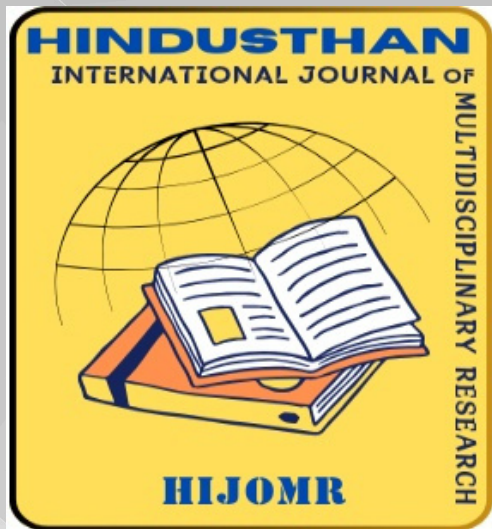




HIJOMR

HINDUSTHAN INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH

**Volume: 1
Issue: 1
September
2024**

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EMERGING TRENDS OF ARTIFICIAL INTELLIGENCE IN THE BANKING INDUSTRY

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ABSTRACT

The dynamic advancements in artificial intelligence (AI) within the banking sector are fundamentally altering the operational frameworks, customer engagement practices, and risk management approaches of financial institutions. Several prominent trends exemplify this transformation. AI developments in banking are redefining operational models, enhancing customer interactions, and refining risk management techniques. Key trends include Enhanced Customer Experience, Data-Driven Decision Making, Fraud Detection and Prevention, as well as Risk Management and Compliance.

AI innovations, such as chat bots, provide 24/7 support, empowering customers to address issues and conduct transactions independently. By leveraging natural language processing, banks can customize their interactions, thereby improving customer satisfaction and loyalty. Financial institutions are employing AI to scrutinize vast data sets, facilitating rapid and informed decision-making. Machine learning technologies assist in recognizing patterns in customer behavior and market trends, which enables the optimization of product offerings and pricing strategies. Furthermore, AI enhances security by continuously monitoring transaction data to detect anomalies and potential fraud. Continuous improvements in fraud detection systems reduce false positives, thereby protecting both assets and customer confidence. AI is also transforming risk assessment and mitigation, enabling banks to evaluate creditworthiness with greater precision.

Key words: *Artificial Intelligence (AI) - Robotic Process Automation (RPA) - block chain data - AI-powered chat bots-AI technologies*

1. INTRODUCTION

The evolving trends in artificial intelligence (AI) within the banking industry are significantly reshaping the operational structures of financial institutions, enhancing their customer engagement approaches, and refining their risk management methodologies. Firstly, the operational structures of banks are undergoing a transformation as AI technologies are integrated into various processes. Automation of routine tasks, such as data entry and transaction processing, is streamlining operations, allowing banks to allocate resources more efficiently. This transformation reduces operational costs and human error, enhancing precision in financial transactions. AI-powered analytics enable banks to process large data sets in real-time, facilitating quicker decision-making and improving operational efficiency. As a result, financial institutions are becoming more adaptable to market changes. AI is also revolutionizing customer engagement by allowing banks to deliver personalized experiences through machine learning, which analyzes customer behaviors to tailor products and services.



Additionally, AI enhances risk management by using predictive analytics to assess credit risk, detect fraud, and manage operational risks. This proactive approach strengthens transaction security and ensures regulatory compliance while supporting stress testing and scenario analysis. Overall, AI is driving significant changes in banking operations, customer engagement, and risk management, positioning institutions for greater efficiency and competitiveness.

2. EMERGING TRENDS OF ARTIFICIAL INTELLIGENCE

The changing landscape of artificial intelligence (AI) in the banking sector is reshaping operational frameworks, customer engagement, and risk management strategies. Notable trends include:

2.1. Enhanced Customer Experience

Artificial intelligence is being utilized to enhance customer service via chatbots and virtual assistants. These technologies offer round-the-clock assistance, addressing inquiries, facilitating transactions, and delivering customized financial guidance. Through the analysis of customer data, AI is capable of personalizing services and suggestions, resulting in a more interactive and fulfilling customer experience.

2.2. Advanced Fraud Detection and Prevention

The use of AI algorithms for the real-time identification of fraudulent activities is increasing. By analyzing transaction patterns and detecting anomalies, AI systems can pinpoint suspicious behavior more accurately than traditional methods. Additionally, machine learning models improve their predictive and preventive abilities as they process larger datasets.

2.3. Risk Management and Compliance

Artificial intelligence is transforming risk management in banking by improving credit risk assessment. Advanced machine learning algorithms analyze large datasets, including unconventional sources, to evaluate borrower creditworthiness. Additionally, AI helps financial institutions meet regulatory standards by streamlining reporting and monitoring transactions for compliance.

2.4. Process Automation and Operational Efficiency

Robotic Process Automation (RPA) powered by AI is streamlining back-office operations, reducing manual errors, and increasing efficiency. It includes data entry, account reconciliation, and transaction processing can be automated, allowing employees to focus on more strategic activities. This method not only cuts costs but also improves the speed of service delivery.

2.5. Personalized Financial Products

AI enables banks to create personalized financial products tailored to individual customer needs. By analyzing customer behavior and preferences, banks can offer customized loans, investment options, and savings plans. It enhances customer loyalty and drives product adoption.



2.6. Predictive Analytics for Market Trends

Financial institutions are utilizing AI-driven predictive analytics to forecast market trends and consumer behavior. By analyzing historical data in conjunction with current market conditions, AI empowers banks to make informed decisions regarding investments, product development, and marketing strategies. This proactive approach helps banks stay ahead of the competition.

2.7. Improved Decision-Making

AI tools provide banks with insight resulting from data analysis, enabling better decision-making. Executives can leverage AI-generated reports and dashboards to understand market dynamics, customer preferences, and operational performance, leading to extra tactical and informed business decisions.

2.8. Cyber security Enhancements

As cyber threats grow more complex, artificial intelligence is becoming crucial for enhancing cyber security measures in financial institutions. Moreover, banks can customize their services to meet the distinct needs of different customer segments. For instance, AI can help identify customers who could benefit from particular investment opportunities, savings plans, or loan options, allowing banks to promote these offerings in a proactive manner. This level of personalization not only boosts customer satisfaction but also encourages loyalty and retention among clients.

2.9. Predictive Analytics for Better Decision-Making

The integration of AI-driven predictive analytics is increasingly essential for strategic decision-making within banking institutions. By utilizing historical data alongside sophisticated algorithms, these financial entities can anticipate market trends, customer behaviors, and potential risks. This predictive capability empowers banks to make well-informed choices concerning product innovation, marketing approaches, and resource distribution, thereby enhancing profitability and establishing a competitive edge.

2.10. Enhanced Cyber security Measures

With the banking industry progressively depending on digital platforms, the importance of strong cyber security measures has reached unprecedented levels. Artificial Intelligence is crucial in strengthening cyber security by detecting potential threats and vulnerabilities in real-time. Machine learning algorithms are capable of examining network traffic patterns and user behaviors to identify anomalies that could signify a cyber attack, enabling banks to react promptly and reduce risks.

2.11. Improved Investment Strategies

AI is revolutionizing investment management by providing tools that analyze vast datasets to identify investment opportunities and optimize portfolios. Robo-advisors, powered by AI, can assess an investor's risk tolerance and financial goals to recommend tailored investment strategies. This democratization of investment advice makes it accessible to a broader audience, enabling more individuals to participate in wealth-building activities.

2.12. Streamlined Loan Processing

The loan approval process is being transformed by AI-driven automation, which uses machine learning to evaluate credit applications more quickly. This technology analyzes a

borrower's financial history and credit score, leading to faster decision-making and improved customer satisfaction. Unlike traditional methods that rely on extensive paperwork and manual evaluations, AI assesses various factors, including alternative data, to offer a broad evaluation of creditworthiness. This not only speeds up approvals but also enhances accuracy, reducing default risks and improving risk management for banks.

2.13. Integration of Block chain Technology

AI and block chain technology are increasingly being integrated to enhance transparency and security in banking operations. AI can analyze, identify trends and patterns, while block chain provides a secure and immutable ledger for transactions. This combination can improve the efficiency of cross-border payments, reduce fraud, and streamline compliance processes, ultimately leading to other secure and efficient banking ecosystem.

2.14. Personalized Customer Experiences

In an era where customer expectations are continually evolving, banks are leveraging AI to create personalized experiences that cater to individual needs. By analyzing customer data, including transaction history and preferences, banks can offer tailored recommendations and services. For example, AI can suggest specific financial products based on a customer's spending habits or alert them to potential savings opportunities. This cultivates a deeper connection between the bank and its customers' satisfaction.

2.15. Efficient Regulatory Compliance

The banking sector faces strict regulations, making compliance challenging and resource-intensive. Artificial intelligence can streamline compliance by automating transaction oversight and identifying potential regulatory breaches. Machine learning can detect patterns of fraud or non-compliance, allowing banks to address issues proactively. This approach reduces the risk of costly penalties and enhances the institution's reputation.

2.16. Enhanced Customer Support

The integration of AI-driven chat bots and virtual assistants is revolutionizing customer support within the banking industry. These technologies are capable of managing a diverse array of inquiries, including account balance inquiries and transaction disputes, thereby offering customers round-the-clock assistance. By automating standard queries, financial institutions can allow human representatives to concentrate on more intricate matters, thereby enhancing overall service efficiency. Furthermore, AI can evaluate customer interactions to pinpoint prevalent issues, allowing banks to improve their services and better meet customer demands.

2.17. Data-Driven Marketing Strategies

AI technology facilitates the development of data-centric marketing strategies within banks, leading to improved effectiveness and targeting. By scrutinizing customer demographics, behaviors, and preferences, banks can implement highly customized marketing campaigns that connect with particular segments of their clientele. This targeted strategy not only raises the probability of conversion but also enhances the overall customer experience. Furthermore, AI can optimize marketing expenditures by determining the most effective channels and strategies, thus ensuring efficient use of resources.

2.18. Financial Education and Empowerment

AI has the capacity to play a crucial role in enhancing financial literacy among consumers. By supplying personalized educational resources and tools, banks can free their human agents to focus on more complicated issues that demand a personal touch. This not only increases efficiency but also elevates the overall customer experience. Customers appreciate the swift resolution of their inquiries, which can lead to improved satisfaction and loyalty. Furthermore, AI systems can adapt based on interactions, progressively refining their responses and becoming more adept at fulfilling customer needs over time.

2.19. Streamlined Operations and Cost Reduction

The implementation of artificial intelligence in banking operations can result in significant cost reductions and enhanced operational efficiency. By automating routine tasks such as data entry, transaction processing, and compliance checks, banks can greatly reduce the time and resources spent on manual workflows. This not only decreases the potential for human error but also allows staff to focus on more strategic projects that encourage growth and innovation. For instance, AI-driven chat bots can handle numerous customer inquiries at once, thereby lessening the need for large customer service teams. This automation can lead to reduced labor costs and quicker response times, as customers receive immediate assistance without the delays typical of conventional service channels.

Furthermore, AI can streamline back-office operations by automating processes like reconciliation and fraud detection, further enhancing efficiency. Moreover, the use of AI in predictive analytics can help banks optimize their resource allocation. By analyzing customer behavior and market trends, banks can better anticipate demand for services and adjust staffing levels accordingly. This anticipatory approach not only helps in reducing operational costs but also ensures that banks are optimally positioned to satisfy customer needs during times of increased demand. In terms of cost reduction, AI can also assist in identifying areas where expenses can be trimmed. For instance, by analyzing transaction data, AI can uncover inefficiencies in payment processing or identify underperforming products that may require reevaluation. This data-driven approach enables banks to make informed decisions about where to invest or cut back, ultimately leading to a healthier bottom line.

2.20. Improved Financial Forecasting

AI's analytical capabilities extend to financial forecasting, where it can provide banks with more accurate predictions of future trends and performance. By analyzing historical data, market conditions, and economic indicators, AI can help banks anticipate changes in customer behavior, interest rates, and overall market dynamics. This foresight enables banks to make strategic decisions regarding lending, investment, and resource allocation, ultimately leading to better financial outcomes.

3. CONCLUSION

The integration of artificial intelligence in banking marks a significant shift in operations and customer interactions, moving beyond a temporary trend. As AI technologies like machine learning and predictive analytics advance, financial institutions adopting these innovations will enhance efficiency, customer satisfaction, and service innovation. For example, machine learning can improve credit risk assessments, detect fraud, and refine

investment strategies, enabling banks to respond swiftly to market changes. AI also personalizes customer service and provides insights into consumer behavior, aiding targeted marketing and product development. Additionally, AI can reduce operational costs by automating tasks and streamlining workflows. While AI adoption boosts profitability and fosters innovation, it also poses challenges such as regulatory compliance, data security, and the need for skilled professionals. Overall, the future of banking is closely linked to AI, and those who adapt will gain a competitive edge.

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NEURAL NETWORK APPROACHES IN INTERNET OF THINGS

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ABSTRACT

Security is the most challenging part of developing internet and network applications. The expertise of neural network - Deep Learning could be used to act on the weaknesses in the system, attacks, and incursions such as viruses, spamming, hacking, and attacks happening in the virtual environment to secure the data of a company. Machine learning, one of the subfields of artificial intelligence, is the source of deep learning. Deep learning provides better predictive value, more sophistication, and improves prediction over time. We can leverage all this data volume for training our machine learning algorithms. This paper reviews some IoT security challenges that deep learning solves.

Keywords: *Deep Learning, Encoding, Decoding, Neural Networks, Internet of Things Security.*

1. INTRODUCTION

Security in IoT is a generic term that applies to all measures, policies, instruments, and guidelines instituted in unison to counter unauthorized access to computing power, communications, applications, and data. This has existing cyber defense measures at the application, network, host, and data levels. Nowadays, there are intrusion prevention and identification systems, network firewalls, software for antivirus protection, and among many other solutions, working in isolation to prevent attacks and detect problems in security. As the number of systems connected to the Internet increases, so does the risk of incursion, along with the number of attacks. It is intended for readers who want to begin investigating deep learning for IoT security.

The rest of this paper is structured as follows: Section 2 provides an overview of Deep Learning in IoT Security. Section 3 provides a breakdown of several Deep Learning techniques applied in network security, and Section 4 finishes the article with a brief summary of the major points and additional concluding notes.

Deep learning is absolutely a much more recent activity, with its first computer implementation dating back to 2006 [1]. In its simplest form, deep learning is a set of machine learning algorithms that aim to learn at multiple levels; each of them associated with a distinct degree of abstraction. The levels distinguish high-level concepts from weaker ones, and the same lower concepts also contribute to the definition of several higher-level perceptions [2]. The first few layers of the deep network handle feature extraction. There are three Deep Learning architectures: blended, supervised, and unsupervised. A Deep neural networks are networks that can learn new skills on its own. The same can be said for any

other algorithm in machine learning. Two recent advances in technology make it possible for the average person to build a DL model with relative ease. First, increasingly, access to GPUs is becoming ubiquitous; these provide much faster computation. The second benefit of a Deep Learning model's layers is that they can be trained apart from one another [3]. This implies that a massive model having millions of parameters can be optimized using far fewer resources in short, more manageable pieces.

This is what is depicted by Figure 1: Monitoring IoT devices that could provide a witty defense against novel or zero-day attackers. Technologies that are effective in data analysis to learn "regular" or "unusual" behavior about how IoT devices and their components interact with one another are machine learning and deep learning. The input data from each element of the IoT system can be gathered and analyzed in search of common trends or patterns of interaction that can help in spotting malignant behavior very early. To be successful and safe systems, IoT systems must move from just secure device-to-device connectivity towards integrating security-driven intelligence that is based on deep learning or machine learning technologies.

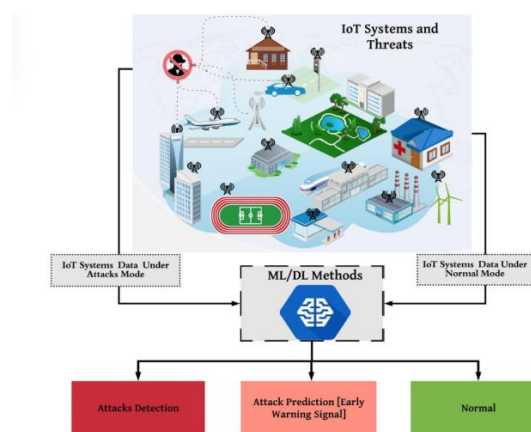


Figure1 : Deep Learning in IoT Industry

2. RELATED WORKS

Huseyin Ahmetoglu and ResulDas [4] addressed machine learning methods' approaches to identifying attacks. The segmentation, aggregation, analysis, and network flow features of threats linked to intrusion detection system were investigated. Techniques for analysing malware behaviours and Mobile malware detection were summarised by Naser Mahmood, Mohammad Javed, and Morshed Chowdhury [5]. It combines several machine learning and deep learning algorithms for detecting behavior-based viruses. YadigarImamverdiyev and FarganaAbdullayeva [6] evaluated the datasets used to evaluate the performance of cyberattack detection systems proposed by researchers. For cyber security intrusion detection, the datasets used, and comparison research, a statistical analysis of articles published on cybersecurity with the use of DL over the years is performed. It specifically reviews intrusion detection systems based on deep learning methodologies. Because the dataset is important in intrusion detection, we describe 35 well-known cyber datasets and categorise them into seven categories: network traffic-based dataset, electrical

network-based dataset, internet traffic-based dataset, virtual private network-based dataset, android apps-based dataset, IoT traffic-based dataset, and internet-connected devices-based dataset. MuderAlmianilia and Abu ghazleh et al [7] provided a fully automated intrusion detection solution for Fog security from cyber-attacks. Multi-layered recurrent neural networks, which are intended to be used for Fog computing security close to end users and IoT devices, are used in the proposed model. Deep learning with cybersecurity is mostly discussed by Priyanka Dixit and Sanjay Silakari [8]. Bhavuk Sharma [9] discussed the deep learning issues, challenges in Cyber security in broad manner. It explains how to face the issues raised when the malicious intervention occurred in IoT.

