring experiential learning to students' learning styles can make management education more inclusive, effective, and future-ready**.**

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AI-DRIVEN PREDICTIVE ANALYTICS FOR PERSONALIZED AND PROACTIVE HEALTHCARE SYSTEMS

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ABSTRACT
Predictive systems made possible by artificial intelligence (AI) are revolutionising healthcare by allowing for more precise, rapid, and individualised medical procedures. Using data analytics, NLP, and machine learning algorithms, this article delves into the ways AI is being applied to predictive healthcare, specifically in the areas of illness risk prediction, treatment plan optimisation, and patient outcome improvement. Using massive datasets derived from genetic information, electronic health records, and real-time monitoring equipment, predictive algorithms seek out trends and outliers that can suggest possible health problems. In the long run, these innovations help save healthcare costs and improve service delivery by facilitating early diagnosis, preventative care, and effective use of resources. Data privacy, ethics, and the necessity for legal frameworks are some of the obstacles to AI implementation that the research delves into. Intelligent, person-centred medical treatment is possible with the help of AI-driven prediction technologies, which will allow the healthcare industry to change its focus from a reactive to a proactive paradigm.

Keywords: Artificial Intelligence, Applications, Predictive Healthcare Systems

INTRODUCTION
- AI enables early diagnosis, personalized treatments, and efficient resource management.
- Predictive models analyze data from EHRs, wearables, genetics, and lifestyle factors.
- Proven success in predicting diseases like diabetes, cardiovascular issues, Alzheimer's, and cancer.
- AI-powered wearables provide real-time alerts, supporting proactive patient behavior.
- Key challenges: data privacy, algorithmic bias, and lack of interpretability (black-box issue).
- Solutions include Explainable AI (XAI), ethical frameworks, and cross-sector collaboration.
- Future direction: AI will drive precision medicine, telehealth, and equitable global healthcare access.

LITERATURE REVIEW
- **Wu, Yutong. (2024)** These days, artificial intelligence (AI) technology has a good effect on healthcare decision-making, early disease identification, and service optimization. Many different forms of data may be used with artificial intelligence. This article has reviewed the latest developments in artificial intelligence (AI) technology, applications in healthcare, pros and cons, and ethical considerations.
- **Hasan, (2023)** Modern medicine is being improved and revolutionized by artificial intelligence due to its capacity to comprehend, learn, act, and predict. This is the same regardless of whether the technology is utilised to guide robotic surgeons or to unearth previously unknown relationships between genes. Unlike humans, it is able to pick up on subtle patterns.
- **Datta, (2019)** Artificial intelligence (AI) is fast changing the healthcare industry due to its numerous potential applications. Diagnostic assistance, administrative simplification, personalised medicine, and predictive analytics are just a few of the various applications of artificial intelligence (AI) covered in this article.

RESULTS AND DISCUSSION
Here we contrast the current PSO and RBF-TSVM method with the suggested OCSO and RBF-TSVM technique.

(a) Accuracy
The ratio of factual positive or negative results is known as accuracy. It determines the degree to which an evaluation of a situation is accurate. The indication for it is,

$$Accuracy = \frac{TP+TN}{TP+FP+TN+FN} \times 100$$

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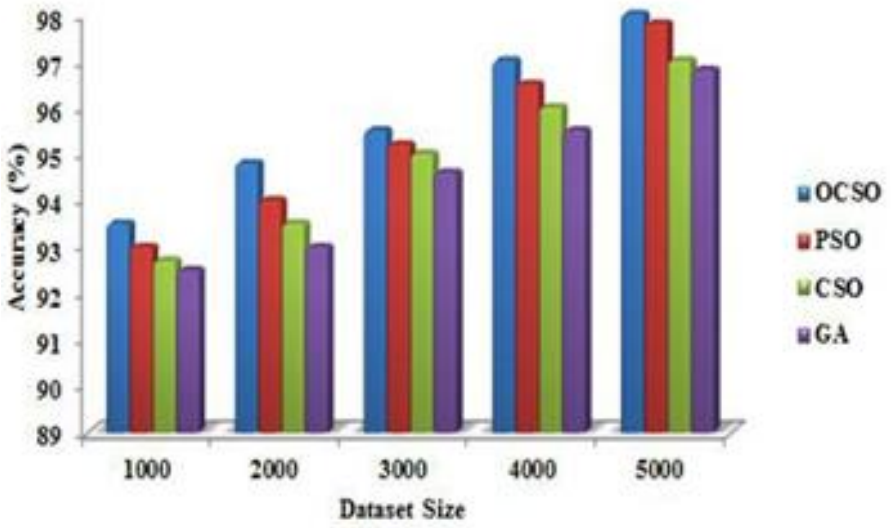

Figure 4 Results graph for accuracy

In Figure 4, we can see the results of comparing the accuracy of the classification techniques based on OCSO and RBF-TSVM with the ones based on PSO, CSO, and GA. The Y-axis shows the accuracy rate, while the X-axis shows the amount of the dataset.

- **Sensitivity**

This study compares the accuracy of the current PSO and RBF-TSVM based classification technique with that of the proposed OCSO and RBF-TSVM based classification approach, On the X-axis, we have the dataset size, and on the Y-axis, we have the sensitivity. Additionally, RBF-TSVM is used to accomplish an effective categorization. The suggested OCSO and based RBF-TSVM classification method outperformed the state-of-the-art system across all dataset sizes.

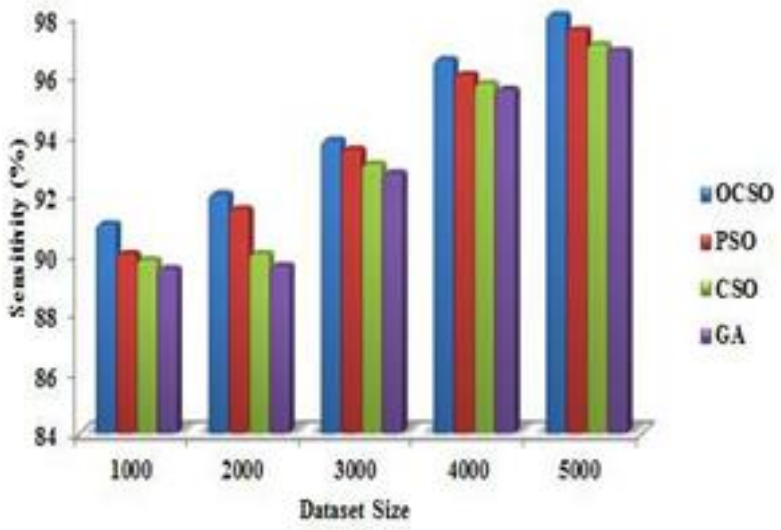

Figure 5 Results graph for sensitivity

$$Sensitivity = \frac{TP}{TP + FN}$$

- **Specificity**
- In Figure we can see the accuracy comparison between the current PSO and RBF-SVM based classification method and the proposed OCSO and RBF-TSVM based method.
- On the one hand, we have the dataset size (X-axis) and the specificity (Y-axis). The suggested OCSO and based RBF-TSVM classification method outperformed the state-of-the-art system across all dataset sizes.