3. DEEP LEARNING METHODS USED IN IOT SECURITY

3.1 Deep Autoencoders

That means that some unsupervised neural network, an autoencoder, takes a vector as input and tries to make the output as similar to the original vector as possible. Taking the input, changing its dimensionality, and reconstructing the input allows making a higher or lower multidimensional representation of data. This will create a very flexible sort of neural network because it is trained using unsupervised learning of the compressed data encoding. Moreover, they can be pre-trained one layer at a time, which reduces the computing power needed for training a useful model. When the hidden levels have less dimensions than the input and output layers, the network is used for data encoding. As illustrated in Figure 2, by training an autoencoder to reconstruct the input from a noisy version of the input. However, as shown in Figure 2, an autoencoder could be created in order to be more robust and decrease noise [10]. It turned out that such an approach is more resistant and generalizable than the traditional auto-encoder approach.

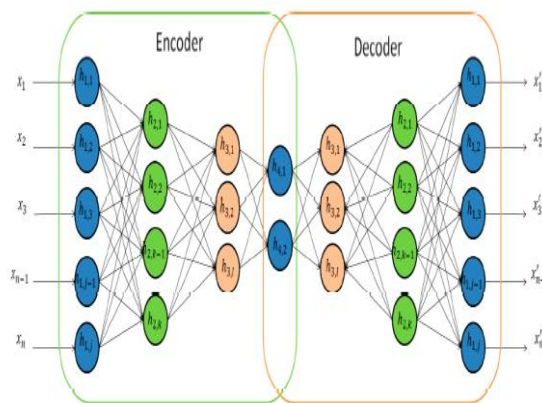


Figure 2: Autoencoder

3.2 Restricted Boltzmann Machines

DBNs are based on RBMs (Restricted Boltzmann Machines), themselves two-layer, bipartite, undirected graphical models – data can flow in both directions, rather than just one [11]. Like auto-encoders RBMs are taught unsupervisedly, one layer at a time. The top layer will be referred to as the input layer, and the lower layer as the hidden layer. There is

complete connectivity between all nodes in the input layer and all other nodes in the hidden. There are no intra-layer connections—that is, no connection between nodes in the same layer.

Usually, binary components could only exist in the input and hidden layers. Taking most of the math from statistical mechanics, the network is trained to minimize "energy," a function that measures the model's compatibility. Actually, the training of the model was aimed at finding the functions that would minimize the energy of the system—and thus the hidden state.

3.3 Recurrent Neural Network

A recurrent neural network is a neural network that, besides the usual function with fixed-length data inputs limited only to normal neural networks, is capable of dealing with variable-length input sequences. This is run by the RNN one at a time through the use of the output from the hidden unit as an additional input for the next element. Therefore, RNNs can not only deal with speech and language problems but also time series problems. Because the gradients can easily explode or vanish, RNNs are usually harder to train [12]. RNNs have been shown to be quite effective for time-series prediction applications relating to language translation, image captioning, speech recognition, and word prediction in phrases [13–16].

3.4 Convolutional Neural Networks

One of the types of neural networks working with input stored in arrays is a Convolutional Neural Network (CNN). Then, a simple example for the input will be a 2D array of pixels that portray a color or grayscale image. More often than not, CNNs are implemented for processing audio spectrograms and 2D picture arrays. Another quite common use for them is videos and volumetric images in 3D. Although less frequent, their use with one-dimensional (1D) arrays (signals) is increasing. CNNs are applied regardless of dimensionality anywhere there is temporal or spatial ordering. A CNN includes three different types of layers as building blocks of its architecture, as seen in Figure 3: the convolution layers, the pooling layers, and the classification layer.

The real core of any CNN is its convolutional layers. Here, the weighted convolution kernel, otherwise known as the receptive field, views the original input one small window at a time. This basically applies these filters across the whole input to create what is called a feature map and then passes it through a non-linearity, most frequently a ReLU. These convolutional kernels, named so for the mathematical convolution process, allow accounting for close physical or temporal relationships within the data by using the same kernel all over an image. This assists in memory conservation.

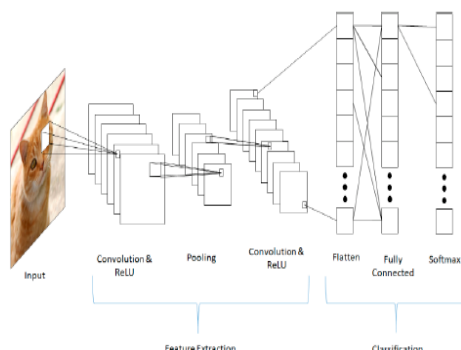
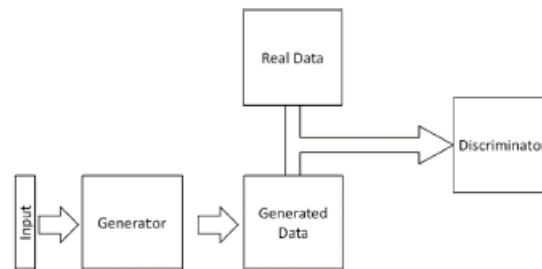


Figure 3: Convolutional Neural Network

3.5 Generative Adversarial Networks

Basically, GANs involve setting up a game between two neural networks in a zero-sum scenario. This design of a neural network applies to unsupervised machine learning. As designed by Goodfellow et al., one network is a generator and the other is a discriminator. It takes in input data and produces output data, generating output that is identical to the source data on attributes. The discriminator tries to find distinctions between real input and fake generated input to make an authentic-fraudulent decision. Then, after training, a generator can generate new data that isn't far from other data.



Since their inception, GANs have had numerous applications, most of them image-related. This includes optical flow estimation, caption generation, and image enhancement. There is even an open-sourced pre-trained GAN for image generation available on Facebook, under the name of DCGAN, or deep convolution generative adversarial network.

4. CONCLUSION

With the increasing pace of cyber network attacks, which seems to be getting ahead in comparison with the ability of cyber defenders to generate and deploy new signatures that identify emerging threats, there is a good opportunity for detecting new malware variants and zero-day attacks using deep learning techniques based on neural networks in cyber security apps. In this survey article, we focus on the application of deep learning techniques against various types of cyber security vulnerabilities that target data, networks, host systems, and application software. We have also presented a detailed review of the Deep Learning techniques used earlier to identify such forms of online threats.

Current techniques treat these different types of assaults separately. Future research should investigate how malignant behaviors propagate through an attack lifecycle

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AI AND COMPUTATIONAL SUSTAINABILITY: HARNESSING TECHNOLOGY FOR A CYBER FUTURE

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ABSTRACT

Artificial intelligence (AI) is increasingly recognized as a transformative tool in addressing global sustainability challenges. From climate change monitoring to smart cities, AI-driven solutions are enabling more informed decision-making and efficient resource management. However, alongside these advancements, ethical considerations such as data privacy, bias, and the environmental impact of AI itself must be addressed. Computational sustainability is an emerging field that leverages artificial intelligence (AI) and computational methods to address complex environmental and societal challenges. This abstract explores the transformative potential of AI in advancing sustainability efforts, particularly in areas such as environmental conservation, resource management, and climate change mitigation. Through ecosystem modeling, precision agriculture, and energy optimization, AI-driven solutions enable more efficient and scalable approaches to preserving natural resources and promoting long-term environmental health. However, the integration of AI in sustainability also raises ethical considerations, including data privacy, bias, and the environmental impact of AI technologies themselves. This abstract highlights the dual role of AI as both a powerful tool for achieving sustainability goals and a subject of scrutiny regarding its broader implications, emphasizing the need for responsible and collaborative approaches in harnessing AI for a cyber future.

Keywords: *Artificial Intelligence, Computation, Cyber Future, Sustainability.*

1. INTRODUCTION

The concept of AI is not a recent phenomenon; it has its roots in the 1950s, driven by the goal of creating machines that can replicate human abilities such as sensing, reasoning, and thinking. While AI technology and ideas have existed for over fifty years, significant advancements in sophisticated algorithms, access to larger datasets, and the growing adoption of digital technologies have accelerated its development. Today, numerous products and services incorporate AI-based methods, such as voice recognition virtual assistants and autonomous vehicles. AI is expected to have a substantial impact on nearly every aspect of life. By emulating cognitive functions and engaging in continuous self-learning and improvement, AI facilitates the resolution of complex tasks through four primary types of AI systems: autonomous systems that make decisions without human input (e.g., medical diagnosis); automated systems that perform repetitive and labor-intensive tasks (e.g., forest management); assisted systems that help humans carry out tasks (e.g., smart home technologies); and augmented systems that aid individuals in understanding and predicting complex future events (e.g., agricultural decision-making)[2].



As the world grapples with pressing environmental and societal challenges, the need for innovative solutions that balance development with sustainability has never been more critical. Computational sustainability is an interdisciplinary field that harnesses the power of artificial intelligence (AI) and computational methods to address complex problems related to the environment, natural resource management, and societal well-being. By integrating AI with sustainability science, this field aims to develop scalable and efficient strategies that support long-term ecological health and human prosperity.

AI's role in computational sustainability is pivotal, offering advanced tools for analyzing vast datasets, predicting future trends, and optimizing processes across various domains. From monitoring ecosystems and conserving biodiversity to enhancing energy efficiency and mitigating climate change, AI-driven approaches are transforming the way we understand and interact with our environment. These technologies are not only improving decision-making but are also paving the way for more sustainable practices across industries and communities.

However, as computational sustainability evolves, it also brings forth challenges and ethical considerations. The environmental impact of AI technologies, issues of data privacy, and the potential for bias in AI models must be carefully addressed to ensure that the benefits of these innovations are realized without unintended consequences.

This article surveys the landscape of computational sustainability, examining the AI methods employed, the sustainability issues addressed, and the contributions made to decision-making processes. By exploring these dimensions, the paper sets the stage for a deeper synthesis of how AI can evolve into sophisticated and holistic decision-making and advisory agents, capable of driving meaningful change towards a more sustainable future.

2. RELATED WORK

The article reviews the dark side of Artificial Intelligence and sustainability for cyber future.

[1] Sustainability is a significant concern, encompassing a broad range of challenges arising from the interactions between natural ecosystems and human-developed environments across various timeframes and geographical scales. This complexity has driven computer science researchers to focus their expertise on addressing environmental and societal sustainability issues. Among the technologies being utilized, AI stands out as one of the most crucial for helping humanity navigate and manage the intricate challenges associated with sustainability.

[3] Development Goals The first principles related to sustainability emerged as early as the 18th century (Von Carlowitz, 1713). Nowadays, we mainly refer to the Brundtland report (Brundtland et al., 1987). This report emphasizes that the needs of the present should be met without compromising the ability of future generations. To consider the broadness of the term, this paper draws on two conceptualizations for making sustainability more manageable (see Appendix A): First, a widely accepted approach is given by the differentiation between three interrelated dimensions—the Triple Bottom Line (Elkington, 1997)—for the economy (e.g., financial success), environment (e.g., benefits for the nature), and society (e.g., benefits for people). Second, as another universally applicable conceptualization, we build upon the UN's 2030 Agenda. This agenda organizes targets and indicators across 17 SD which seek to preserve peace and prosperity for humanity and the planet (United Nations, 2015).

[4] Gomes defined research efforts at the intersection of computing and sustainability as computational sustainability, aiming to create innovative computational models, methods,



and tools that support the balancing of environmental, economic, and societal needs to achieve a sustainable future.

[5] The paper also highlights potential gaps in the current landscape of computational sustainability, noting a relative shortage of research on AI applications for sustainable design and a lack of focus on addressing the unintended consequences that may result from AI interventions.

[7] Research in computational sustainability within AI has previously been categorized by (a) the AI techniques utilized, (b) the sustainability issues targeted, and (c) the impact on decision-making, which typically involves human decisions.

[6] Describing sustainable AI as a movement aimed at transforming the entire lifecycle of AI products—encompassing idea generation, training, deployment, and governance—toward enhancing ecological integrity and social justice. This perspective emphasizes that sustainable AI is concerned with more than just AI applications; it encompasses the entire socio-technical system surrounding AI.

There are two key dimensions to consider: the application of AI to support sustainability efforts (referred to as "AI for sustainability") and the importance of making sure that AI systems themselves are sustainable (known as the "sustainability of AI"). Regarding the first dimension, researchers acknowledge AI's considerable potential in driving sustainability initiatives, such as the Sustainable Development Goals (SDGs). AI is increasingly recognized for its impact across various areas: socially, by promoting workforce development, gender diversity, and transparent hiring practices; environmentally, through its role in managing energy use and waste; and economically, by improving industry efficiency. However, AI technologies also pose risks, often referred to as the "dark side of AI." As Vinuesa et al. (2020) point out, AI failures can compromise transparency, safety, and ethical standards. Berente et al. (2021) also highlight that many of the challenges associated with AI are rooted in moral and ethical issues. Therefore, it's crucial that AI is developed and deployed in a trustworthy and ethical manner, adhering to human values and ensuring non-discrimination, diversity, and inclusivity, as emphasized by scholars like Galaz (2021) and Holzinger (2021).

Their review particularly emphasized environmental topics, including biodiversity, water resources, energy conservation, smart cities, and climate change. The authors explored how AI could contribute to achieving the 17 Sustainable Development Goals (SDGs). Drawing on a "consensus-based expert elicitation process, informed by three prior studies mapping SDG interlinkages" (p. 1), they found that AI could potentially support approximately two-thirds of the UN's goals. This conclusion represents the collective insights of experts from various fields.

In a more focused study, Di Vaio et al. (2020) examined the role of AI in developing sustainable business models by conducting a quantitative bibliometric analysis of 73 publications from 1990 to 2019. Although their research offered valuable insights, the reliance on quantitative methods often lacked the nuanced understanding that qualitative approaches provide. Additionally, the study's word cloud analysis highlighted a strong focus on technology, while the connection between technology and sustainability was relatively underexplored.

On the other hand, Holzinger et al. (2021) examined the potential risks associated with using AI for sustainability. The authors highlighted that while AI technologies offer significant promise, they also pose unforeseen threats that must be addressed. They discussed



several critical issues, including bias, data privacy, data resilience, method transparency, and trust in outcomes.

Our analysis, utilizing data from AISEL and Top Basket (see Appendix B), reveals a growing interest within the information systems (IS) community in leveraging AI for sustainability (refer to Figure 2, left). Over 69% of the articles were presented at conferences, with significant contributions from HICCS (15%), ICIS (14%), AMCIS (13%), PACIS (11%), and ECIS (3%). A similar trend is seen in journals, where about 28% of our sample includes publications in JMIS (9%), ISR (8%), and MISQ (4%). The thematic analysis underscores a strong focus on the social aspects of sustainability (see Figure 2, right). Technologically, nearly all articles (96%) utilize some form of machine learning (ML), employing a range of algorithms from both supervised and unsupervised learning methods. [8]

3. SUSTAINABILITY-ORIENTED GOALS AND AI METHODS FOR CYBER FUTURE

To address the first question regarding goals (Q1), we used an inductive approach to identify topics, mapped them to the Sustainable Development Goals (SDGs), counted their frequency within our sample, and examined their connection to sustainability (see Table 2). Each topic was accompanied by a descriptive term indicating the type of decision or task involved, such as classification, prediction, or monitoring. In some cases, it was difficult to assign a topic to just one SDG, so the overview of goals is not mutually exclusive; an article could be linked to multiple goals.

Our analysis of 95 IS articles shows that the majority (76%) contribute to social sustainability. Within this domain, the primary focus is on good health and well-being (SDG 3), addressing topics like physical health (e.g., gait analysis, blood pressure), mental health (e.g., depression, addictions), and healthcare (e.g., activity monitoring). Other significant areas include peace and justice (SDG 16), covering issues such as fraud detection, dark web activities, and misinformation, as well as education (SDG 4), which looks at tutoring systems, personalized learning, and automatic error correction.

Regarding ecological concerns, which made up 17% of the sample, articles focused on modern energy (SDG 7) through load shifting, forecasting, and management; responsible consumption and production (SDG 12) with an emphasis on consumption forecasting; and zero hunger (SDG 2), including studies on plant seedling classification. In terms of economic goals (24%), the research addressed infrastructure and innovation (SDG 9), particularly in the context of smart cities, as well as working conditions and economic growth (SDG 8), focusing on labor market predictions and sales forecasting[10].

"While IS researchers may not create new algorithms, they utilize existing ones to address business or social problems, making it essential for them to understand these technologies and methods." We explored the technological aspect of research (AI methods, Q3). Consequently, we extracted, quantified, coded, and classified the full range of approaches, methods, and algorithms from our literature corpus. We distinguished between key AI-related concepts based on our understanding in Section 2.1, including ML, ANN, DL, NLP, and CV [13].