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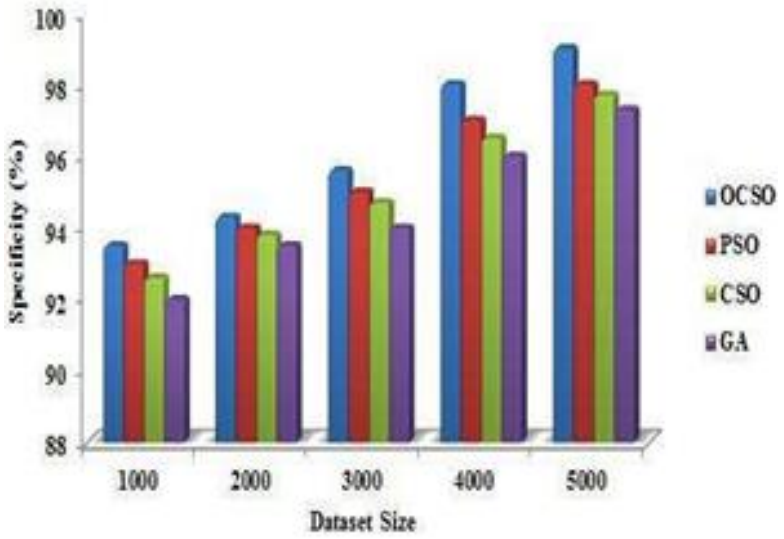

Figure: Results graph for specificity

$$Specificity = \frac{TN}{TN + FP}$$

The findings of OCSO's comparison with PSO, CSO, and GA are shown in Tables 1, 2, and 3, respectively

Table 1 Evaluation of OCSO vs. PSO

Data Size	Accuracy		Sensitivity		Specificity	
	OCSO	PSO	OCSO	PSO	OCSO	PSO
1000	93.5	93	91	90	93.8	93
2000	95	94	92	91.8	94.2	94
3000	95.5	95	94	93.5	95.8	95.4
4000	97	96	96	95.6	98	96.4
5000	98	97	98	97.5	99	97.5

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Table 2 Results Evaluation of OCSO and CSO

Data Size	Accuracy		Sensitivity		Specificity	
	OCSO	CSO	OCSO	CSO	OCSO	CSO
1000	93.5	92.5	91	90	93.8	91.6
2000	95	93.5	92	90.5	94.2	93.8
3000	95.5	94.8	94	93	95.8	95.2
4000	97	95.6	96	95.4	98	96.2
5000	98	96.5	98	97.2	99	97.4

Table 3 Comparison Results of OCSO and GA

Data Size	Accuracy		Sensitivity		Specificity	
	OCSO	GA	OCSO	GA	OCSO	GA
1000	93.5	92.1	91	88	93.8	91.4
2000	95	93	92	90	94.2	93.4
3000	95.5	94.5	94	92.2	95.8	95
4000	97	95.2	96	95	98	96
5000	98	96.2	98	96.6	99	97

Table: 4.7 Percentage-wise Improvement Table of OCSO over PSO

Data Size	Accuracy	Sensitivity	Specificity
1000	0.53	1.09	0.85
2000	1.05	0.21	0.21
3000	0.52	0.53	0.41
4000	1.03	0.41	1.63
5000	1.02	0.51	1.51

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Table: 4.8 Percentage wise Improvement Table of OCSO over CSO

Data Size	Accuracy	Sensitivity	Specificity
1000	1.06	1.09	2.34
2000	1.57	1.63	0.42
3000	0.73	1.06	0.62
4000	1.44	0.62	1.83
5000	1.53	0.81	1.61

Table: 4.9 Percentage wise Improvement Table of OCSO over GA

Data Size	Accuracy	Sensitivity	Specificity
1000	1.49	3.29	2.55
2000	2.1	2.17	0.84
3000	1.04	1.91	0.83
4000	1.85	1.04	2.04
5000	1.83	1.42	2.02

CONCLUSION AND FUTURE WORK

- **Conclusion**
- **Robust Models for Heart Disease Prediction** This study presents three automated and intelligent models—MFA-RBF-SVM, PSO-RBF-TSVM, and OCSO-RBF-TSVM—designed to classify cardiovascular risk with high accuracy. These models minimize manual intervention and provide a reliable solution for early and efficient disease detection.
- **Enhanced Diagnostic Accuracy and Performance** The MFA-RBF-SVM framework demonstrates strong performance in sensitivity, specificity, and precision through effective dimensionality reduction and optimized classification. It efficiently processes large clinical datasets, ensuring robust and consistent predictions.
- **Optimized Feature Selection and Classification** The PSO-RBF-TSVM model improves prediction by eliminating redundancy using PSO and Rough Set Theory. Further enhancement is achieved by the OCSO-RBF-TSVM, which ensures superior accuracy, recall, and classification through optimal feature reduction.

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MANUSCRIPT SUBMISSION

GUIDELINES FOR CONTRIBUTORS

1. Manuscripts should be submitted preferably through email and the research article / paper should preferably not exceed 8 – 10 pages in all.
2. Book review must contain the name of the author and the book reviewed, the place of publication and publisher, date of publication, number of pages and price.
3. Manuscripts should be typed in 12 font-size, Times New Roman, single spaced with 1" margin on a standard A4 size paper. Manuscripts should be organized in the following order: title, name(s) of author(s) and his/her (their) complete affiliation(s) including zip code(s), Abstract (not exceeding 350 words), Introduction, Main body of paper, Conclusion and References.
4. The title of the paper should be in capital letters, bold, size 16" and centered at the top of the first page. The author(s) and affiliations(s) should be centered, bold, size 14" and single-spaced, beginning from the second line below the title.

First Author Name1, Second Author Name2, Third Author Name3

1Author Designation, Department, Organization, City, email id

2Author Designation, Department, Organization, City, email id

3Author Designation, Department, Organization, City, email id

5. The abstract should summarize the context, content and conclusions of the paper in less than 350 words in 12 points italic Times New Roman. The abstract should have about five key words in alphabetical order separated by comma of 12 points italic Times New Roman.
6. Figures and tables should be centered, separately numbered, self explained. Please note that table titles must be above the table and sources of data should be mentioned below the table. The authors should ensure that tables and figures are referred to from the main text.

EXAMPLES OF REFERENCES

All references must be arranged first alphabetically and then it may be further sorted chronologically also.

- **Single author journal article:**

Fox, S. (1984). Empowerment as a catalyst for change: an example for the food industry. *Supply Chain Management*, *2*(3), 29–33.

Bateson, C. D.,(2006), 'Doing Business after the Fall: The Virtue of Moral Hypocrisy', Journal of Business Ethics, 66: 321 – 335

- **Multiple author journal article:**

Khan, M. R., Islam, A. F. M. M., & Das, D. (1886). A Factor Analytic Study on the Validity of a Union Commitment Scale. *Journal of Applied Psychology*, *12*(1), 129-136.

Liu, W.B, Wongcha A, & Peng, K.C. (2012), "Adopting Super-Efficiency And Tobit Model On Analyzing the Efficiency of Teacher's Colleges In Thailand", International Journal on New Trends In Education and Their Implications, Vol.3.3, 108 – 114.

- **Text Book:**

Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2007). *Designing and Managing the Supply Chain: Concepts, Strategies and Case Studies* (3rd ed.). New York: McGraw-Hill.