The random forest algorithm, an ensemble learning technique using decision trees for classification and regression (Ho, 1995), is applied in several articles to address social issues.

For instance, it is used to classify conditions like asthma (#T97) and schizophrenia (#117), as well as to predict various entities within the Bitcoinblockchain ecosystem (#T43). Additionally, random forests are employed to assess the impact of weather on electricity demand (#418) and to forecast agricultural yields (#35). In the ecological realm, articles examine the relationship between weather conditions and electricity load profiles (#418) and classify animal health (#62). For economic sustainability, random forests are used to predict labor market competition (#T18) [17].

Convolutional Neural Networks (CNNs), inspired by biological vision and natural signal processing, are popular learning architectures. In the context of social issues, CNNs analyze medical images for conditions like glaucoma (#96), diabetes (#71), and brain tumors (#404). They are also utilized in education and peace initiatives by predicting sentiments in online courses (#405) and identifying threats on the dark web (#T41). Economically, CNNs help analyze consumer behavior (#T5) and labor markets (#T18). However, CNNs were notably not applied to environmentally focused topics [15].

Recurrent Neural Networks (RNNs), with their internal feedback loops, can learn sequential patterns and model time dependencies by creating memory. They are commonly used for time-series data, event sequences, and natural language processing. However, simple RNNs often struggle with limited memory capacity when handling long sequences, leading to vanishing gradient issues. To overcome this, RNNs can be enhanced with Long Short-Term Memory (LSTM) cells (LeCun et al., 2015). In our sample, RNN-related articles focus on social concerns, such as detecting drug addictions (#57), supporting learning tutors (#50), and identifying fake news (#415), as well as economic aspects like designing an image-based fashion curation system for personalized outfits (#61) [16].

4. RESULT AND DISCUSSION

1. AI's Contribution to Sustainable Development:

- **Environmental Impact:** AI is increasingly being used to optimize resource usage, reduce waste, and manage energy consumption. Techniques such as machine learning and deep learning are applied to predict energy demands, monitor environmental changes, and optimize supply chains, directly contributing to several Sustainable Development Goals (SDGs), such as affordable and clean energy (SDG 7) and climate action (SDG 13).
- **Social Impact:** AI technologies are being deployed to improve health outcomes, enhance educational systems, and promote social equity. For example, AI-driven systems are helping to diagnose diseases, personalize learning experiences, and detect biases in hiring processes. These applications align with SDGs focused on good health and well-being (SDG 3) and quality education (SDG 4).
- **Economic Impact:** AI is also contributing to economic sustainability by increasing efficiency across industries, fostering innovation, and supporting the development of smart cities. AI-driven automation and predictive analytics are helping businesses optimize operations, reduce costs, and create new opportunities for growth.

2. Ethical and Moral Considerations:

- **Trustworthiness and Transparency:** The discussion often highlights the importance of ensuring that AI systems are transparent and trustworthy. This involves addressing issues related to algorithmic bias, data privacy, and the potential for AI to be misused. Scholars emphasize the need for AI to align with human values and to be developed in ways that promote fairness, inclusivity, and non-discrimination.
- **Sustainability of AI Itself:** There is a growing concern about the environmental impact of AI technologies, particularly in terms of the energy consumption required for training large models. Researchers are calling for more sustainable practices in AI development, including the use of renewable energy sources and the optimization of algorithms to reduce their carbon footprint.

3. Technological Advancements:

- **Innovations in AI Methods:** The development of more efficient algorithms, such as those in machine learning, neural networks, and natural language processing, is crucial for enhancing the capability of AI systems to address sustainability challenges. These advancements are enabling AI to process larger datasets, make more accurate predictions, and provide more effective solutions to complex problems.
- **Cybersecurity and Resilience:** As AI systems become more integral to critical infrastructure, ensuring their security and resilience against cyber threats is paramount. This involves not only protecting AI systems from attacks but also leveraging AI to detect and respond to cyber threats in real time.

Discussion

The discussion around AI and Computational Sustainability typically centers on balancing the benefits of AI with the potential risks and challenges. While AI offers significant opportunities for advancing sustainability goals, it also raises important questions about ethical considerations, environmental impact, and the need for robust governance frameworks.

- **Ethical AI:** Ensuring that AI technologies are developed and deployed in ways that respect human rights and promote social good is a key theme in the discussion. This includes addressing algorithmic bias, ensuring transparency in AI decision-making, and promoting diversity and inclusivity in AI development.
- **Sustainable AI Development:** The conversation also focuses on the need for more sustainable AI practices, particularly in terms of reducing the environmental impact of AI systems. Researchers are exploring ways to make AI more energy-efficient and to integrate sustainability considerations into the AI development lifecycle.
- **The Role of Policy and Regulation:** There is a growing recognition of the need for policy and regulatory frameworks to guide the development and use of AI in ways that promote sustainability. This includes setting standards for ethical AI, promoting transparency and accountability, and encouraging the use of AI for social and environmental good.



5. CONCLUSION

This article provides a comprehensive overview of computational sustainability research, examining the field through the lens of AI methods used, the sustainability challenges tackled, and the contributions to decision-making, often focused on human decision processes. By exploring these aspects, the paper lays the groundwork for a more in-depth analysis, which will include the potential to develop advanced and integrated AI systems capable of making decisions and offering advice in a holistic manner. In conclusion, the intersection of AI and Computational Sustainability offers a promising avenue for addressing some of the most pressing challenges of our time. However, realizing this potential requires careful consideration of the ethical, environmental, and technological implications of AI, as well as strong governance to ensure that AI is harnessed for the benefit of all. As another limitation, we particularly shed light on research results that comprise artefacts and situated instances in the form of algorithms, methods, and systems.

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AN ANALYSIS OF FACTORS AFFECTING WOMEN'S ENTREPRENEURIAL GROWTH IN TIRUPPUR DISTRICT

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ABSTRACT

In the past, it was common for men to be the primary earners in a family, while women were responsible for childcare and household duties. Over time, it became clear that women were also contributing to the family's finances, supporting their husbands and other family members. Consequently, many women began to actively participate in income generation alongside their male relatives, helping to bolster the family's overall financial well-being.

Recently, women have made significant strides in breaking free from traditional domestic roles by venturing into a variety of professions and services. Female entrepreneurs have demonstrated business acumen on par with their male counterparts, emerging as innovative and dynamic leaders in their fields. Entrepreneurship offers a vital path for women to challenge and overcome their traditional subordination within both the family and society. As a result, the promotion of female entrepreneurship has garnered special attention from policymakers.

The new industrial policy emphasizes the importance of implementing specialized Entrepreneurial Development Programs (EDPs) for women. Additionally, there is now a network of institutions across the country dedicated to fostering entrepreneurship. This network includes commercial banks and financial institutions, which play a crucial role. Numerous organizations and associations support and nurture entrepreneurship by offering financial assistance at reduced interest rates. EDPs are designed to equip individuals with the essential skills, knowledge, and capabilities needed for successful entrepreneurship.

Keywords: *Socio culture Entrepreneurships, Micro Finance Institutions, Education, Religion, Social Support, Risk Taking.*

1. INTRODUCTION

The term "entrepreneur" originated from the French language, where it initially referred to an organizer of musical or other entertainments. In the early 16th century, the term began to be applied to individuals involved in military campaigns. By the 17th century, its usage expanded to include those engaged in construction and fortification projects. In the 18th century, the term started to encompass economic activities. Over the past 400 years, the concept of entrepreneurship has evolved significantly, and the term "entrepreneur" has come to represent various roles, including risk bearer, organizer, and innovator.

2. KEY FACTORS

To run a successful enterprise, an entrepreneur is expected to embody several key qualities, including:

1. **Vision:** The ability to see and plan for future opportunities and challenges.

2. **Risk-Taking:** Willingness to take calculated risks to achieve business goals.
3. **Innovation:** Capability to generate new ideas and approaches to solve problems or meet market needs.
4. **Decision-Making:** Skill in making informed and timely decisions.
5. **Leadership:** The ability to inspire and guide a team towards achieving business objectives.
6. **Resilience:** Capacity to bounce back from setbacks and persist through challenges.
7. **Adaptability:** Flexibility to adjust strategies and operations in response to changing market conditions.
8. **Resourcefulness:** Skill in effectively utilizing available resources and finding creative solutions.
9. **Financial Acumen:** Understanding of financial principles and effective management of finances.
10. **Networking:** Ability to build and maintain relationships that can provide support and opportunities.

These qualities collectively help entrepreneurs navigate the complexities of running a business and drive it towards success.

3. STATEMENT OF THE PROBLEM

To enhance female entrepreneurship in our country, it is essential to provide appropriate encouragement and motivation. Identifying the economic, social, and motivational factors that affect the growth of women entrepreneurs is crucial for addressing these issues effectively. Understanding these factors will help in pinpointing the reasons behind the success of some entrepreneurs while also identifying areas where improvements are needed to promote female entrepreneurship more effectively. In light of this, the current study focuses on Tiruppur District, a major industrial center in Tamil Nadu, to explore these factors and their impact on the advancement of women's entrepreneurial activities.

4. SIGNIFICANCE OF THE STUDY

Women encounter numerous social, economic, and structural obstacles that hinder their success in entrepreneurial ventures. A significant number of businesswomen in developing countries work within the informal economy, limiting their opportunities for business growth. Additionally, they often face challenges in accessing training and business development services that are crucial for expanding their enterprises.

5. OBJECTIVES OF THE STUDY

- To examine the conceptual framework surrounding women entrepreneurs.
- To analyze the socio-economic and industry profiles of women entrepreneurs.
- To identify the key factors influencing the growth and success of women entrepreneurs.

6. HYPOTHESES OF THE STUDY

These two hypotheses are examples of **null hypotheses** in a research study:

Null Hypothesis 1 (H_0): There is no association between the demographic profile (such as age, gender, education, etc.) and clusters of entrepreneurial growth.

This hypothesis suggests that demographic factors do not play a role in determining or influencing the clusters or groups of entrepreneurial growth.



Null Hypothesis 2 (H_0): There is no significant difference among the problems faced by entrepreneurs.

This hypothesis implies that all entrepreneurs, regardless of their background or business type, face similar types of challenges without any notable differences.

7. METHODOLOGY

Methodology Overview

Nature of the Study:

Descriptive Research: This aspect of the study focuses on gathering facts and information, with adequate interpretation, to provide a clear understanding of the existing conditions related to entrepreneurial growth and the challenges faced by entrepreneurs.

Prescriptive Research: This approach aims to go beyond just describing phenomena by that help individuals or entities conform to certain normative principles, such as best practices in entrepreneurship.

8 STATISTICAL TOOLS USED

- ❖ Descriptive Statistics
- ❖ Chi-square test

9. LIMITATIONS OF THE STUDY

The study has been conducted specifically in Tiruppur District, which was selected due to the researcher's familiarity with the area and its unique topographical characteristics. However, this purposive selection introduces a limitation:

Generalizability: The findings from Tiruppur may not be applicable to other districts or regions. Differences in local economic conditions, infrastructure, and cultural factors might result in different entrepreneurial experiences. Thus, the conclusions drawn may not fully reflect the experiences of entrepreneurs in other areas unless similar factors exist.

10. PROFILE OF THE IDUSTRY

The performance of business units is influenced by several key factors. Analyzing these factors provides insights into how different conditions affect the success or struggles of entrepreneurs. The study conducted focused on the following parameters:

Nature of Industry:

The industry type (e.g., manufacturing, services, retail) plays a crucial role in determining performance outcomes. Different industries face unique challenges, such as market demand, competition, regulatory hurdles, and supply chain dependencies.

Status of Domicile of Business Units:

Whether the business is operating in its home district, region, or has expanded beyond its domicile. This factor helps to understand the business's reach and the possible advantages or disadvantages of operating locally versus regionally/nationally.

Age of Business Units:

The number of years a business has been operational can significantly affect performance. Older businesses might benefit from established networks and experience, while younger businesses may face challenges related to market entry and growth.



Findings of the study

The findings point to a **demographically diverse** entrepreneurial ecosystem, where certain age groups and educational backgrounds are prominent.

Marital status and family size are not major influencers of entrepreneurial growth, suggesting that external and personal factors like motivation and individual ambition are more critical drivers.

The **family structure**, particularly the joint family system, seems to play a supportive role in fostering growth among women entrepreneurs. This might be due to the shared responsibilities and stronger family backing that allow more flexibility and resource allocation for business endeavors.

Suggestions of the Study

Based on the findings, here are recommendations that could foster entrepreneurial growth and improve the business environment for entrepreneurs, particularly women:

Direct Support of Men in Business Activities:

Encourage Active Male Participation in Women's Entrepreneurship: Men should be encouraged to support women in their entrepreneurial endeavors, both within the household and in the broader community. This can involve sharing responsibilities at home, participating in joint ventures, or offering mentorship and guidance in business activities.

Promote Gender-Inclusive Workspaces: Encourage the creation of more gender-inclusive work environments where men and women collaborate effectively, breaking down traditional gender roles that may hinder the progress of women entrepreneurs.

Accelerating Women Economic Empowerment Initiatives:

Expand Women-Focused Business Support Programs: Strengthen programs that provide training, mentorship, funding, and networking opportunities specifically for women entrepreneurs. Empowerment initiatives should also address barriers such as access to finance, skill development, and market access.

Encourage Female Role Models and Mentorship: Highlight successful women entrepreneurs as role models to inspire others and create mentorship networks where experienced businesswomen can guide new or aspiring entrepreneurs.

Provide Legal and Policy Support: Governments and institutions should implement policies that promote gender equality in entrepreneurship and eliminate legal or structural barriers that disproportionately affect women.

Initiatives to Extend Government Schemes and Programs to All Categories:

1.Increase Awareness and Accessibility of Government Schemes: Ensure that government schemes and programs designed to support entrepreneurs reach all categories of entrepreneurs, regardless of gender, location, or business size. This can be done by conducting targeted awareness campaigns and simplifying the application processes for such programs.

2.Enhance Local Government Involvement: Local governments should be more proactive in disseminating information about available schemes and programs, especially to

underrepresented groups such as women and rural entrepreneurs. This could involve setting up dedicated outreach teams or using digital platforms to reach a wider audience.

3.Ensure Equitable Distribution of Resources: Review the implementation of government schemes to ensure that all categories of entrepreneurs, including women, marginalized groups, and those in rural areas, benefit equally from available resources and support.

11. CONCLUSION

While the Government of India has made significant strides in promoting women's entrepreneurship, **localized barriers** continue to slow progress. Identifying and addressing these barriers through targeted interventions, increased awareness, and enhanced support systems can help transform the "distant dream" of widespread women's entrepreneurship into a reality, leading to significant contributions to the nation's economic growth.

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CYBER SECURITY: PROTECTING THE DIGITAL FRONTIER

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ABSTRACT

As the digital landscape expands, the significance of cyber security is more pronounced than ever. This paper delves into the core components of cyber security, examining how the threat environment has evolved and identifying the strategies essential for defending against cyber-attacks. With the rise of interconnected devices and online services, the risk of cyber threats has increased, making it crucial to establish a strong cyber security framework. It also emphasizes the need for organizations and individuals to protect sensitive data, maintain privacy, and ensure the seamless operation of digital systems. Cyber security is no longer just about preventing unauthorized access; it involves a comprehensive approach that includes risk assessment, incident response planning, and ongoing education and awareness. By understanding the current threat landscape, including challenges like malware, phishing, and advanced persistent threats, stakeholders can better prepare and implement effective defenses. The importance of a robust cyber security framework cannot be overstated. It is the foundation for safeguarding personal and professional information against breaches and ensuring that digital operations continue without disruption. This paper serves as a guide to understanding the critical elements of cyber security and the proactive measures necessary to protect our digital world.

Keywords: *Threat Landscape, Strategies, AI in Cyber Security, Challenges*

1. INTRODUCTION

Cybersecurity encompasses the strategies, technologies, and processes aimed at safeguarding networks, devices, applications, and data from attacks, damage, and unauthorized access. With the exponential growth of the internet and the widespread use of connected devices, cybersecurity has become a paramount issue for governments, businesses, and individuals. The digital landscape has transformed significantly, with cyber threats evolving from basic viruses to sophisticated, state-sponsored attacks. This progression underscores the critical need for robust and adaptive security measures. The modern world's reliance on digital technology exposes vulnerabilities that can be exploited by cybercriminals, making cybersecurity a vital component in protecting sensitive information and ensuring the continuity of operations. As threats become more advanced, the methods to counter them must also evolve, requiring continuous innovation and vigilance in the development and implementation of cybersecurity defenses. Effective cyber security not only involves preventing unauthorized access but also encompasses a proactive approach to identifying and



mitigating potential threats before they cause harm. This requires a comprehensive understanding of the current threat landscape, ongoing risk assessments, and the implementation of advanced technologies to detect and respond to threats in real time. The importance of cybersecurity will only grow as digital technology becomes increasingly integrated into every aspect of daily life, making it essential to stay ahead of emerging threats and protect the integrity of digital environments.

2. THE EVOLVING THREAT LANDSCAPE

The cyber security threat landscape is in a constant state of flux, driven by rapid technological advancements and the ingenuity of cybercriminals. As new technologies emerge, so do sophisticated methods of exploitation, making it imperative for cybersecurity measures to evolve continuously. Several key threats have become increasingly prominent in this dynamic environment:

2.1. Malware:

This category includes various types of malicious software, such as viruses, worms, ransomware, and spyware. Malware is designed to infiltrate systems, steal sensitive data, or disrupt operations, often causing significant damage to organizations and individuals alike.