S. Neelamegham," Marketing in India, Cases and Reading, Vikas Publishing House Pvt. Ltd, III Edition, 2000.

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- **Electronic sources should include the URL of the website at which they may be found, as shown:**

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- **Unpublished dissertation/ paper:**

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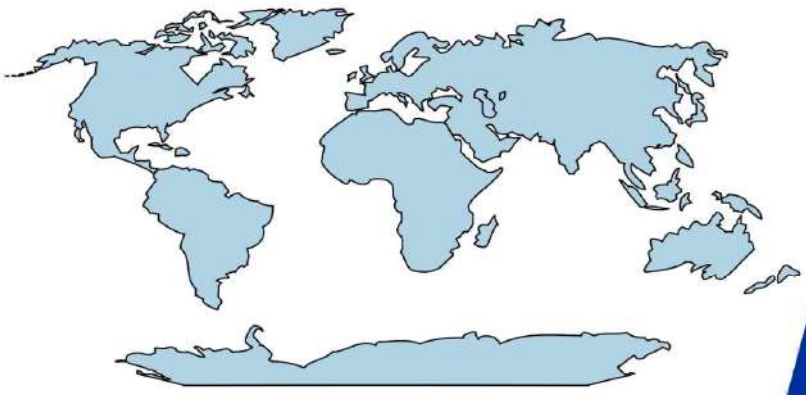

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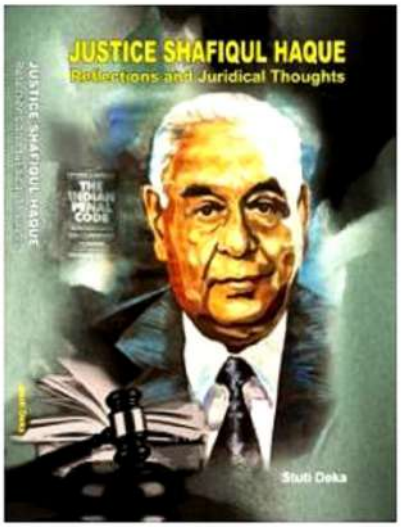

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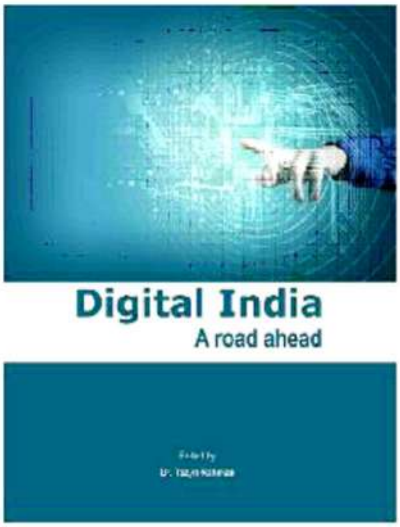

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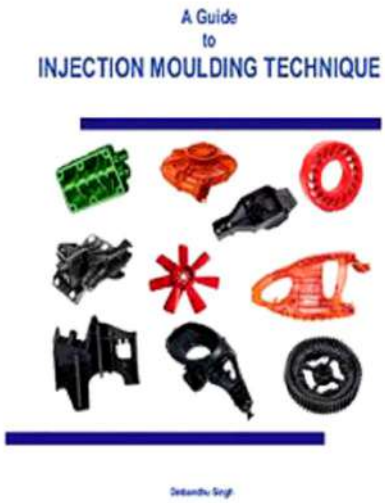

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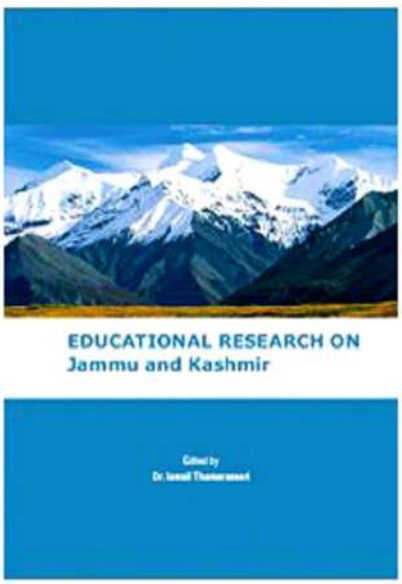

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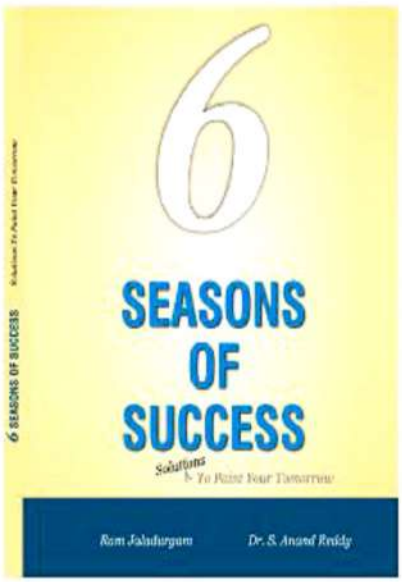

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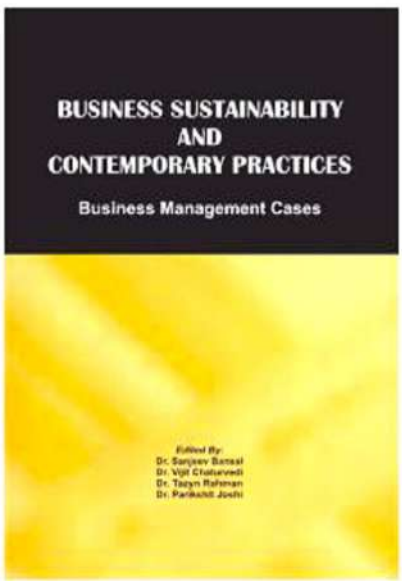

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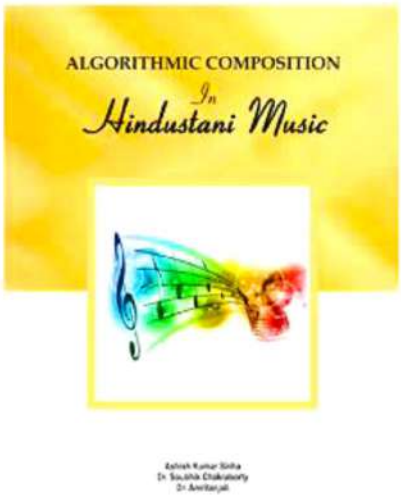

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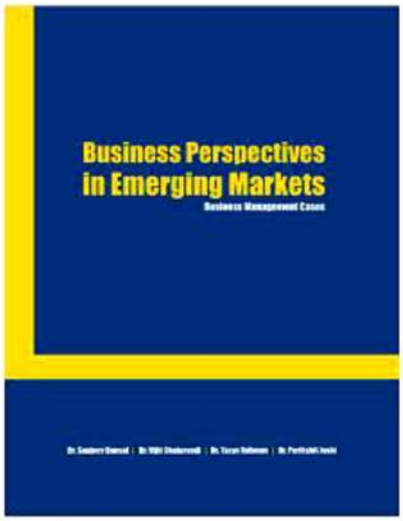