2.2. Phishing:

Phishing attacks involve deceptive tactics where cybercriminals pose as legitimate entities in electronic communications to trick individuals into divulging sensitive information, such as passwords or financial details. These attacks are often highly targeted and can have severe consequences.

2.3. Denial of Service (DoS) Attacks:

These attacks aim to overwhelm a network or website with excessive traffic, rendering it inaccessible to legitimate users. DoS attacks can cripple an organization's online presence and disrupt its operations.

2.4. Advanced Persistent Threats (APTs):

APTs are prolonged, targeted attacks typically carried out by highly skilled and well-funded adversaries, often linked to nation-states. These attackers infiltrate networks and remain undetected for extended periods, gathering valuable information or compromising systems.

2.5. Insider Threats:

Insider threats originate from within an organization, where individuals with legitimate access to sensitive information misuse their privileges. These threats can be particularly challenging to detect and mitigate.

2.6. Supply Chain Attacks:

These attacks exploit vulnerabilities in third-party vendors or suppliers to gain access to a primary target. By compromising a trusted partner, cybercriminals can infiltrate an organization's network, often with devastating effects.



3. CYBERSECURITY STRATEGIES AND BEST PRACTICES

To effectively counter the continually evolving cyber threats, organizations need to implement a comprehensive cybersecurity strategy. This strategy should encompass several critical components:

3.1. Risk Assessment and Management:

Organizations must regularly conduct risk assessments to identify potential vulnerabilities and threats within their systems. By thoroughly understanding the specific risks they face, organizations can prioritize their resources effectively and implement the most appropriate security measures to mitigate those risks.

3.2. User Education and Awareness:

Human error remains a leading cause of cybersecurity breaches. Regular training and awareness programs are essential to help employees recognize and avoid common threats, such as phishing scams and social engineering attacks. Educating users on safe online practices significantly reduces the likelihood of security incidents.

3.3. Network Security:

Safeguarding the integrity and confidentiality of data as it travels across networks is crucial. Organizations should implement robust network security measures, including firewalls, intrusion detection systems, and encryption protocols, to protect data in transit and prevent unauthorized access.

3.4. Endpoint Security:

With the rise of remote work and the increasing use of mobile devices, securing endpoints—such as laptops, smartphones, and tablets—has become more critical than ever. Endpoint security can be enhanced through antivirus software, regular system updates, and mobile device management (MDM) solutions, ensuring that these devices do not become entry points for cyber threats.

3.5. Incident Response Planning:

Despite the best defenses, security breaches can still occur. Organizations must have a well-defined incident response plan to quickly detect, contain, and remediate any security incidents. This plan should include regular drills and updates to ensure it remains effective against emerging threats.

3.6. Data Protection and Privacy:

Protecting sensitive data is a top priority. This involves using data encryption, enforcing strict access controls, and performing regular backups to guard against data breaches and loss. Ensuring the privacy and security of data is essential for maintaining trust and compliance with regulations.

4. THE ROLE OF ARTIFICIAL INTELLIGENCE IN CYBER SECURITY

Artificial Intelligence (AI) and machine learning are becoming crucial in enhancing cybersecurity. AI can sift through massive volumes of data to identify patterns and anomalies that suggest potential cyber attacks. By detecting these irregularities, AI helps in early threat detection, enabling quicker responses. Additionally, machine learning algorithms are capable of predicting and adapting to new threats in real time, continuously improving their accuracy.

and effectiveness. This dynamic approach allows cybersecurity systems to stay ahead of evolving threats, enhancing the overall speed and efficiency of defensive measures. As cyber threats become more sophisticated, the integration of AI and machine learning in cybersecurity strategies is essential for protecting networks, data, and systems from potential breaches.

5. CHALLENGES IN CYBERSECURITY

Despite significant advancements in cybersecurity, several challenges persist:

5.1. Sophistication of Threats:

Cybercriminals are continuously evolving their techniques to bypass existing security measures, which makes it challenging for organizations to stay ahead of emerging threats. The constant innovation in attack methods requires equally dynamic and advanced defensive strategies.

5.2. Resource Constraints:

Many organizations, particularly small and medium-sized enterprises (SMEs), face limitations in resources, which hinders their ability to implement comprehensive cybersecurity solutions. These constraints can make it difficult for smaller entities to afford and maintain robust security infrastructures.

5.3. Regulatory Compliance:

Navigating the complex web of regulations and standards related to cybersecurity can be a daunting task for organizations. This challenge is amplified in a global context where different regions may have varying compliance requirements, making it hard for organizations to ensure they meet all necessary standards.

5.4. Talent Shortage:

There is a growing shortage of skilled cybersecurity professionals, creating difficulties for organizations in finding and retaining the expertise required to safeguard their systems. The scarcity of qualified personnel impacts an organization's ability to effectively manage and respond to cybersecurity threats.

6. CONCLUSION

In conclusion, while strides in cybersecurity have been substantial, significant challenges remain that organizations must address to effectively protect their digital assets. The evolving sophistication of cyber threats requires continual adaptation and innovation in defensive measures. Resource constraints, particularly for small and medium-sized enterprises, underscore the need for scalable and cost-effective security solutions. Navigating the complex landscape of regulatory compliance presents ongoing hurdles, especially in a global context where regulations vary. Additionally, the shortage of skilled cybersecurity professionals exacerbates the difficulty in building and maintaining robust security teams. Overcoming these obstacles is crucial for strengthening cybersecurity defenses and ensuring the protection of sensitive information. By addressing these challenges through strategic planning, resource allocation, and investment in talent, organizations can better safeguard their systems against an ever-changing threat landscape.

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STARTUP INDIA SEED FUND SCHEME (SISFS) & FUND OF FUNDS FOR STARTUPS (FFS): FUNDING CRITERIA AND FINANCIAL PERFORMANCE

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ABSTRACT

Having access to capital is crucial for entrepreneurs in the early phases of their ventures, just starting out. There are various funding options available to them, such as venture capital firms and angel investors. These funding sources will only provide financial support to startups that can demonstrate the viability of their business concepts. Similarly, banks may offer loans, but only to applicants with collateral. It's particularly vital to secure seed funding for startups with innovative business models aiming to test their concepts. The Government, through the Startup India initiative, does not directly finance startups. To address capital needs at different stages of a business's development, the Government has introduced the Fund of Funds for Startups (FFS) Scheme and Startup India Seed Fund Scheme (SISFS). This research is based on secondary data from the Fund of Funds for Startups (FFS) Scheme and Startup India Seed Fund Scheme (SISFS). The data has been examined using tables and graphs. The findings suggest that there is a significant number of startups in our country, and the Government has implemented measures to support these startups.

keywords: *Government Schemes, Funding options, India Initiative.*

1. INTRODUCTION

Entrepreneurs require initial funding to launch their ventures. It's challenging for individuals to secure personal funds for starting a business. Entrepreneurs seek financial support to kickstart their entrepreneurial journey. This funding is essential not just at the beginning but throughout the business's lifecycle. Having access to capital is crucial for entrepreneurs in the early stages when the business is in its infancy. Various funding sources are available to entrepreneurs, including venture capital firms and angel investors. These sources will only provide funding if the startup can demonstrate the viability of its concept. Similarly, banks may offer loans to startups, but such loans are only available to those with collateral. It's critical to provide seed funding to startups with innovative concepts for conducting proof of concept trials. The SISF Scheme is designed to offer financial backing to startups engaged in proof of concept, product trials, market entry, prototype development, and commercialization. This support enables startups to refine their ideas, potentially attracting venture capitalists or angel investors, or securing loans from financial institutions or commercial banks. These funding options allow entrepreneurs to pursue their innovative ideas with dedication, contributing to societal growth and impacting the economy. Seed funds are distributed only to startups that partner with eligible incubators in India.



2. STARTUP INDIA SEED FUND SCHEME (SISFS) & FUND OF FUNDS FOR STARTUPS (FFS)

Through the Startup India initiative, which was launched in 2016 under G.S.R. notification 127 (E), the government designates qualifying organizations as 'Startups.' Over the last five years, up to March 21, 2022, a total of 66,359 startups have received this recognition. While the Startup India initiative does not provide direct funding to startups, it has introduced two significant schemes: the Fund of Funds for Startups (FFS) and the Startup India Seed Fund Scheme (SISFS). The FFS, established in 2016 with a corpus of 10,000 crores, is intended to enhance the startup ecosystem and improve access to domestic capital, operating across the 14th and 15th Finance Commission cycles. Although it does not make direct investments in startups, the SISFS aims to provide financial assistance to startups that have a proof of concept, are conducting product trials, entering the market, developing prototypes, and commercializing their products. This support is designed to help startups reach a stage where they can attract funding from venture capitalists, angel investors, or financial institutions. Entrepreneurs lacking extensive business experience who are planning to launch a new venture should initially seek seed capital from the government, which will enable them to successfully establish their business. As they accumulate experience and gain insights into their operations, they can then seek further investment from other sources to advance their ventures.

3. STARTUPS REQUIREMENTS AND INITIATIVES

The startup ecosystem in India faces significant challenges due to a lack of capital during the seed and 'Proof of Concept' development stages. The funding required at this critical juncture can determine the success or failure of startups with promising business ideas. While entrepreneurs may seek additional financing later, the initial phase demands substantial investment. The necessary funds to launch a business can vary in size, yet they may not be readily available to the entrepreneur. It is essential for them to assess their concept through surveys or by analyzing the advantages and disadvantages of their proposed project, which can motivate them to embark on their entrepreneurial journey with a well-founded rationale, thereby avoiding high-risk ventures. Frequently, businesses encounter setbacks when they fail to research similar enterprises prior to launching their own. Although innovative ideas often emerge from the youth of our nation, their limited knowledge may hinder their ability to evaluate their business concepts effectively. Therefore, it is advisable for them to seek guidance from experienced individuals in similar fields before committing to an investment. Numerous innovative business ideas remain unrealized due to insufficient funding. The seed capital available to startups should be utilized in the most effective manner possible, as financial support is crucial for transforming an idea into a successful business.

The development of these concepts should encompass a comprehensive perspective, rather than relying solely on the individual's limited knowledge. It is advisable to engage with a diverse group of individuals who may contribute insights, even if they do not provide financial support. Prior to launching the business, it is essential to create a prototype of the product and the business model, followed by conducting trials to allow potential customers to experience the product. Once the product has been tested and refined through public feedback, the business can achieve significant success through a strategic market entry. Proper identification of the target market is crucial, and after conducting thorough surveys and finalizing the product prototype, the commercialization process can commence. Entrepreneurs often face uncertainty regarding the product's benefits, leading them to attempt



a large-scale launch prematurely, which can result in substantial challenges and financial losses.

4. ELIGIBILITY CRITERIA

Startups must meet specific eligibility criteria to apply for the "Startup India Seed Fund Scheme (SISFS)." The following conditions apply:

- A startup must be recognized by the Department for Promotion of Industry and Internal Trade (DPIIT) and should have been incorporated no more than two years prior to the application for SISFS.
- The startup should be centered around a business idea that aims to develop a product or service with market potential, scalability, and commercial viability.
- The focus of the startup should involve the application of technology in its core product or service, distribution model, business model, and the methodologies employed to address the targeted problem.
- Priority within the SISFS is given to startups that offer innovative solutions in sectors such as waste management, social impact, financial inclusion, water management, oil and gas, agriculture, biotechnology, education, textiles, defense, railways, energy, food processing, space, healthcare, and mobility.
- Startups seeking funding may have previously received financial support from other agencies; however, the total amount received must not exceed Rs. 10 lakhs under any Central or State Government scheme. This limit does not include prize money from competitions, subsidized working space, founders' monthly allowances, or access to prototyping facilities or labs.
- Promoters must hold a minimum of 51% shareholding in the startup when applying for funds from the incubator, in accordance with SEBI (ICDR) Regulations, 2018, and the Companies Act, 2013.
- No startup is eligible to receive seed support more than once, as stipulated in provisions 8.1 (i) and 8.1 (ii).

5. LITERATURE REVIEW

Jain (2017) noted in their research that the Indian populace has long been dedicated to development and innovation. A significant mercantile community has been engaged in business for generations and is expected to continue in similar ventures for the foreseeable future. In the early post-independence era, private enterprises played a minimal role in the business landscape, as the government took the lead due to the severely damaged economy. However, the introduction of globalization saw the entry of numerous multinational corporations, propelling the economy to new heights. This shift led to a comprehensive transformation of the Indian economic framework. The focus of this study is to explore the potential of startups in contributing to GDP growth and inspiring individuals to foster a resilient economy while creating valuable opportunities for entrepreneurs.

Rawal (2018) has indicated in the study that the concept of startups holds various interpretations within the Indian context. In India, startups are typically associated with young and dynamic individuals who collaborate to establish companies aimed at generating value for both customers and themselves. Startups embody vision, entrepreneurial characteristics, growth potential, and a forward-looking approach. It is essential for India and other developing nations to adopt both dialectical and practical measures to address

developmental gaps. The Indian government has initiated a wave of support for startups, launching numerous schemes designed to benefit these enterprises. State governments have acknowledged the significance of startups and their potential contributions to economic advancement. The researcher emphasizes the necessity of fostering an environment conducive to startup growth, as progress in this area has been limited. Furthermore, there is a pressing need to establish acceleration and incubation centers, particularly in rural and non-urban regions, to attract innovative ideas from diverse sectors of the economy.

Objectives

- To analyze the significance of SISFS and FFS programs in Indian startups.
- To assess the financial performance of startups in India over the past years.

6. ANALYSIS AND DISCUSSION.

The information obtained from the Government of India's Ministry of Commerce and Industry, specifically the Department for Promotion of Industry and Internal Trade, in the document titled "Allocation and Distribution of Funds to Startups," dated March 25, 2022, has been thoroughly examined. This study aims to analyze the impact of the SISFS and FFS schemes implemented by the Government of India over the past seven years. A comprehensive state-wise and year-wise enumeration of recognized startups across the nation has been compiled for the five-year period from 2016-17 to 2021-22. The data presented indicates a consistent increase in the number of startups during this timeframe. Notably, Maharashtra leads with the highest number of startups at 12,333, followed by Karnataka with 8,243, Delhi with 7,914, Uttar Pradesh with 5,964, and Gujarat with 4,378.

During the period from 2015-16 to 2021-22, a total of ₹2,791.29 crores has been allocated under the FFS scheme. Established in 2016, the FFS scheme commenced with a corpus of ₹10,000 crores, which was distributed over the 14th and 15th Finance Commission cycles. This allocation was contingent upon the progress of implementation and aimed at enhancing the startup ecosystem in India while facilitating access to domestic capital. The Department allocated ₹2,791.29 crores to SIDBI, which subsequently provided support to Alternative Investment Funds (AIFs).

7. RESEARCH FINDINGS

- There has been a notable increase in the number of startups from 2016-17 to 2021-22.
- Maharashtra has recorded the highest number of startups during the period from 2016 to 2021-22.
- The total funding allocated under the Fund of Funds for Startups (FFS) amounts to 2,791.29 crores from 2015-16 to 2021-22.
- Maharashtra leads in cumulative drawdown, followed by Karnataka.
- The largest allocation of funds under the Startup India Seed Fund Scheme (SISFS) occurred in the year 2022-23, totaling 346.50 crores.
- Karnataka has received the highest state-wise approval of funds under the SISFS scheme, amounting to 39.5 crores, with Telangana following closely.

9. CONCLUSION

The Government has been actively promoting startups for an extended period. The Startup India Seed Fund Scheme (SISFS) is designed to provide financial support to startups that have a proof of concept, are conducting product trials, entering the market, developing prototypes, and commercializing their products. Under these initiatives, the Government identifies eligible entities as 'Startups,' recognizing them under the Startup India initiative, which was launched in 2016 through G.S.R. notification 127 (E). Over the past five years, including the current year up to March 21, 2022, a total of 66,359 startups have been recognized. It is important to note that the Government does not directly fund startups under the Startup India initiative. To facilitate capital at various stages of the business lifecycle, the Government has established the Fund of Funds for Startups (FFS) Scheme and the Startup India Seed Fund Scheme (SISFS). The capital required at this stage can be crucial for startups with promising business ideas. Numerous innovative business concepts fail to launch due to insufficient funding. The seed funds provided to startups can be utilized effectively to foster their growth.

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AN ANALYSIS OF CUSTOMER PERCEPTIONS AND OVERALL SATISFACTION WITH THE PRODUCT AND SERVICES PROVIDED BY CITY UNION BANK WITH REFERENCE TO COIMBATORE CITY

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ABSTRACT

The globalization and liberalization of banking sectors have led to increased competition. Consequently, Banking institutions have broadened the variety of products and services they offer to their clientele. They are compelled to develop innovative strategies aimed at enhancing customer engagement to achieve their objectives. The primary goal is to deliver optimal service to their clientele. However, customers can only take advantage of the diverse services provided by banks if they are adequately informed about them. It is essential for bankers to comprehend the needs of their customers, just as it is crucial for customers to be aware of the various services that banks offer. A heightened awareness among customers typically results in increased preferences. The current study focuses on analyzing customer perceptions and satisfaction with the banking services provided by City Union Bank.

Keywords: *Customer Perception, Satisfaction, City Union Bank, Products & Service.*

1. INTRODUCTION

The financial sector plays a crucial role in the expansion of the Indian economy. Prior to independence, the development of this sector was insufficient, as banks primarily focused on generating profits rather than providing services to the general public. Ensuring customer satisfaction is a vital objective for all banks involved in service delivery. Any failure in this regard can lead to a diminished customer base. In a highly competitive environment, even minor shortcomings can result in the loss of clients. Customer loyalty is essential for retaining existing clients. In the context of liberalization and a free economy, measuring customer satisfaction in banks has become increasingly important. Over the past few years, regulatory and technological advancements have driven significant changes within the financial industry. These regulatory reforms have also contributed substantially to the sector's growth. Currently, banks are adeptly introducing new and innovative services frequently, thereby attracting clients to utilize their offerings. Customers are the cornerstone of any business, and the financial sector is particularly service-oriented. It is imperative for banks to ensure that their clients are satisfied with the services provided, as this is crucial for retaining and delighting them over extended periods. Banks offer a variety of products and services that must align with customer needs and are likely to generate revenue for the institution. There has been a remarkable and transformative shift in the approach towards customer focus in recent years. As the financial industry relies heavily on customer satisfaction, it is essential for policymakers and branch executives to address this issue with careful consideration.

2. REVIEW OF LITERATURE

1. Kumar T S and Vinothini V (2020) Enhancing customer service will assist in the development of new policies pertaining to customer relations.
2. Rameena KA (2020) In general, the respondents rated these three services positively, noting that the employees were quite helpful in relation to them.
3. Chitra S and Ramasethu A (2021) It has been noted that a significant number of customers lack awareness of the various facilities offered by SBI. Therefore, SBI should implement more effective awareness campaigns.
4. Kolanchinathan G and Elango S (2021) While banks are making considerable efforts to offer optimal security options to their customers, numerous factors still deter individuals from establishing an internet banking account.

3. STATEMENT OF THE PROBLEM

This study is to explore and assess customer satisfaction regarding banking services, particularly in relation to City Union Bank. The problem statement can be articulated as follows: In the highly competitive environment of the banking industry today, the significance of customer satisfaction is paramount in influencing the success and long-term sustainability of banking institutions. Grasping and fulfilling customer expectations is vital for delivering high-quality services, improving customer satisfaction, and sustaining a competitive advantage. Consequently, it is essential to investigate and identify the various expectations that customers have for banking services, particularly in the context of City Union Bank.

What banking services are offered by City Union Bank and In what ways do these services contribute to customer satisfaction?

What are the key factors influencing customer contentment in banking services?

OBJECTIVES

1. To evaluate the degree of customer perceptions and customer satisfaction regarding the banking services provided by City Union Bank.
2. To determine the primary factors that influence customer satisfaction regarding the banking services provided by City Union Bank.

RESEARCH METHODOLOGY

Research methodology is the systematic way to solve the research problem. It gives an idea about the various steps systematically adopted by the research with objectives to a study on service quality of City Union bank in Tirunelveli Municipal Corporation.

DATA COLLECTION:

Research Design:

The research may utilize a descriptive research design aimed at detailing and examining customer satisfaction with banking services. This approach can incorporate both qualitative and quantitative methodologies to obtain a thorough understanding.

Primary Data:

Primary data refers to information that is gathered for the first time specifically for our research purposes. This data is characterized as original and is obtained through the use of questionnaires designed for our study. In this research, primary data was collected from participants through the administration of questionnaires and personal interviews.

Secondary Data:

Secondary data can be obtained from a variety of sources, including research articles, corporate reports, and publications from the Reserve Bank of India (RBI). These resources offer valuable background information, insights from customer feedback, and existing research pertaining to customer satisfaction within the banking sector.

SAMPLE SIZE

In order to finalize the analysis, a meticulously designed questionnaire was distributed to 300 individuals, from which 280 responses were received. However, 10 of these responses were incomplete, resulting in a final sample size of 270.

SAMPLING TECHNIQUES

In the research concerning the service quality of City Union Bank in Coimbatore City, a convenient sampling method was employed. Samples were chosen based on the ease and convenience for the researcher.

STATISTICAL TOOLS

The statistical instruments facilitate a systematic assessment of the issues being examined. In the analysis of primary data, this study employs statistical methods including percentage analysis.

DATA ANALYSIS

In this study carried out a survey involving 270 customers to assess their levels of satisfaction and expectations. To facilitate this analysis, I developed a questionnaire aimed at gathering relevant information from them.

ANALYSIS OF ACCOUNT HOLDERS SATISFACTION

3.1. Gender

Table: 1 Gender

Particular	Responses	Percentage
Male	146	54.07
Female	124	45.93
Total	270	100

Interpretation:

The data reveals a slight predominance of Male participants, comprising 54.07%, in contrast to Female participants, who account for 45.93%. This suggests that there is an increased probability that the bank's customer demographic is predominantly male.

3.2. Age

Table: 2 Age

Particular	Responses	Percentage
Below 20 years	38	14.07
21 - 40 years	109	40.37
41 - 50 years	74	27.41
51 years & above	49	18.15
Total	270	100

Interpretation:

The table presented above reveals that 14.07% of the participants are under the age of 20, whereas 40.37% belong to the age range of 21 to 40. Furthermore, 27.41% of the respondents are categorized within the 41 to 50 age bracket, and the remaining 18.15% are aged 51 years or older.

3.3. Educational Background

Table: 3 Educational Background

Particular	Responses	Percentage
Illiterate	12	4.44
School	43	15.93
Under Graduation	120	44.44
Post Graduation	95	35.19
Total	270	100

Interpretation:

The educational profiles of City Union Bank customers exhibit considerable diversity. Statistical data indicates that 15.93% are currently enrolled in school, 44.44% hold undergraduate degrees, 35.19% possess postgraduate qualifications, and 4.44% are classified as illiterate.

3.4. Occupations of Respondents.

Table 4: Occupations

Particular	Responses	Percentage
Student	78	28.89
Employee	74	27.41
Agriculture	52	19.26
Business	38	14.07
Other	28	10.37
Total	270	100

Interpretation:

The table presented above illustrates the various occupations of customers at Union Bank in the city. Among them, 28.89% are students, 27.41% are employees, 19.26% are engaged in agriculture, 14.07% are business professionals, and 10.37% belong to other occupational categories.

3.5. Monthly Income.

Table 5: Monthly Income

Particular	Responses	Percentage
Dependent to Family	77	28.52
Below ₹ 10000	37	13.70
₹10000 - ₹20000	42	15.56
₹20000 - ₹30000	72	26.67
Above ₹30000	42	15.56
Total	270	100

Interpretation:

The table presented above illustrates the income distribution among customers of City Union Bank. It indicates that 28.52% rely on family support, 13.70% earn less than 10,000, 15.56% have incomes ranging from 10,000 to 20,000, 26.67% fall within the 20,000 to 30,000 income bracket, and 15.56% earn more than 30,000.

3.6. Years of Relationship

Table: 6 Years of Relationship

Particular	Responses	Percentage
Less than 1 years	57	21.11
1 to 2 years	36	13.33
2 to 5 years	86	31.85
More than 5 years	91	33.70
Total	270	100

Interpretation:

The table presented above illustrates the duration of relationships between customers of City Union Bank and the institution itself. Specifically, 21.11% of customers have maintained their accounts for less than one year, 13.33% for a period ranging from one to two years, 31.85% for two to five years, and 33.70% for more than five years.

3.7. Preferred Banking Channels

Table: 7 Preferred Banking Channels

Particular	Responses	Percentage
Branch	67	24.81
ATM	84	31.11
Online	65	24.07
Mobile	54	20.00
Total	270	100

Interpretation:

The table presented above illustrates the banking channel preferences among customers of City Union Bank. From a total of 270 respondents, 67 indicated a preference for branch banking, 84 opted for ATMs, 65 selected online banking, and 54 preferred mobile banking. This indicates that the bank serves a diverse clientele with varying preferences for managing their finances.

3.8. Level of Satisfaction with the Existing Banking Services

Table: 8 Satisfaction with existing Banking Services

Particular	Responses	Percentage
Very Dissatisfied - Rating 1	6	2.22
Slightly Dissatisfied - Rating 2	15	5.56
Neutral - Rating 3	42	15.56
Moderately Satisfied- Rating 4	176	65.19
Very Satisfied -Rating 5	31	11.48
Total	270	100

4. INTERPRETATION

The table presented above illustrates the satisfaction levels of customers of the City Union Bank regarding the bank's existing banking services. Specifically, 2.22% of customers assigned a level 1 rating, 5.56% provided a level 2 rating, 15.56% rated it at level 3, 65.19% awarded a level 4 rating, and 11.48% gave a level 5 rating.

Table: 9 Level of Satisfaction following variables

Particular	Poor		Average		Fair		Good		Very Good	
	Re spo nse s	%	Re sp on ses	%	Re sp on ses	%	Re sp on ses	%	Re sp on ses	%
Efficiency and Promptness of Service	9	3.33	53	19.63	85	31.48	60	22.22	63	23.33
Accuracy of Transactions	11	4.07	40	14.81	91	33.7	90	33.33	38	14.07
Staff Competence and Knowledge	12	4.44	42	15.56	108	40	75	27.78	33	12.22
Availability and Accessibility of Banking Channels	8	2.96	46	17.04	83	30.74	96	35.56	37	13.70
Responsiveness to Queries and Complaints	15	5.56	42	15.56	79	29.26	96	35.56	38	14.07
Banking Products and Services	11	4.07	48	17.78	91	33.7	86	31.85	34	12.59
Interest Rates and Fees	13	6.3	62	13.33	88	23.33	65	30.37	42	26.67
Account Opening Process	17	6.3	36	13.33	63	23.33	82	30.37	72	26.67
Deposit and Withdrawal Transactions	13	4.81	69	25.56	53	19.63	60	22.22	75	27.78
Fund Transfers and Payments	6	2.22	67	24.81	83	30.74	95	35.19	19	7.04
Loan Services	6	2.22	71	26.3	96	35.56	55	20.37	42	15.56

Interpretation:

The table presented above illustrates the evaluations provided by customers of City Union Bank regarding the timeliness and effectiveness of the bank's services. A total of 3.3%



of customers rated the services poorly, 19% rated them as average, 31.7% provided a fair rating, 22.2% rated them as good, and 23.3% offered a very good rating.

The table displayed above provides an overview of the assessments of customers regarding the precision of the bank's transactions. A total of 3.9% of customers assigned a poor rating, 15% offered an average rating, 33.9% rated it as fair, 33.3% classified it as good, and 13.9% provided a very good rating.

The table above depicts the assessments provided by customers of City Union Bank regarding the competence and knowledge of the bank's staff. Specifically, 4.4% of customers assigned a poor rating, 15.6% rated it as average, 40% offered a fair rating, 27.8% deemed it good, and 12.2% rated it as very good.

The data illustrated in the table indicates that respondents have rated the availability and accessibility of banking channels at CUB as follows: 4.4% classified it as Poor, 15.6% as Average, 30.6% as Fair, 35.6% as Good, and 13.9% as Very Good.

The information provided in the table reveals that the ratings for Responsiveness to Queries and Complaints of City Union Bank are as follows: 3.9% of respondents rated it as Poor, 17.8% as Average, 33.9% as Fair, 31.7% as Good, and 12.8% as Very Good .

According to the information presented, respondents evaluated the quality of products and services offered by CUB in the following manner: 5% rated them as poor, 22.8% as fair, 32.8% also as fair, 23.9% as good, and another 22.8% rated them as good. Additionally, 15.6% classified the offerings as very good.

The data presented in the table indicates that respondents rated the Interest Rates and Fees of City Union Bank as follows: 6.1% classified it as Poor, 13.3% as Average, 23.3% as Fair, 30.6% as Good, and 26.7% as Very Good.

The data presented in the table indicates the ratings for the CUB Account Opening Process as follows: 5% of participants classified it as Poor, 25.6% as Fair, 19.4% as Good, 22.2% as Very Good, and 27.8% as Very Good.

The information presented in the table reveals that among the respondents regarding the Deposit and Withdrawal Transactions of CUB, 2.2% classified their experience as Poor, 25% as Fair, 30.6% as Good, 35% as Very Good, and 7.2% as Very Good.

The data presented in the table indicates that customer ratings for city Union Bank Fund Transfers and Payments are as follows: 2.2% rated the service as Poor, 26.1% as Fair, 30.6% as Good, 26.6% as Very Good, and 15.6% as Very Good.

According to the provided table, a portion of the respondents rated CUB loan services as follows: 6.7% gave a Poor rating, 30.6% rated it as Fair, 33.3% as Good, 21.7% as Very Good, and 7.8% as Very Good.

Table Showing the Factors Influencing Respondents Loyalty towards City Union Bank

Table 10: Factors Influencing Respondents Loyalty

Particular	Responses	Rank
Quality of service	42	1
Banking Products & Services	32	2
Interest Rates and Processing Fees	36	3
Security level	47	4
Convenience and Accessibility	29	5
Complaints management:	28	6
Information management:	18	7
Goodwill & Brand Image	16	8
Personal attention	14	9
Rewards Points	8	10

Interpretation:

The slab showing overhead indicates that out of 270 surveyed respondents of City Union Bank, 103 individuals opted for Quality of service, 79 for Banking Products and Services, 87 for Interest Rates and Fees, 114 for Security level, 71 for Convenience and Accessibility, 66 for Complaints management, 45 for Information management:, 38 for Goodwill & Brand Image, 36 for Personal attention, and 17 for Rewards Points.

5. CONCLUSION

In this thorough research, I explored customer satisfaction regarding banking services, with a specific emphasis on City Union Bank. By conducting an in-depth analysis of multiple factors and dimensions related to banking services, we have gained valuable insights into the dynamics that influence customer experiences and perceptions. The findings of this study underscore the essential role that customer satisfaction plays in the success and longevity of financial institutions. Through the examination of customer preferences, satisfaction levels, and opinions, we have pinpointed the primary factors that impact overall satisfaction with the services offered by City Union Bank.

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ESTIMATING SHORTEST ROUTE FOR NAVA DIVYA DESAMS

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ABSTRACT

In this paper Diagonal Completion technique is applied to solve the Travelling Salesman Problem (TSP) whose objective is to minimize the cost. Given a set of cities and the distance between every pair of cities, the problem of finding the shortest route between a set of points and locations that must be visited. When engaging on a spiritual journey, one prefers shortest route (minal distance) to travel Nava Divya Desams namely Srirangam, Thirupathi, Srivaikuntam, Azhagar Kovil (Madurai), Thiruvananthapuram (Kerala), Kanchipuram, Thiruvellarai, Thirukoshtiyur, Srivilliputhur. Our problem is not possible to solve by penalty method because five cities are not covered in the route. So we solve the problem by Diagonal Completion technique. In this method we found the route to cover Nava Divya Desams in two sub tours.

Keywords: *Divya Desams, Interval numbers, Branch and Bound Technique, Diagonal Completion Techniques.*

1. DIVYA DESAMS

Divya Desams are 108 Vishnu temples that are mentioned in the works of the Alvars, the Tamil poet-saints of the 6th-9th centuries AD. These temples are of great significance in the Vaishnavism tradition of Hinduism and are spread across India, predominantly in the Tamil Nadu region, with others in Andhra Pradesh, Kerala, Gujarat, and Uttar Pradesh, and one in Nepal. There are 84 Divya Desams in Tamil Nadu, and 11 in the northern and southern areas of Kerala. 105 of the 108 Divya Desams are dispersed over the Indian subcontinent's states, including Tamil Nadu, Kerala, Andhra Pradesh, Gujarat, Uttar Pradesh, and Uttarakhand. While one is in Nepal, the other two are beyond earthly worlds, namely Thirupalkadal (the ocean of milk) and Paramapadam (Vaikuntha, where Lord Vishnu resides).

1.1 History of Divya Desams:

- **Alvars and their Hymns:** The Alvars, twelve in number, were ardent devotees of Lord Vishnu. They composed hymns in praise of Vishnu, which were later compiled into a collection known as the "Nalayira Divya Prabandham." The hymns dedicated to the temples are considered to mark them as Divya Desams.

- **Geographical Spread:** The majority of Divya Desams are located in Tamil Nadu, with significant clusters in and around the temple towns of Kanchipuram, Tiruchirapalli, and Madurai. The rest are scattered across various states in India and one in Nepal, emphasizing the widespread influence of Vaishnavism.
 - **Architectural Significance:** The temples are renowned for their architectural beauty and historical significance. They feature Dravidian architecture, characterized by towering gopurams (gateway towers), intricately carved pillars, and expansive courtyards.
 - **Religious Practices:** The Divya Desams follow specific rituals and traditions. The daily worship and festivals in these temples are conducted according to the Pancharatra Agama and Vaikhanasa Agama scriptures.
 - **Pilgrimage:** Visiting the 108 Divya Desams is considered a sacred pilgrimage for devotees of Lord Vishnu. It is believed that visiting these temples and offering prayers can lead to salvation (moksha).
 - **Prominent Divya Desams:**
 - Srirangam (Sri Ranganathaswamy Temple):** Located in Tiruchirapalli, Tamil Nadu, it is the largest functioning Hindu temple in the world.
 - Tirupati (Sri Venkateswara Temple):** Located in Andhra Pradesh, it is one of the most visited pilgrimage sites in the world.
 - Srivilliputhur (Srivilliputhur Andal Temple):** Known for its connection to Andal, the only female Alvar.
 - Thiruvananthapuram (Padmanabhaswamy Temple):** Located in Kerala, it is famous for its wealth and the reclining form of Vishnu.
- The Divya Desams hold a cherished place in the spiritual landscape of India, representing the rich cultural and devotional heritage of Vaishnavism.