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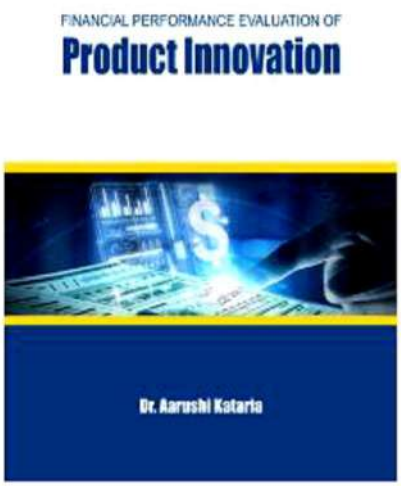

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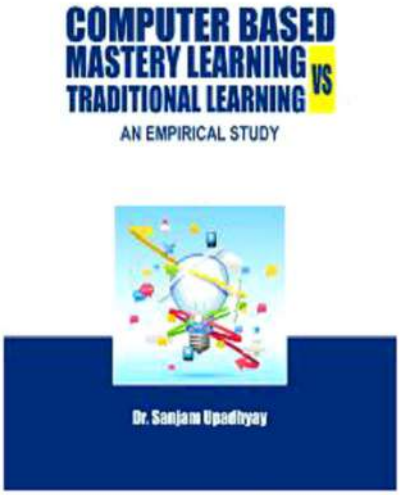

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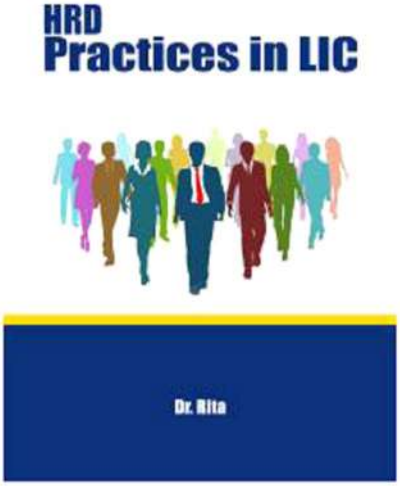

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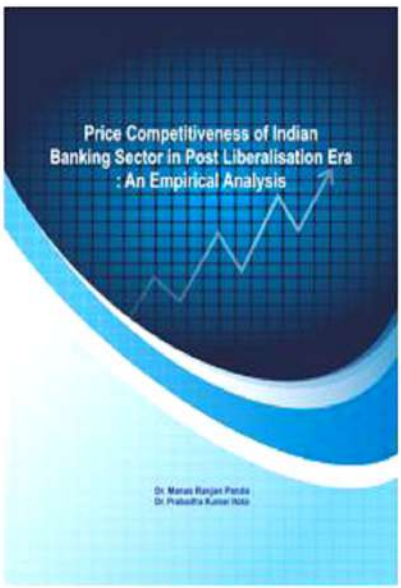

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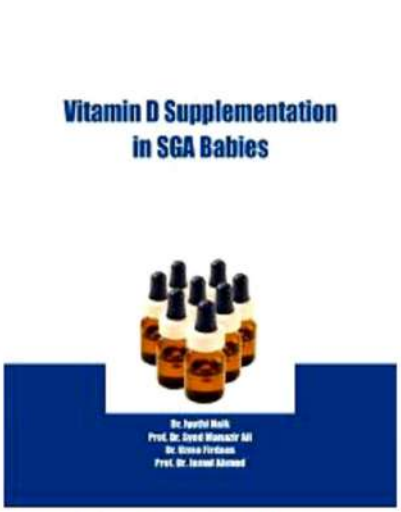

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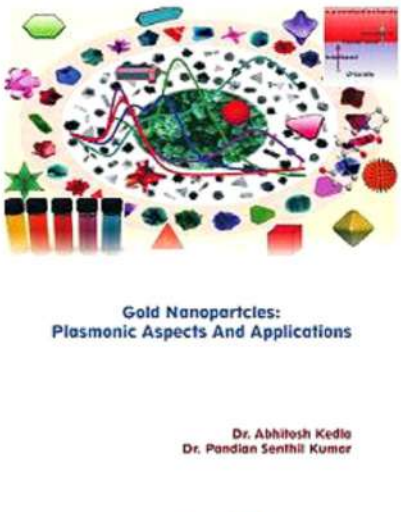

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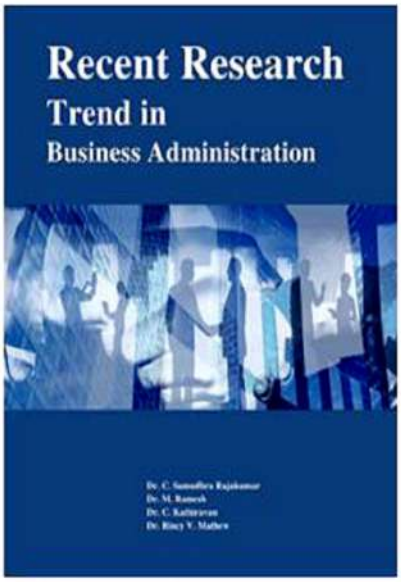

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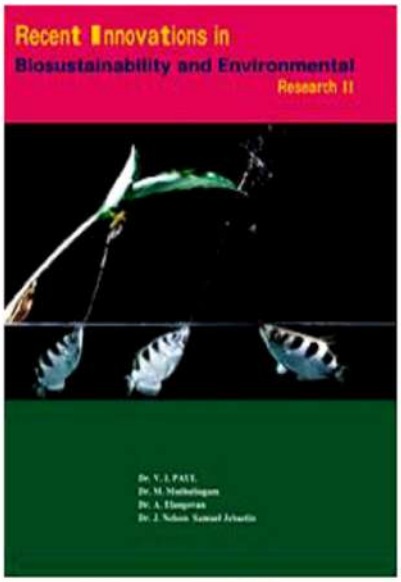

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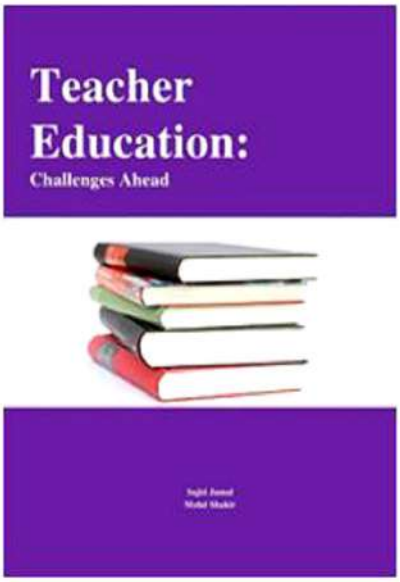

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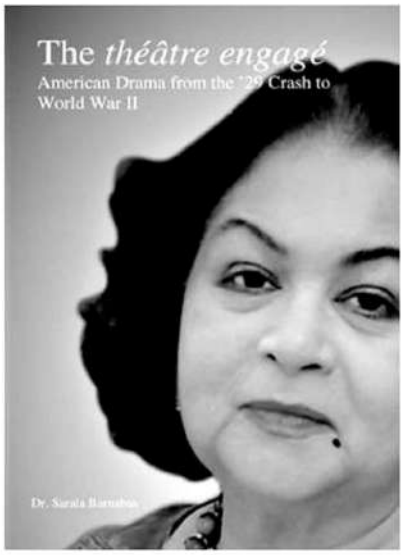