2. TRAVELING SALESMAN PROBLEM

The Travelling Salesman Problem (TSP) is one of the most researched problems in optimization and computer science. It is concerned with determining the shortest possible route for a traveling salesman to visit each city on a given list exactly once before returning to the starting point. Despite its basic concept, TSP is well-known for its computational complexity and diverse variety of practical applications. The TSP has remained a benchmark problem in optimization and computer research. Solving it efficiently has far-reaching consequences for industries ranging from logistics and transportation to network design and bioinformatics. Its research has also resulted in advances in algorithm design and computational complexity theory.

2.1 Problem Definition:

The Travelling Salesman Problem (TSP) is a well-known problem in optimization and computer science.

Given a list of cities and the distances between each pair of cities, the task is to find the shortest possible route that visits each city exactly once and returns to the original city.

Key Components:

Cities: A set of locations that need to be visited.

Distances: The distance (or cost) between each pair of cities.

Objective: The objective is to minimize the total travel distance (or cost) of the tour that visits each city exactly once and returns to the starting city.

2.2 Mathematical Formulation:

Decision Variables: Let x_{ij} be a binary variable that equals 1 if the tour goes directly from city i to city j , and 0 otherwise.

Objective Function: Minimize the total distance:

$$\text{Minimize } Z = \sum_{i,j=1}^n d_{ij} x_{ij}$$

Where d_{ij} is the distance between cities i and j and n is the number of cities.

2.3 Constraints:

Each City is visited Exactly Once: For each city, there must be exactly one incoming and one outgoing edge.

$$x_{ij} = 1 \text{ for all } i, j \neq i \quad x_{ij} = 1 \text{ for all } i, i \neq j$$

2.4. Solution Methods:

❖ Exact Algorithms:

Brute Force: Check all possible permutations of cities. This is feasible only for very small numbers of cities due to its factorial time complexity.

Dynamic Programming: The Held-Karp algorithm is a dynamic programming approach that reduces the time complexity to $O(n^2 2^n)$ but it is still exponential in nature.

Integer Linear Programming (ILP): Use linear programming formulations with integer constraints and solve using solvers like CPLEX or Gurobi.

❖ Heuristic Methods:

Nearest Neighbour: Start from a city and repeatedly visit the nearest unvisited city. This is simple but does not guarantee the optimal solution.

Greedy Algorithm: Build a tour incrementally by choosing the shortest available edge at each step.

Genetic Algorithms: Use evolutionary strategies to find good solutions through operations like mutation and crossover.

Simulated Annealing: Search for better solutions by probabilistically accepting worse solutions with the hope of escaping local optima.

❖ Approximation Algorithms:

Christofides' Algorithm: Provides a solution that is within 1.5 times the optimal tour length for metric TSP, where distances satisfy the triangle inequality.

2.5 Applications:

Logistics and Route Planning: Optimizing delivery routes for salespeople, delivery trucks, or other vehicles.

Manufacturing: Optimizing the path of a drill or other tools on a circuit board.

Computer Networking: Designing efficient network layouts.

3. BRANCH AND BOUND

Branch and Bound (B&B) is a popular algorithmic technique for solving combinatorial optimization problems like the Travelling Salesman Problem (TSP). It is a general method for finding optimal solutions by systematically exploring and pruning the solution space.

Branch and Bound works by breaking the problem into smaller subproblems (branching) and using bounds to determine which subproblems need to be explored further (bounding). It is particularly effective for problems with a large but finite solution space, where a brute-force approach would be computationally infeasible.

3.1 Steps in Branch and Bound for TSP:

Initialization:

Start with an initial upper bound on the solution (often obtained through a heuristic or a simple greedy algorithm). Initialize the best known solution as the initial upper bound.

Branching:

Divide the problem into smaller sub problems. For the TSP, this involves creating subsets of cities and constructing partial tours. Each branch represents a decision point, such as including a specific edge in the tour or not. This can be done by considering all possible edges that can be added to the tour and creating sub problems based on these choices.

Bounding:

For each sub problem, compute a lower bound on the cost of the tour that can be achieved from that sub problem. Various bounding techniques can be used, such as the Minimum Spanning Tree (MST) or the Linear Programming relaxation of TSP. If the lower bound of a sub problem is greater than or equal to the current best known solution, discard that sub problem (pruning).

Pruning:

Discard branches where the lower bound exceeds the current best solution or where constraints cannot be met. This helps in reducing the number of sub problems that need to be explored.

Updating:

Update the best known solution if a better solution is found in any sub problem.

Termination:

The algorithm terminates when all branches have been either explored or pruned, and the best known solution is the optimal solution.

4. DIAGONAL COMPLETION METHOD:

The diagonal completion method is a technique used in the field of operations research, specifically in the context of optimization problems, such as the assignment problem. This method helps in finding an optimal solution by systematically improving a feasible solution until optimality is achieved. The Travelling Salesman Problem (TSP) is a classic optimization problem in operations research where the goal is to find the shortest possible route that visits a set of cities and returns to the origin city. Although the diagonal completion method is typically used for assignment problems, it can be adapted for solving TSP in certain contexts.

Key Concepts

Travelling Salesman Problem (TSP): A problem where a salesman must visit each city exactly once and return to the starting city, minimizing the total travel cost or distance.

Cost Matrix: A matrix where the entry C_{ij} represents the cost or distance of traveling from city i to city j .

4.1 Steps in Applying the Diagonal Completion Method to TSP

Construct the Cost Matrix: Create a cost matrix where each entry represents the travel cost between two cities.

Initial Feasible Solution: Start with an initial feasible solution, which can be generated using heuristics such as the Nearest Neighbor, Minimum Spanning Tree, or any other TSP heuristic.

Cost Adjustment: Similar to the assignment problem, adjust the cost matrix to facilitate finding an optimal tour. This may involve reducing the cost matrix by subtracting the smallest value in each row and column.

Optimization by Diagonal Completion: Improve the current feasible solution by examining potential swaps and reassignments to reduce the total tour cost. In the context of TSP, this may involve completing cycles in the cost matrix that correspond to potential improvements in the tour.

Iterative Improvement: Repeatedly adjust the cost matrix and reassign paths until no further improvements can be made, indicating an optimal or near-optimal solution has been found.

5. DISTANCE BETWEEN NAVA DIVYA DESAMS

Table 1: Collected Data Details-The distance between Nava divya desams

Distance Place	Srirangam	Tirupathi	Sri Vaikuntam	Azhagarkovil-Madurai	Thiruvananthapuram-Kerala	Kanchipuram	Thiruvellarai	Thirukoshtiyur	Srivilliputhur
Srirangam	∞	370	312	124	460	274	16	112	223
Tirupathi	370	∞	679	492	826	108	400	478	589
Sri Vaikuntam	312	679	∞	195	177	590	397	237	141
Azhagarkovil - Madurai	124	492	195	∞	344	403	138	54	106
Thiruvananthapuram-Kerala	460	826	177	344	∞	730	474	385	184
Kanchipuram	274	108	590	403	730	∞	282	388	500
Thiruvellarai	16	400	397	138	474	282	∞	124	235
Thirukoshtiyur	112	478	237	54	385	388	124	∞	147
Srivilliputhur	223	589	141	106	184	500	235	147	∞

Consider: Srirangam (A), Tirupathi (B), Sri Vaikuntam (C), Azhagarkovil- Madurai (D), Thiruvananthapuram-Kerala (E), Kanchipuram (F), Thiruvellarai (G), Thirukoshtiyur (H), Srivilliputhur (I).

Find Solution of Travelling salesman problem using branch and bound (penalty) method (MIN case)

Distance Place	A	B	C	D	E	F	G	H	I
A	x	370.	312	124	460	274	16	112	223
B	370	x	679	492	826	108	400	478	589
C	312	679	x	195	177	590	397	237	141
D	124	492	195	x	344	403	138	54	106
E	460	826	177	344	x	730	474	385	184
F	274	108	590	403	730	x	282	388	500
G	16	400	397	138	474	282	x	124	235
H	112	478	237	54	385	388	124	x	147
I	223	589	141	106	184	500	235	147	x

Solution:

The number of rows = 9 and columns = 9

A	B	C	D	E	F	G	H	I	
A	M	370	312	124	460	274	16	112	223
B	370	M	679	492	826	108	400	478	589
C	312	679	M	195	177	590	397	237	141
D	124	492	195	M	344	403	138	54	106
E	460	826	177	344	M	730	474	385	184
F	274	108	590	403	730	M	282	388	500
G	16	400	397	138	474	282	M	124	235
H	112	478	237	54	385	388	124	M	147
I	223	589	141	106	184	500	235	147	M

Steps of penalty methods, which is not to solve the problem.

We know that the sum of row minimum gives us the lower bound.

Step-1: Find out the each row minimum element and subtract it from that row

	A	B	C	D	E	F	G	H	I	
A	M	354	296	108	444	258	0	96	207	(-16)
B	262	M	571	384	718	0	292	370	481	(-108)
C	171	538	M	54	36	449	256	96	0	(-141)
D	70	438	141	M	290	349	84	0	52	(-54)
E	283	649	0	167	M	553	297	208	7	(-177)
F	166	0	482	295	622	M	174	280	392	(-108)
G	0	384	381	122	458	266	M	108	219	(-16)
H	58	424	183	0	331	334	70	M	93	(-54)
I	117	483	35	0	78	394	129	41	M	(-106)

So, row minimum will be 780. $(16+108+141+54+177+108+16+54+106=780)$

Step-2: Find out the each column minimum element and subtract it from that column.

	A	B	C	D	E	F	G	H	I	
A	M	354	296	108	408	258	0	96	207	
B	262	M	571	384	682	0	292	370	481	
C	171	538	M	54	0	449	256	96	0	
D	70	438	141	M	254	349	84	0	52	
E	283	649	0	167	M	553	297	208	7	
F	166	0	482	295	586	M	174	280	392	
G	0	384	381	122	422	266	M	108	219	
H	58	424	183	0	295	334	70	M	93	
I	117	483	35	0	42	394	129	41	M	
	(-0)	(-0)	(-0)	(-0)	(-36)	(-0)	(-0)	(-0)	(-0)	

So, column minimum will be 36. $(0+0+0+0+36+0+0+0+0+0=36)$

we get the lower bound = $780+36=816$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	A	B	C	D	E	F	G	H	I
A	M	354	296	108	408	258	0(166)	96	207
B	262	M	571	384	682	0(520)	292	370	481
C	171	538	M	54	0(42)	449	256	96	0(7)
D	70	438	141	M	254	349	84	0(93)	52
E	283	649	0(42)	167	M	553	297	208	7
F	166	0(520)	482	295	586	M	174	280	392
G	0(166)	384	381	122	422	266	M	108	219
H	58	424	183	0(58)	295	334	70	M	93
I	117	483	35	0(35)	42	394	129	41	M

Here maximum penalty is 520, occur at XB, F or XF, B , so we choose XF, B to begin branch
There are two branches.

1. If $XF, B=0$, then we have an additional cost of 520 and the lower bound becomes $816+520=1336$

2. If $XF, B=1$, we can go $F \rightarrow B$

So we can't go $B \rightarrow F$, so set it to M.

Now we leave row F and column B , so reduced matrix is

	A	C	D	E	F	G	H	I
A	M	296	108	408	258	0	96	207
B	262	571	384	682	M	292	370	481
C	171	M	54	0	449	256	96	0
D	70	141	M	254	349	84	0	52
E	283	0	167	M	553	297	208	7
G	0	381	122	422	266	M	108	219
H	58	183	0	295	334	70	M	93
I	117	35	0	42	394	129	41	M

Step-1: Find out the each row minimum element and subtract it from that row

	A	C	D	E	F	G	H	I	
A	M	296	108	408	258	0	96	207	(-0)
B	0	309	122	420	M	30	108	219	(-262)
C	171	M	54	0	449	256	96	0	(-0)
D	70	141	M	254	349	84	0	52	(-0)
E	283	0	167	M	553	297	208	7	(-0)
G	0	381	122	422	266	M	108	219	(-0)
H	58	183	0	295	334	70	M	93	(-0)
I	117	35	0	42	394	129	41	M	(-0)

So, row minimum will be 262. $(0+262+0+0+0+0+0+0+0=262)$.

Step-2: Find out the each column minimum element and subtract it from that column.

	A	C	D	E	F	G	H	I	
A	M	296	108	408	0	0	96	207	
B	0	309	122	420	M	30	108	219	
C	171	M	54	0	191	256	96	0	
D	70	141	M	254	91	84	0	52	
E	283	0	167	M	295	297	208	7	
G	0	381	122	422	8	M	108	219	
H	58	183	0	295	76	70	M	93	
I	117	35	0	42	136	129	41	M	
	(-0)	(-0)	(-0)	(-0)	(-258)	(-0)	(-0)	(-0)	(-0)

So, column minimum will be 258. $(0+0+0+0+258+0+0+0+0=258)$

We get the lower bound = $816+262+258=1336$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	A	C	D	E	F	G	H	I
A	M	296	108	408	0(8)	0(30)	96	207
B	0(30)	309	122	420	M	30	108	219
C	171	M	54	0(42)	191	256	96	0(7)
D	70	141	M	254	91	84	0(93)	52
E	283	0(42)	167	M	295	297	208	7
G	0(8)	381	122	422	8	M	108	219
H	58	183	0(58)	295	76	70	M	93
I	117	35	0(35)	42	136	129	41	M

Here maximum penalty is 93, occur at XD, H , so we choose XD, H to begin branch
There are two branches.

1. If $XD, H=0$, then we have an additional cost of 93 and the lower bound becomes $1336+93=1429$

2. If $XD, H=1$,

we can go $D \rightarrow H$

So we can't go $H \rightarrow D$, so set it to M.

Now we leave row D and column H , so reduced matrix is

	A	C	D	E	F	G	I
A	M	296	108	408	0	0	207
B	0	309	122	420	M	30	219
C	171	M	54	0	191	256	0
E	283	0	167	M	295	297	7
G	0	381	122	422	8	M	219
H	58	183	M	295	76	70	93
I	117	35	0	42	136	129	M

Step-1: Find out the each row minimum element and subtract it from that row

	A	C	D	E	F	G	I	
A	M	296	108	408	0	0	207	(-0)
B	0	309	122	420	M	30	219	(-0)
C	171	M	54	0	191	256	0	(-0)
E	283	0	167	M	295	297	7	(-0)
G	0	381	122	422	8	M	219	(-0)
H	0	125	M	237	18	12	35	(-58)
I	117	35	0	42	136	129	M	(-0)

So, row minimum will be 58. ($0+0+0+0+0+58+0=58$)

we get the lower bound = $1336+58+0=1394$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	A	C	D	E	F	G	I
A	M	296	108	408	0(8)	0(12)	207
B	0(30)	309	122	420	M	30	219
C	171	M	54	0(42)	191	256	0(7)
E	283	0(42)	167	M	295	297	7
G	0(8)	381	122	422	8	M	219
H	0(12)	125	M	237	18	12	35
I	117	35	0(89)	42	136	129	M

There are two branches.

1. If $XI, D=0$, then we have an additional cost of 89 and the lower bound becomes $1394+89=1483$

2. If $XI, D=1$,

we can go $I \rightarrow D$

Now we leave row I and column D , so reduced matrix is

	A	C	E	F	G	I
A	M	296	408	0	0	207
B	0	309	420	M	30	219
C	171	M	0	191	256	0
E	283	0	M	295	297	7
G	0	381	422	8	M	219
H	0	125	237	18	12	35

Here we have 0 in every row and column. So, the lower bound remains the same
i.e, $1394+0=1394$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	A	C	E	F	G	I
A	M	296	408	0(8)	0(12)	207
B	0(30)	309	420	M	30	219
C	171	M	0(237)	191	256	0(7)
E	283	0(132)	M	295	297	7
G	0(8)	381	422	8	M	219
H	0(12)	125	237	18	12	35

Here maximum penalty is 237, occur at XC,E , so we choose XC,E to begin branch
There are two branches.

1. If $XC,E=0$, then we have an additional cost of 237 and the lower bound becomes $1394+237=1631$

2. If $XC,E=1$,

we can go $C \rightarrow E$

So we can't go $E \rightarrow C$, so set it to M.

Now we leave row C and column E, so reduced matrix is

	A	C	F	G	I
A	M	296	0	0	207
B	0	309	M	30	219
E	283	M	295	297	7
G	0	381	8	M	219
H	0	125	18	12	35

Step-1: Find out the each row minimum element and subtract it from that row

	A	C	F	G	I	
A	M	296	0	0	207	(-0)
B	0	309	M	30	219	(-0)
E	276	M	288	290	0	(-7)
G	0	381	8	M	219	(-0)
H	0	125	18	12	35	(-0)

So, row minimum will be 7. ($0+0+7+0+0=7$)

Step-2: Find out the each column minimum element and subtract it from that column.

	A	C	F	G	I
A	M	171	0	0	207
B	0	184	M	30	219
E	276	M	288	290	0
G	0	256	8	M	219
H	0	0	18	12	35
	(-0)	(-125)	(-0)	(-0)	(-0)

So, column minimum will be 125. ($0+125+0+0+0=125$)

we get the lower bound = $1394+7+125=1526$.