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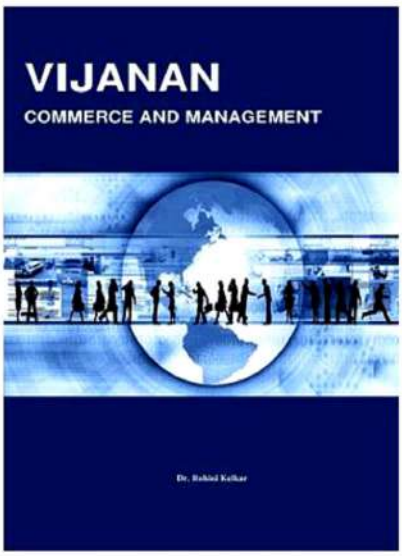

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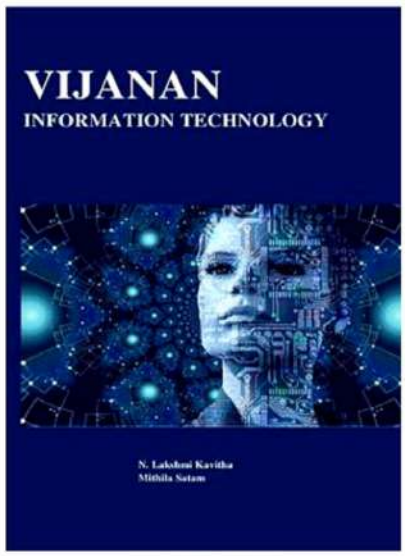

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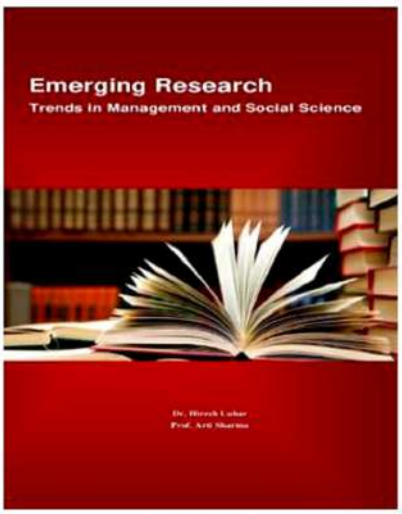

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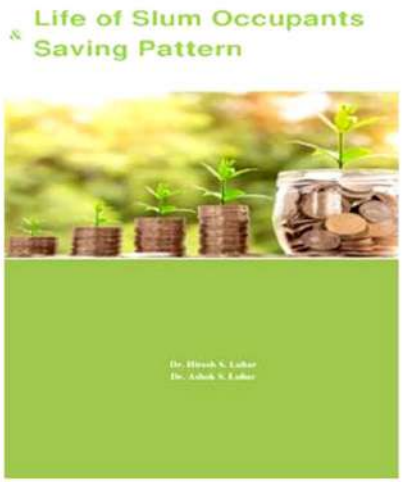

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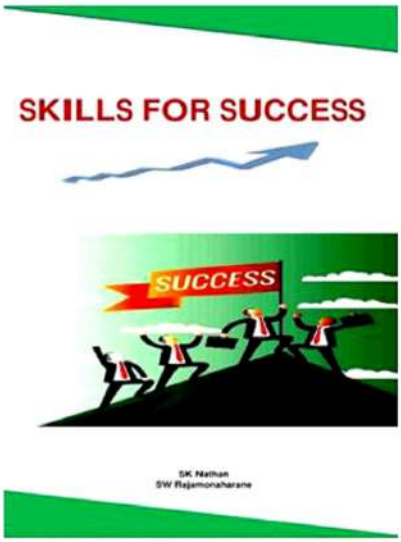

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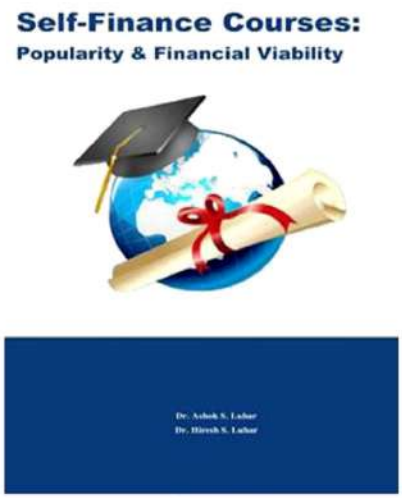

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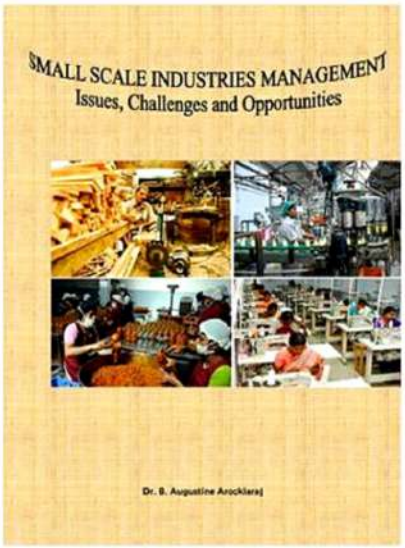

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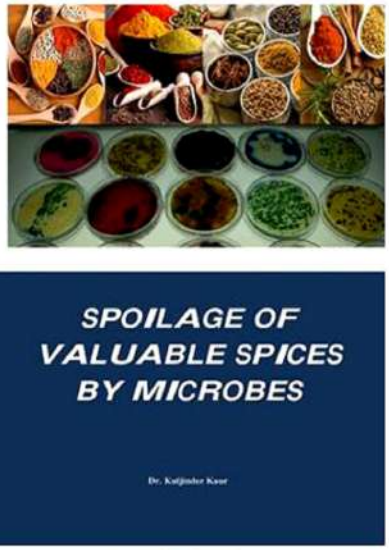

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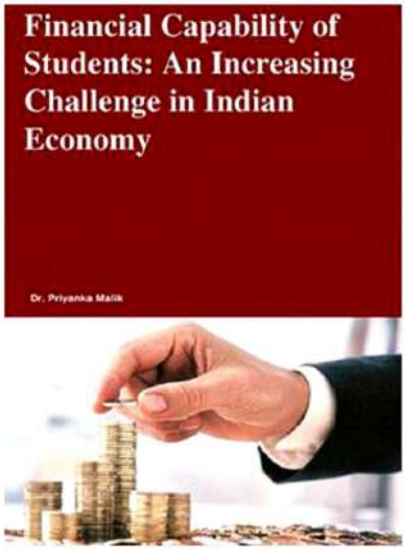

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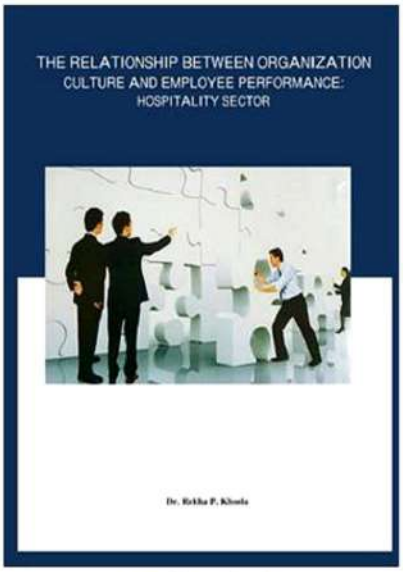

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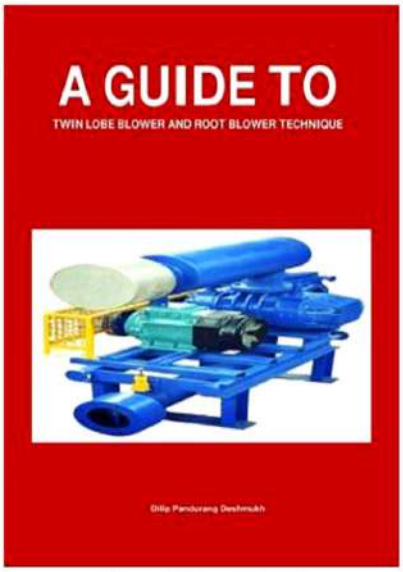

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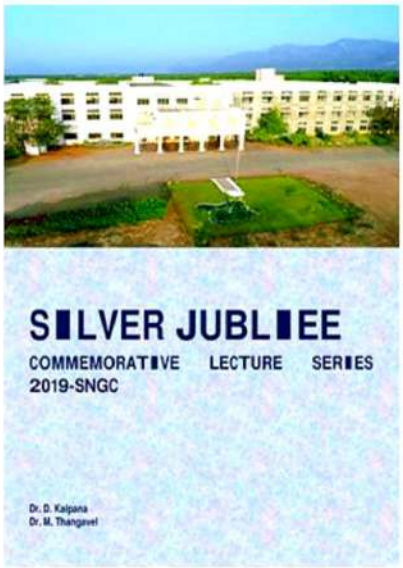

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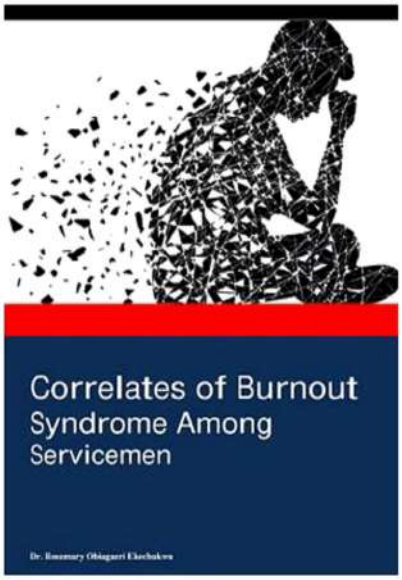

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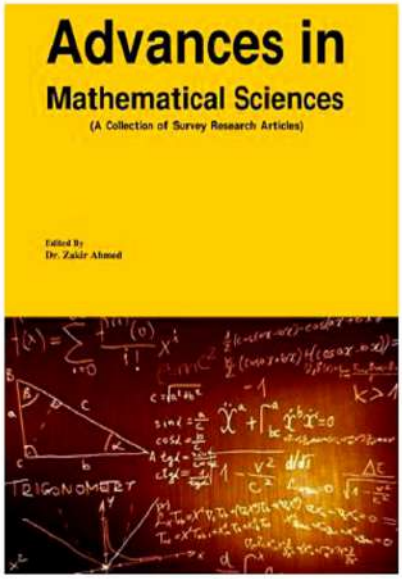

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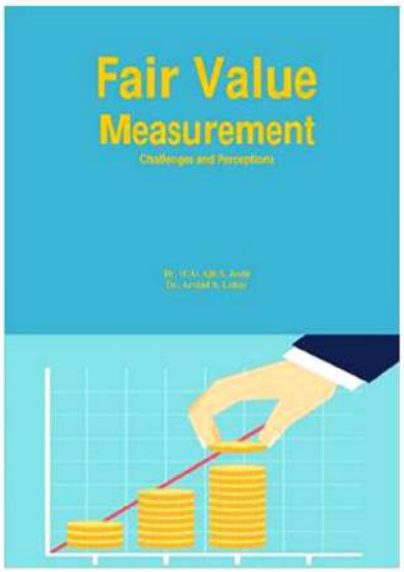

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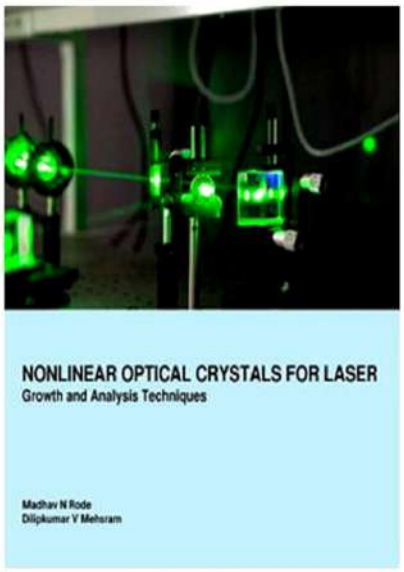

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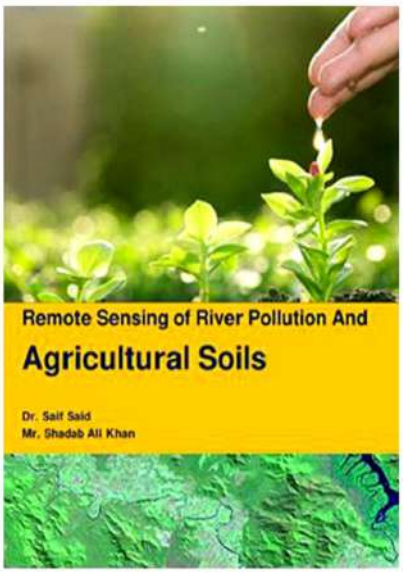

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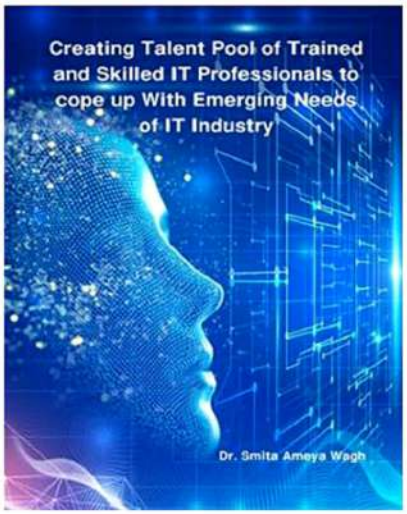

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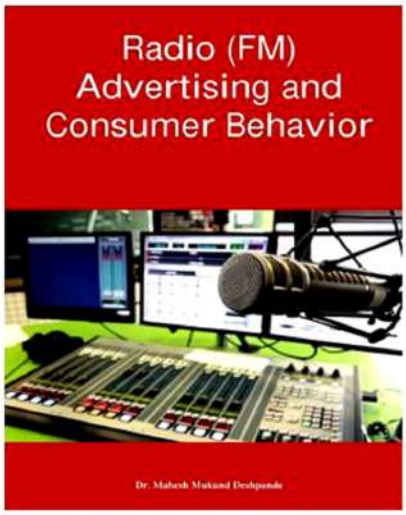