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column).

	A	C	F	G	I
A	M	171	0(8)	0(12)	207
B	0(30)	184	M	30	219
E	276	M	288	290	0(311)
G	0(8)	256	8	M	219
H	0(0)	0(171)	18	12	35

Here maximum penalty is 311, occur at XE, I , so we choose XE, I to begin branch
There are two branches.

1. If $XE, I=0$, then we have an additional cost of 311 and the lower bound

becomes $1526+311=1837$

2. If $XE, I=1$,

we can go $E \rightarrow I$

Now we leave row E and column I , so reduced matrix is

	A	C	F	G
A	M	171	0	0
B	0	184	M	30
G	0	256	8	M
H	0	0	18	12

Here we have 0 in every row and column. So, the lower bound remains the same
i.e, $1526+0=1526$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column).

	A	C	F	G
A	M	171	0(8)	0(12)
B	0(30)	184	M	30
G	0(8)	256	8	M
H	0(0)	0(171)	18	12

Here maximum penalty is 171, occur at XH, C , so we choose XH, C to begin branch

There are two branches.

1. If $XH, C=0$, then we have an additional cost of 171 and the lower bound becomes $1526+171=1697$

2. If $XH, C=1$,

we can go $H \rightarrow C$

Now we leave row H and column C , so reduced matrix is

	A	F	G
A	M	0	0
B	0	M	30
G	0	8	M

Here we have 0 in every row and column. So, the lower bound remains the same
i.e, $1526+0=1526$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	A	F	G
A	M	0(8)	0(30)
B	0(30)	M	30
G	0(8)	8	M

Here maximum penalty is 30, occur at XA,G or XB,A , so we choose XA,G to begin branch
There are two branches.

1. If $XA,G=0$, then we have an additional cost of 30 and the lower bound becomes $1526+30=1556$
2. If $XA,G=1$,

we can go $A \rightarrow G$

So we can't go $G \rightarrow A$, so set it to M.

Now we leave row A and column G, so reduced matrix is

	A	F
B	0	M
G	M	8

Step-1: Find out the each row minimum element and subtract it from that row

	A	F	
B	0	M	(-0)
G	M	0	(-8)

So, row minimum will be 8. ($0+8=8$)

we get the lower bound = $1526+8+0=1534$

Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

A	F	
B	0(0)	M
G	M	0(0)

we can go $B \rightarrow A$ and $G \rightarrow F$

So our final path is $F \rightarrow B \rightarrow A \rightarrow G \rightarrow F \rightarrow B \rightarrow A \rightarrow G \rightarrow F \rightarrow B$

and total distance is $108+370+16+282+108+370+16+282+108=1660$

Our program is not able to solve this problem by penalty method, so we are trying to solve using diagonal completion method to solve this

Step-1: Find out the each row minimum element and subtract it from that row

	1	2	3	4	5	6	7	8	9	
1	M	354	296	108	444	258	0	96	207	(-16)
2	262	M	571	384	718	0	292	370	481	(-108)
3	171	538	M	54	36	449	256	96	0	(-141)
4	70	438	141	M	290	349	84	0	52	(-54)
5	283	649	0	167	M	553	297	208	7	(-177)
6	166	0	482	295	622	M	174	280	392	(-108)
7	0	384	381	122	458	266	M	108	219	(-16)
8	58	424	183	0	331	334	70	M	93	(-54)
9	117	483	35	0	78	394	129	41	M	(-106)

Step-2: Find out the each column minimum element and subtract it from that column.

	1	2	3	4	5	6	7	8	9	
1	M	354	296	108	408	258	0	96	207	
2	262	M	571	384	682	0	292	370	481	
3	171	538	M	54	0	449	256	96	0	
4	70	438	141	M	254	349	84	0	52	
5	283	649	0	167	M	553	297	208	7	
6	166	0	482	295	586	M	174	280	392	
7	0	384	381	122	422	266	M	108	219	
8	58	424	183	0	295	334	70	M	93	
9	117	483	35	0	42	394	129	41	M	
	(-0)	(-0)	(-0)	(-0)	(-36)	(-0)	(-0)	(-0)	(-0)	

Step-3: Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	1	2	3	4	5	6	7	8	9
1	<i>M</i>	354	296	108	408	258	0(166)	96	207
2	262	<i>M</i>	571	384	682	0(520)	292	370	481
3	171	538	<i>M</i>	54	0(42)	449	256	96	0(7)
4	70	438	141	<i>M</i>	254	349	84	0(93)	52
5	283	649	0(42)	167	<i>M</i>	553	297	208	7
6	166	0(520)	482	295	586	<i>M</i>	174	280	392
7	0(166)	384	381	122	422	266	<i>M</i>	108	219
8	58	424	183	0(58)	295	334	70	<i>M</i>	93
9	117	483	35	0(35)	42	394	129	41	<i>M</i>

Step-4: List the penalties $P(i,j)$ in descending order by value.

$P(2,6)=520$

$P(6,2)=520$

$P(1,7)=166$

$P(7,1)=166$

$P(4,8)=93$

$P(8,4)=58$

$P(3,5)=42$

$P(5,3)=42$

$P(9,4)=35$

$P(3,9)=7$

Step-5: The links (2,6),(1,7),(4,8),(3,5),(9,4) are selected for inclusion in the feasible partial tour.

Step-6: Feasible partial tour contains the following chains

$2 \rightarrow 6, 1 \rightarrow 7, 9 \rightarrow 4 \rightarrow 8, 3 \rightarrow 5$

(6,2),(7,1),(8,9),(5,3) can not be selected, because they are the closing links and create prohibited subtours.

Step-7: The new sub matrix is :

	2	1	9	3
6	<i>M</i>	274	500	590
7	400	<i>M</i>	235	397
8	478	112	<i>M</i>	237
5	826	460	184	<i>M</i>

Step-1: Find out the each row minimum element and subtract it from that row

	2	1	9	3	
6	M	0	226	316	(-274)
7	165	M	0	162	(-235)
8	366	0	M	125	(-112)
5	642	276	0	M	(-184)

Step-2: Find out the each column minimum element and subtract it from that column.

	2	1	9	3	
6	M	0	226	191	
7	0	M	0	37	
8	201	0	M	0	
5	477	276	0	M	
	(-165)	(-0)	(-0)	(-125)	

Step-3: Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	2	1	9	3	
6	M	0(191)	226	191	
7	0(201)	M	0(0)	37	
8	201	0(0)	M	0(37)	
5	477	276	0(276)	M	

Step-4: List the penalties $P(i,j)$ in descending order by value.

$$P(5,9)=276$$

$$P(7,2)=201$$

$$P(6,1)=191$$

$$P(8,3)=37$$

$$P(7,9)=0$$

$$P(8,1)=0$$

Step-5: The links (5,9),(7,2),(6,1),(8,3) are selected for inclusion in the feasible partial tour.

Step-6: Feasible partial tour contains the following chains

$2 \rightarrow 6 \rightarrow 1 \rightarrow 7 \rightarrow 2, 9 \rightarrow 4 \rightarrow 8 \rightarrow 3 \rightarrow 5 \rightarrow 9$

(2,2),(9,9) can not be selected, because they are the closing links and create prohibited subtours.

Step-7: The new sub matrix is :

	2	9
2	M	589
9	589	M

Repeat from step-1 to step-7

Step-1: Find out the each row minimum element and subtract it from that row

	2	9	
2	M	0	(-589)
9	0	M	(-589)

Step-3: Calculate the penalty of all 0's (penalty = minimum element of that row + minimum element of that column.)

	2	9
2	M	0(0)
9	0(0)	M

Step-4: List the penalties $P(i,j)$ in descending order by value.

$P(2,9)=0$

$P(9,2)=0$

Step-5: The links (2,9) are selected for inclusion in the feasible partial tour.

Step-6: Feasible partial tour contains the following chains

$2 \rightarrow 6 \rightarrow 1 \rightarrow 7 \rightarrow 2 \rightarrow 9 \rightarrow 4 \rightarrow 8 \rightarrow 3 \rightarrow 5 \rightarrow 9$

So our final path is $B \rightarrow F \rightarrow A \rightarrow G \rightarrow B \rightarrow I \rightarrow D \rightarrow H \rightarrow C \rightarrow E \rightarrow I \rightarrow B$

and total distance is $108+274+16+400+589+106+54+237+177+184+589=2734$.

5.1 Result

Feasible partial tour contains the following chains.

So our final path is $B \rightarrow F \rightarrow A \rightarrow G \rightarrow B \rightarrow I \rightarrow D \rightarrow H \rightarrow C \rightarrow E \rightarrow I \rightarrow B$

(i.e) Tirupathi $\rightarrow$ Kanchipuram $\rightarrow$ Srirangam $\rightarrow$ Thiruvellarai $\rightarrow$ Tirupathi $\rightarrow$ Srivilliputhur $\rightarrow$ Azhagarkovil (Madurai) $\rightarrow$ Thirukoshtiyur $\rightarrow$ Sri Vaikuntam $\rightarrow$ Thiruvananthapuram (Kerala) $\rightarrow$ Srivilliputhur $\rightarrow$ Tirupathi.

and total distance is $108+274+16+400+589+106+54+237+177+184+589=2734$.

6. CONCLUSION

The Travelling salesman problem can be solved using a variety of ways. In this work, the Diagonal Completion technique is used to discover the best path. Each step calculates the minimum distance (cost matrix). In the tests undertaken, the combined diagonal completion and 2-optimal approach revealed that it is a relatively fast and highly effective Branch and Bound method for delivering good solutions to travelling salesman problems, even those of enormous size.

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CUSTOMER CHURN PREDICTION IN TELECOMMUNICATIONS INDUSTRY USING MACHINE LEARNING TECHNIQUES

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ABSTRACT

Data mining techniques have been developed recently to address the challenging problems of customer attrition in the telecommunications service industry. This paper introduces a novel feature set for predicting land-line customer attrition. This paper takes the features such as two six-month segmentations, accurate four month call details, line data, account data, bill and payment details, demographic profiles, service orders, complaint data, etc. Afterwards, based on the new features, the three prediction techniques Linear Classifications, Naive Bayes, Support Vector Machines Algorithm were used to predict customer turnover. Ultimately, the three modelling methodologies and the new feature set were assessed through comparative tests in order to predict client attrition. The experimental findings indicate that for customer churn prediction in the telecom services industry, the new features utilising the six modelling methodologies are more successful than the current ones.

Keywords: Churn Prediction, Linear Classifications, Naive Bayes, Support Vector Machine.

1. INTRODUCTION

A phenomenon known as customer churn affects service providers, particularly those in the telecommunications industry, as they lose important clients to rivals. The telecommunications sector has seen numerous changes in recent years, including new services, new technologies, and market liberalisation that increased competition. Customer attrition is a major issue that results in a significant loss of telecom services.

As one of the most important customer retention tactics, churn prediction has caused concern in the telecom industry and research [17]. Over the past ten years, the majority of research on churn prediction has focused on voice services that are available over mobile and fixed-line networks. Fewer researchers have examined the churn prediction of land-line services than those of mobile ones.



Figure1: Customer Churn in Telecom

In the mobile telecommunications industry, churn prediction is typically achieved by using customer demographics, contractual data, customer service logs, call details, complaint data, bill and payment information, and other data. Compared to mobile services, land-line service providers have fewer qualifying data available. Data types used by landline and mobile communication services differ. Data from landline communication service providers is sometimes inaccurate, missing, or incomplete. Problem reports, client ages, complaint information, and call specifics for the preceding few months are all absent in some instances.[7]

This work introduces a novel collection of features with three modelling methodologies to increase the precision of customer churn prediction in the telecom service industry. The two six-month Henley segments, exact four-month call details, grant information, line information, bill and payment information, account information, demographic profiles, and service orders all of which are gleaned from the scant information that is now available are the new features. Logic Regression, Naive Bayes, Support Vector Machines are the modelling techniques. Lastly, the comparative studies are completed. According to the experimental results, the six modelling methodologies and characteristics that have been provided are more successful than the current features for predicting customer churn in land-line communication services.

The remainder of this essay is structured as follows: The evaluation standards for churn prediction systems are presented in the following section. Our methodology, which includes feature extraction, normalisation, and prediction algorithms, presents the experimental data along with a commentary, concludes this paper and makes recommendations for further work.

2. LITERATURE REVIEW

There are no publicly available datasets for churn prediction because to privacy and commercial confidentiality concerns.[17] presented a set of features for churn prediction in the field of land-line telecommunication services. These features include the length of service use, the type of payment, the amount and structure of monthly service fees, proportions variables, consumption level rates variables, and the growth rates of the second three months. A collection of features, including a six-month segmentation, line information, bill and payment information, account information, call details, and service log data, among other things, was recently given in [10]. Furthermore, the majority of the literature [23] demonstrates the characteristics that the combined call information are crucial for predicting customer attrition. By adding together the length of time, costs, and the



quantity of calls of any kind made throughout each period, these properties are obtained. Nonetheless, the call information can be further subdivided into more specific categories based on the various call kinds. For churn prediction, this more accurate data may be more helpful than the current call detail features.

3. METHODOLOGY

This work typically consists of three phases: Data Preparation, Classification/Prediction, And Data Sampling. By definition, data sampling chooses a group of customers at random with relevant information. Data cleaning, feature extraction, and normalisation procedures are all part of the data preparation phase, which is also known as data pre-processing. Data cleaning eliminates unnecessary information, such as duplicated data, missing values, special mathematical symbols, human error-caused misspellings, strings that end in "NULL," and so forth. A collection of features that represent customers are extracted through feature extraction. The normalisation process puts feature values into a range, such as between 0 and 1. The projection phase makes predictions about how customers could behave in the near future. The focus of this paper is mostly on feature extraction. The next subsections include descriptions of the feature/variables extraction, normalisation, and prediction/classification processes.

3.1. Feature/variable Extraction

Feature extraction is one of the most significant aspects that might affect how well predictive models function in terms of prediction rates (high TP and low FP). The prediction rates of TP and FP can be greatly increased and decreased, respectively, if a strong set of characteristics can be extracted during this phase. Nevertheless, obtaining such a good set of traits is not simple. Up to now, the majority of feature sets have been introduced for churn prediction in fixed-line telecommunication [10] and mobile telecom business.[7] These current feature sets, meanwhile, still have room for improvement. The following is a description of the new features we propose in this research for customer churn prediction in telecommunication service fields:

- **Demographic profiles:** these depict a market segment or grouping based on demographic data that includes predicted consumer behaviour. Typically, this data consists of gender, age, and social class groups. Gender and county data are chosen as two new features and are offered.
- **Grants information:** a few clients received unique grants that allowed a third party to pay all or a portion of their costs (note: only one new feature is selected). Customers who are over 80 or have a disability, for instance, are more likely to stick with the services.
- **Customer account information:** This includes details about the various service packages available, credit controller and junk mail indicators, the date the account was created, the frequency of bills, the amount of money in the account, the types of payments made, and the summarised attributes (call duration, number of calls, standard prices and fees, current outstanding charges, and charges paid). The customer accounts are described in this data

quite simply (we think that one account number corresponds to one customer). Furthermore, the account information wraps together the bitstream access networks, Local Loop Unbundling (LLU), and broadband indicators. These indicators show whether a customer uses LLU services, is a bit stream user, and has access to broadband service. These three indicators might not be easily located in a single file, unlike other account information (e.g. a table in the database). They are typically located by merging several related files (such as tables) in a database. For example, by combining a few files (tables) of broadband services with the account file (or table), one can find the broadband indicator. Consequently, using a classification model, all of this account data may be used to distinguish between churners and nonchurners.

Customers may receive bills at different intervals. For a predetermined amount of time, the parameters pertaining to call duration, call volume, standard fees, and paid fees must be recalculated. The chosen duration is 60 days because the majority of clients purchased the bills on a monthly basis. Let's say that "Dur," "Ncall," "Standfees," and "Paidfees" stand for the length of the call, the number of calls, the standard fees, and the actual fees paid, in that order. Eq. (4) can be used to recalculate them.

$$Ncall' = \frac{Ncall_M}{nDays} * 60 \quad (1)$$

$$Dur' = \frac{Dur_M}{nDays} * 60 \quad (2)$$

$$Standfees' = \frac{Standfees_M}{nDays} * 60 \quad (3)$$

$$Paidfees' = \frac{Paidfees_M}{nDays} * 60 \quad (4)$$

where, which may be found using Equation (5), "Ncall_M" is the number of calls in the most recent bill, "Dur_M" is the bill's duration, "Standfees_M" is the bill's fees, "Paidfees_M" is the bill's customer fees, and "nDays" is the bill's day count.

$$nDays = ENDDate - startDate \quad (5)$$

where "startDate" and "endDate" denote the beginning and ending dates of the bill, respectively.

- **Service orders:** list the services that the client has requested. We only choose the data from the most recent three service orders because an order list may be quite lengthy. The amount of services purchased, the rental cost, the deadline, and the date that services were approved as new features are all included in this information.