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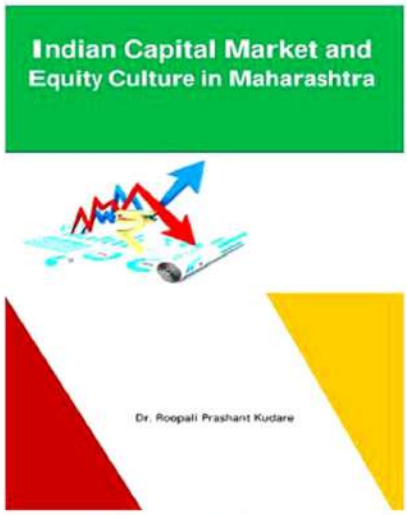

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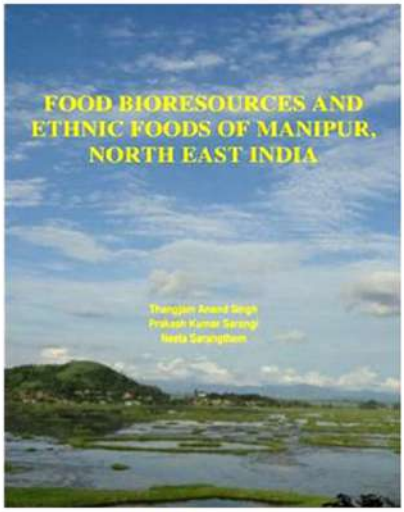

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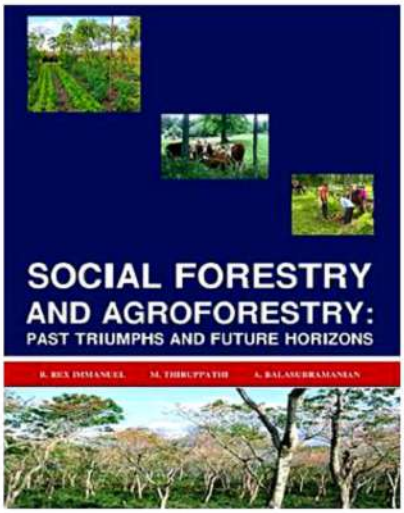

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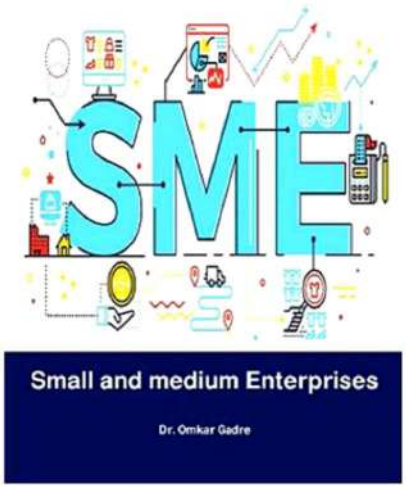

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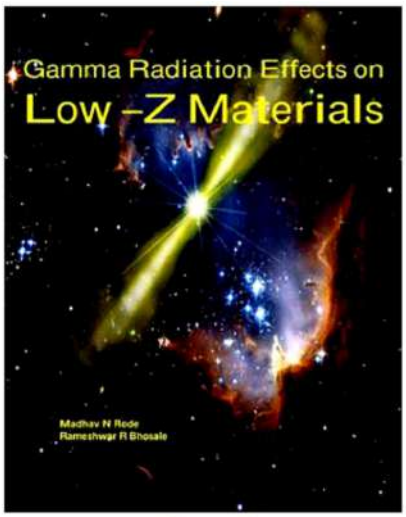

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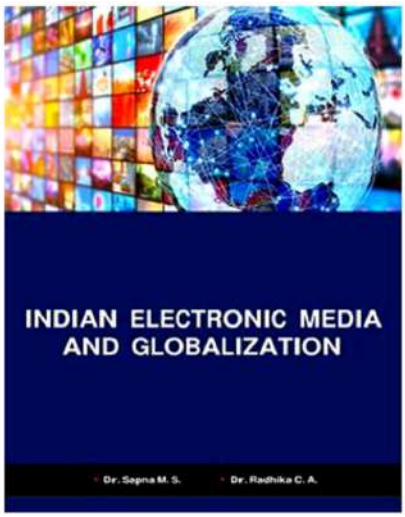

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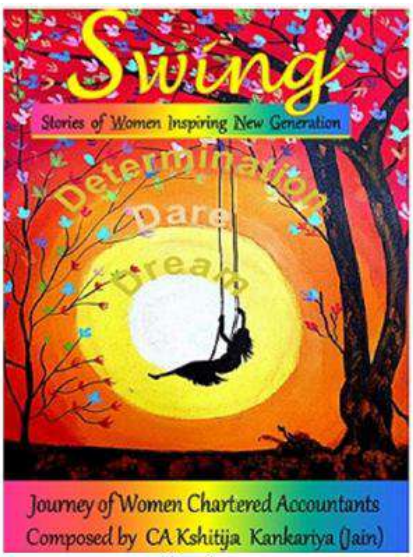

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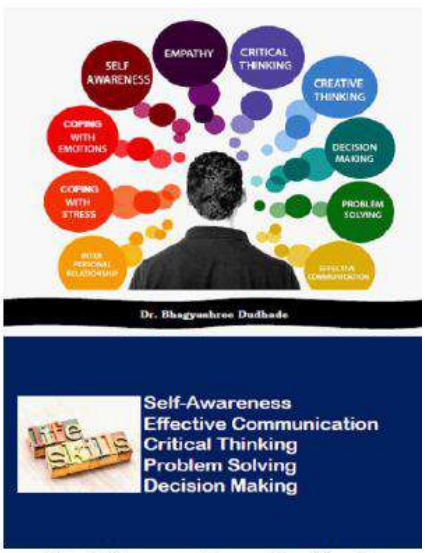

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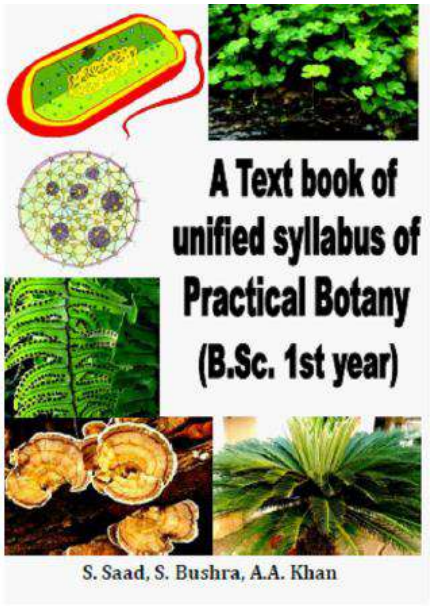

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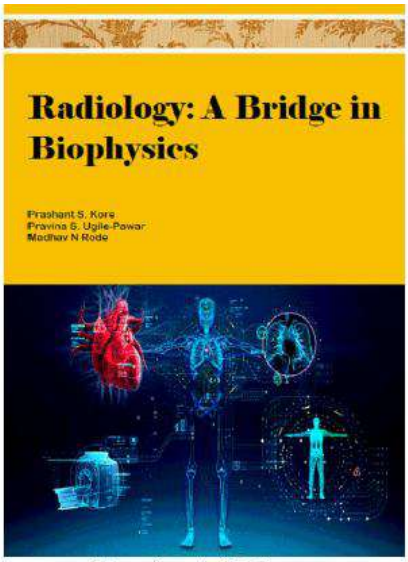

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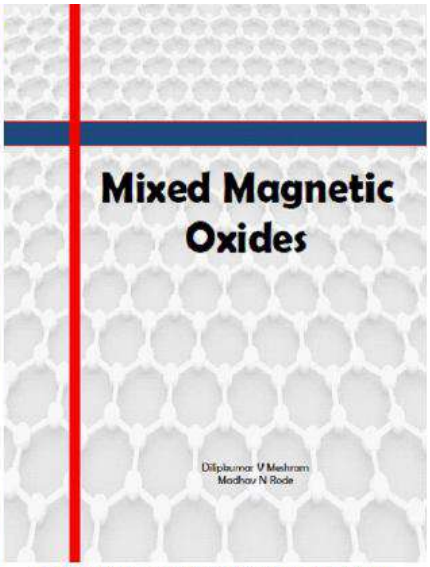

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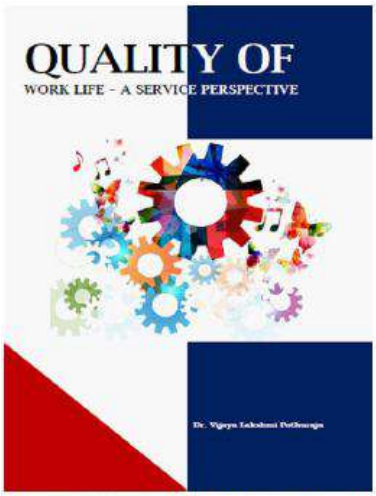

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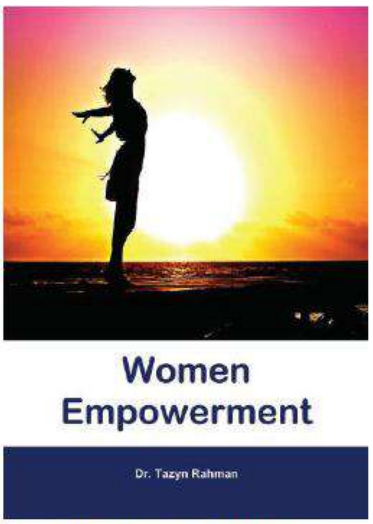

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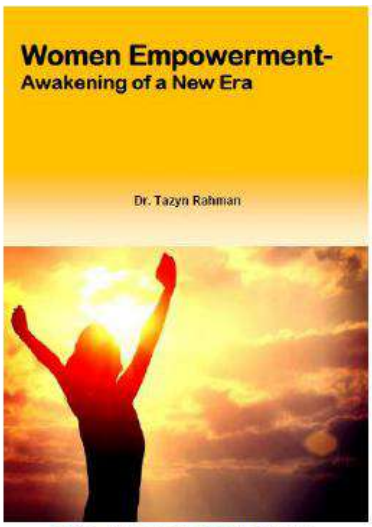

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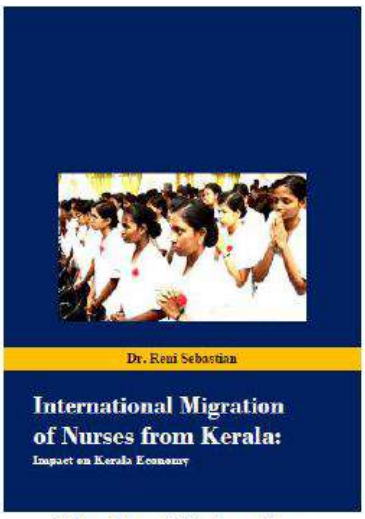

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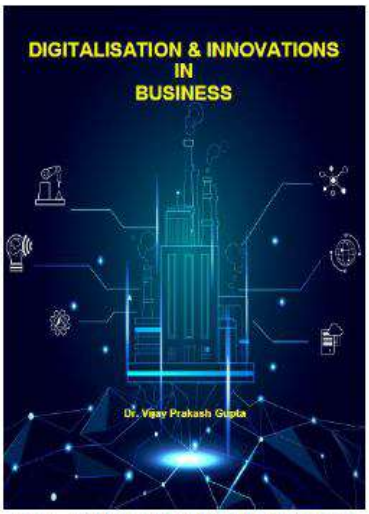

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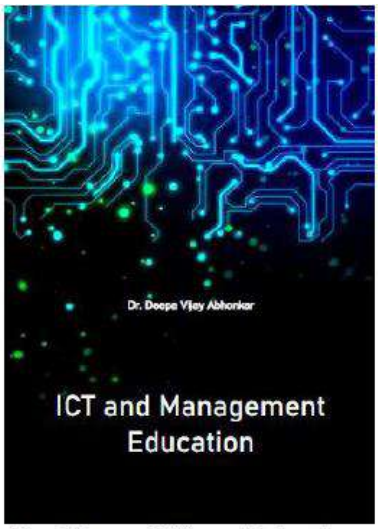

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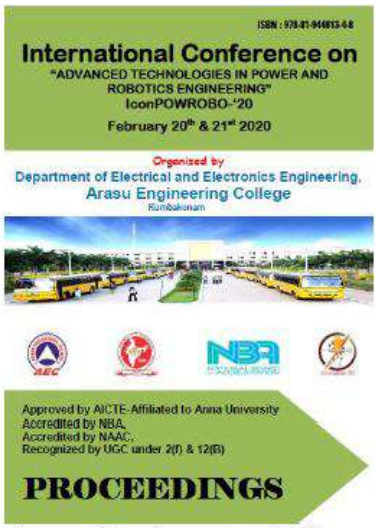

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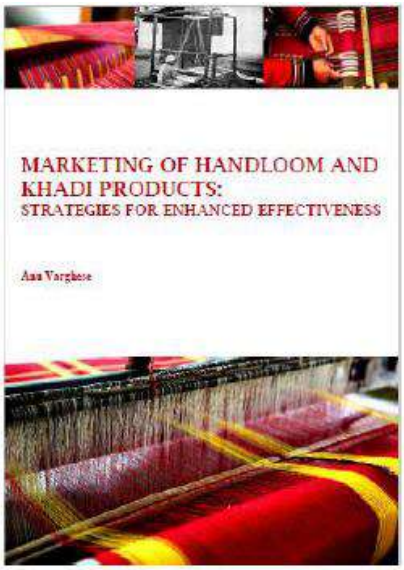

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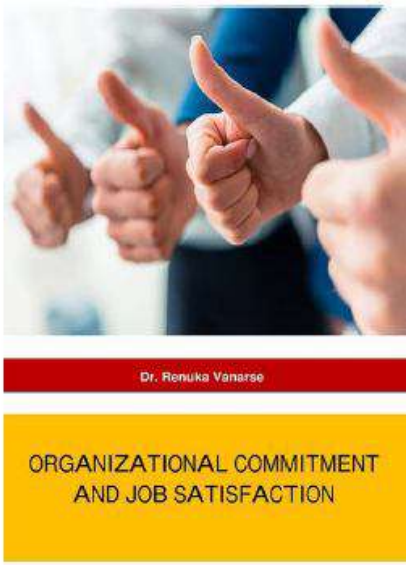

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