- **Henley segments:** based on traits, requirements, and commercial value, the Henley segmentation algorithm splits consumers and potential customers into several categories or levels. The individual and discriminant segments are the two different kinds of Henley segments. Ambitious Techno Enthusiast (ATE) and Communications Intense Families (CIF) Henley segments are included in the individual segment. Mutually exclusive segments (DS)

are discriminant segments that might symbolise client loyalty. The most recent two six-month Henley segments are chosen as new input features. Similar to this, neutral data is used to fill in the gaps in the Henley segments. [8]

- **Telephone line information:** this includes details about the number, kind and district codes of telephone lines as well as if voice mail service is offered. Customers with many phone lines may find the services more appealing and be more inclined to stick with them. A prediction model cannot benefit from this information. As a result, the voice mail service indication, district codes, and phone line count are chosen as new features.

- **Complaint Information:** Customers who have voiced complaints about the telecommunications services have provided this information. Consumers can file complaints about the services via email, letter, or, more commonly, phone call to several departments. Most of the complaint information's specifics are absent from the database. On most occasions, nevertheless, it is possible to locate the indicator that shows the identity of the complainant on a given date. As a result, this paper solely chooses this indicator as a new feature from complaint data.

- **The historical billing and payment data:** this includes the billing details for every client and service over a predetermined period of time. Only our prediction system uses the call data from the previous four months, which are available. The last four months' worth of bill information are chosen so as to include the call specifics for that four months.

As was already indicated, different clients might get bills at different times. As a result, client bills may have varying lengths. We divide the bill whose duration is longer than one month into several monthly bills, each covering one month, in order to ensure that bill durations are consistent. For instance, we must divide a customer's one two-month charge into two separate monthly bills. The total standard charge fees, total rental charges, total value added tax (VAT), total call time, and total fees paid are all detailed in each monthly bill. The eight call kinds local calls, international calls, other sorts of calls, and mobile phone calls are also detailed in each bill. A monthly statement includes a summary of the length of the call, normal fees, actual charged fees, and fees paid for each type of call.

As additional features, this paper extracts the total of the following: total of the standard charge fees, total of the rental charges, total of the value added tax (or total VAT), total of the call duration, total of the fees paid, total of the call duration of each type of call, the standard fees of each type of call, the actual charged fees of each type of call, and the fees paid of each type of call. Let us assume that for the i th month, the total standard charge fees, total rental charges, total VAT, total call length, and total fees paid are, respectively, "TotSF _{i} ," "TotRC _{i} ," "TotVAT _{i} ," "TotDi," and "TotFP _{i} ." Equation (6) can be used to compute the total of the following: the total of all standard charge fees ('SSF'), the total of all rental charges ('SRC'), the total of all VAT ('SVAT'), the total of all call duration ('SD'), and the total of all fees paid ('SFP').

$$SSF = \sum_{i=1}^4 TotSF_i \quad (6)$$

$$SRC = \sum_{i=1}^4 TotRC_i \quad (7)$$

$$SVAT = \sum_{i=1}^4 TotVAT_i \quad (8)$$

$$SD = \sum_{i=1}^4 TotD_i \quad (9)$$

$$SFP = \sum_{i=1}^4 TotFP_i \quad (10)$$

Let the type of calls be k . Consider that the call duration, the standard fees, the actual charged fees and the fees paid for the I th month are MD_k^i , MSF_k^i , MAF_k^i and MPF_k^i , respectively. Let the change of the call duration, and the change of the standard fees, the change of the actual charged fees and the change of the fees paid between the two consecutive months I th and $i - 1$ th for the type of calls k be $ch_MD_k^{i,i-1}$, $ch_MSF_k^{i,i-1}$, $ch_MAF_k^{i,i-1}$, and $ch_MPF_k^{i,i-1}$, respectively. This subset of information is extracted as new features by Eq. (13).

$$ch_MD_k^{i,i-1} = \frac{|MD_k^i - MD_k^{i-1}|}{\sum_{i=2}^4 |MD_k^i - MD_k^{i-1}|} \quad (11)$$

$$ch_MSF_k^{i,i-1} = \frac{|MSF_k^i - MSF_k^{i-1}|}{\sum_{i=2}^4 |MSF_k^i - MSF_k^{i-1}|} \quad (12)$$

$$ch_MAF_k^{i,i-1} = \frac{|MAF_k^i - MAF_k^{i-1}|}{\sum_{i=2}^4 |MAF_k^i - MAF_k^{i-1}|} \quad (13)$$

$$ch_MPF_k^{i,i-1} = \frac{|MPF_k^i - MPF_k^{i-1}|}{\sum_{i=2}^4 |MPF_k^i - MPF_k^{i-1}|} \quad (14)$$

Call details: these include the length of the call, the cost, and the kind of call (local or international, for example) for each and every call. As a result, keeping track of every call's information for every consumer, every month, is challenging. The majority of telecom providers retain call logs dating back a few months. Therefore, the restricted call details are only useful for forecasting client attrition. However, they can still show the frequency of service usage by comparing prices, length of call, and other factors. For instance, the short call length suggests that the clients weren't using the services frequently; In the future, the clients may decide to stop using the services. Should there be an abrupt change in the cost of the services, the client may decide to stop using them earlier. The literature reports on the application of call information to churn prediction. But the majority of researchers simply chose as features the total number of calls, duration, and fees from all different kinds of phone calls. The number of calls, duration, and fees were combined by the authors and were not further separated into categories for international, local, national, mobile phone, free, and whole sale line calls. On the other hand, this split total number of calls, length, and fees might better represent the state of service usage and be more useful for churn prediction. From the call information of the previous four months, this research extracts the number, duration, and fees as new features. The number of calls, duration, and fees that are changed are also regarded as new features based on these features. The following is a description of the process used to extract these additional features the call details into several distinct periods totalise the duration, fees, and calls for each period for all calls made by each customer, including local, national, international, and mobile calls the sum of these total calls, duration, and fees represents the total calls, duration, and fees for the previous four months the variation in calls, duration, and fees can be obtained. According to literature, calling every 15 or 20 days is effective. Thus, in this article, the defined term is 15 days[23].

Let "NCALL," "DUR," and "FEES" stand for the number of calls, duration, and fees, respectively. Additionally, let x stand for any kind of call—local, national, international, mobile, or otherwise. Assume that for the kind of calls x , the total number of calls, duration, and fees on segment i are " $NCALL_x^i$," " DUR_x^i ," and " $FEES_x^i$," respectively. Determine the altered call count, duration, and costs between two successive segments i and $i-1$ of the call type x .

$$ch_DUR_x^i = \frac{|DUR_x^i - DUR_x^{i-1}|}{\sum_{j=2}^{M'} |DUR_x^j - DUR_x^{j-1}|} \quad (15)$$

$$ch_NCALL_x^{i,i-1} = \frac{|NCALL_x^i - NCALL_x^{i-1}|}{\sum_{j=2}^{M'} |NCALL_x^j - NCALL_x^{j-1}|} \quad (16)$$

$$ch_FEES_x^{i,i-1} = \frac{|FEES_x^i - FEES_x^{i-1}|}{\sum_{j=2}^{M'} |FEES_x^j - FEES_x^{j-1}|} \quad (17)$$

where the variables " $ch_DUR_x^{i,i-1}$," " $ch_NCALL_x^{i,i-1}$ " and " $ch_FEES_x^{i,i-1}$ " denote the altered duration, number of calls, and fees between two consecutive segments i and $i-1$ of the call type x , respectively (note: the features of the free calls exclude the features " ch_FEES " and $FEES_i$).

• **Details on incoming calls:** these refer to calls that have been received. Details on incoming calls include the length of the calls, the quantity of calls, and the associated costs. On the other hand, the majority of calls that are received are free. Incoming call fees are not included in the list of new features. The new features from the incoming call details include the number and duration of calls received, the number of calls changed, and the duration of calls changed every 15 days. In a similar vein can be used to determine changes in the quantity of calls made and the length of calls received.

3.2. Normalisation

Certain predictors or classifiers find it challenging to accept the string values of characteristics in the retrieved features. Furthermore, certain numerical features (e.g., the number of lines, duration, calls, fees) lie in different dynamical ranges, even though the values of the features (e.g., change duration, change fees, change fees paid) are in the range between 0 and 1 and these features will not be normalised. The cost functions are more impacted by these features' large values than by their little ones. It cannot, however, convey the idea that large values are more crucial to the predictor or classifier's design.

The values of the characteristics must be normalised for some predictors (such as artificial neural networks) in order to tackle the aforementioned concerns. The following is a description of the normalisation process: First, the values of string characteristics must be converted into binary strings. Secondly, the values of numerical features can be normalised using Eq. (9), putting them within a comparable range.

$$\bar{x}_j = \frac{1}{N} \sum_{i=1}^N x_{ij}, \quad j = 1, 2, \dots, l \quad (18)$$

$$\sigma_j^2 = \frac{1}{N-1} \sum_{i=1}^N (x_{ij} - \bar{x}_j)^2 \quad (19)$$

$$y = \frac{x_{ij} - \bar{x}_j}{r\sigma_j} \quad (20)$$

$$\tilde{x}_{ij} = \frac{1}{1 + e^{-y}} \quad (21)$$

so that the characteristic is x_j . N is the number of occurrences or patterns, j th, i is the number of features, and r is a user-defined constant parameter. R is set to one in this investigation.

3.3. Prediction/classification

Many methods have been put forth for telecom churn prediction. Just three modelling approaches are chosen in this article to serve as churn prediction predictors. The following is an outline of these three modelling techniques:

3.3.1. Logistic Regressions (LR)

An extensively used statistical modelling method for discriminative probabilistic classification is logistic regression[9]. Logistic regression calculates the likelihood that an event will occur. The model is expressed as follows:

$$\text{prob}(y = 1) = \frac{e^{\beta_0 + \sum_{k=1}^K \beta_k x_k}}{1 + e^{\beta_0 + \sum_{k=1}^K \beta_k x_k}} \quad (22)$$

where $x_1, x_2, \dots, x_k$ are the independent inputs and Y is a binary dependent variable that indicates whether the event occurred (e.g., $y = 1$ if event takes place, $y = 0$ otherwise). Based on the given training data, the maximum likelihood technique can estimate the regression co-efficient $b_0, b_1, \dots, b_k$ has the logistic regression models' specifics.

We require a predictive model that can do binary classification, or forecast an output variable of type 1/0 or Yes/No, based on the problem statement. Logistic regression is a popular predictive model used for binary categorisation and outcome prediction. A binary classification procedure that is a part of the generalised linear regression model is called logistic regression. More than two class problems can also be resolved with it. Using the customer turnover data, logistic regression may be used to build a model that predicts whether a specific customer or a group of customers will stop using the service.

One of the variables in the data, for instance, may be "annual income." The customer's "gender" is another variable. The logistic regression function's result will indicate how a customer's likelihood of discontinuing service is influenced by their income and/or gender.

Logistic Regression

The function for logistic regression is shown below:

$$P(Y=1|X) = 1 / (1 + e^{-(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \dots + \beta_n X_n)})$$

where β_0 through β_n different coefficients The independent variables influencing the dependent variable are X_0 through X_n . Furthermore, the probability of a favourable result is $P(Y = 1 | X)$. Take note of the function's exponent. This is the part where $(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \dots + \beta_n X_n)$ uses linear regression. According to the graph above, the logistic regression function is a sigmoid function. The function produces values

between 0 and 1, with a transition between the levels, as the graph illustrates. This feature of the function facilitates binary outcome prediction.

The output can be at level 1 or 0, depending on the values of the variables. This indicates the likelihood that the customer will leave the business or stay with it.

3.3.2. Naive Bayes (NB)

The likelihood that a given input sample belongs to a particular class is determined using a Naive Bayes classifier. To find the probability for the class y_j given an X sample that consists of a feature/variable vector $\{x_1, \dots, x_n\}$, use Eq. (23):

$$p(y_j|X) = p(X|y_j)p(y_j) = p(x_1, x_2, \dots, x_n|y_j)p(y_j) \quad (23)$$

where y_j prior probability is represented by $p(y_j)$. Nonetheless, Naive Bayes makes the assumption that the independent variables' conditional probabilities are statistically independent. The likelihood can be expressed as follows:

$$p(X|y_j) = \prod_{i=1}^n p(x_i|y_j) \quad (24)$$

Thus, the posterior can be written as

$$p(y_j|X) = p(y_j) \prod_{i=1}^n p(x_i|y_j) \quad (25)$$

Assume that $Y = \{y_1, y_2, \dots, y_k\}$ is a set of classes. Therefore, a Naive Bayes classifier decides how to classify an unknown sample X by:

$$c = \operatorname{argmax}_{y_j \in Y} p(y_j|X) \quad (26)$$

3.3.3. Support Vector Machines (SVM)

By determining a maximal margin hyper-plane in terms of a linear combination of training set subsets (support vectors), an SVM classifier can be trained. Using the kernel approach, SVM first maps the data into a high dimensional feature space if the input feature vectors are nonlinearly separable.[2] It next classifies the data according to the maximal margin hyper-plane as follows:

$$f(\vec{x}) = \operatorname{sgn}(\sum_i^M y_i x_i \phi(\vec{x}_i, \vec{x} + \delta)) \quad (27)$$

where ϕ is a kernel function, $\vec{x}$ is an unknown sample feature vector, δ is a threshold, and M is the number of samples in the training set. $\vec{x}_i$ is a support vector with $a_i > 0$.

By applying linear constraints to a convex quadratic programming problem, the parameters $\{a_i\}$ can be found. In practical application, kernel functions are typically implemented using Gaussian radial basis functions (RBF) and polynomial kernels. By considering the Karush–Kuhn–Tucker condition and selecting any i for which $a_i > 0$ (i.e., support vectors), δ can be found. In actuality, though, it is safer to take the mean value of δ across all support vectors.[4]

Because SVM can handle high-dimensional data and is especially helpful for datasets with a lot of features or when the data cannot be linearly separated, it is thought to be successful in forecasting churn. Furthermore, SVMs can deal with imbalanced datasets, which are frequently seen in churn prediction scenarios where the proportion of churning customers is significantly lower than that of non-churning customers. Therefore, anyone

who is interested in learning more about SVM, classification (unsupervised learning), etc., should also work on this project.

We must first collect and prepare the data on your clients before we can utilise SVM for churn prediction. Information on their behaviour, demographics, and other pertinent factors may be included. The data must then be divided into a test set and a training set.

4. EXPERIMENTS

A classifier/predictor will be utilised to forecast the future actions of clients. Evaluating the predictive churn model's performance is one of the crucial elements in making sure the model generalises successfully. In other words, one must take a predictor's prediction rates into account. True churn rate (TP) and false churn rate (FP) are the prediction rates used in this work. The application's goal is to obtain high TP at cheap FP. TP is defined as the percentage of churn cases that were correctly identified based on the confusion matrix, as determined by

$$TP = \frac{a_{11}}{a_{11} + a_{12}} \quad (28)$$

and FP, which is expressed as the percentage of non-churn cases that were mistakenly categorised as churn,

$$FP = \frac{a_{21}}{a_{21} + a_{22}} \quad (29)$$

The Receive Operating Curves (ROC) approach can be used to determine the expected pair of prediction rates (TP and FP) from these pairings of TP and FP.

However, sets of pairs (TP and FP) from various prediction modelling approaches or feature subsets of data are typically difficult to analyse using the ROC technique. In this work, models and feature sets for the churn prediction are assessed using the area under a ROC curve (AUC) method as a solution to the issue. The following formula can be used to get the area under a ROC curve:

$$AUC = \frac{S_0 - n_0 \times (n_0 + 1) \times 0.5}{n_0 n_1} \quad (30)$$

where n_0 is the number of patterns in the test set that are class 0 and SS_0 is the sum of the ranks of the class 0 (churn) test patterns.

4.1. Experiment set-up

The following parameters were used to train each model in the experiments: There are 300 generations in the population, 30 mutations, a Z-value of 1.96 for identifying interesting traits, and 60% and 0.1%, respectively, for crossover and mutation probability.

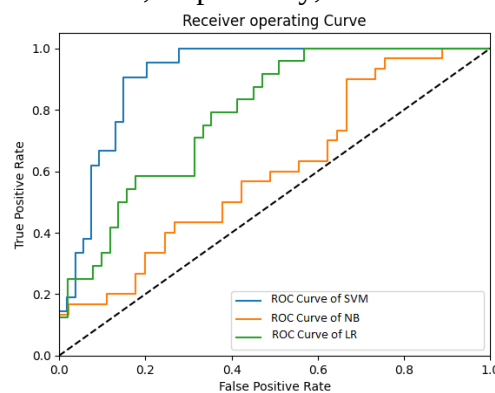


Figure2. Prediction results when using call details.

The experimental outcomes of the first series of trials, which assess the feature subsets of the call detail data for the prediction, are displayed in Fig. 1. This image has two subfigures: the relative AUC values are displayed in the other, while ROC curves are displayed in the one on the left. Each pair of the average FP and average TP from each of the six modelling techniques for a particular sampling rate is represented by a point in Figure 1. This ROC figure consists of three curves with varying colours, each of which represents a particular feature subset for the various sampling rates. In Figure 1, the AUC values and various named detail kinds are shown by the y- and x-axes, respectively. This subfigure shows three distinct coloured curves: the red, grey, and black curves were plotted when FP was 50%, FP was greater than 50%, and FP was zero, respectively.

- The false churn rate may drop when the sampling rate $\frac{n_churners}{non_churners}$ drops (or as the number of non churners rises). However, the actual turnover rate can drop.
- TP is extremely low for any feature subset or modelling technique when FP is less than or equal to 5%. Any ROC curve's AUC values are roughly equal when FP is greater than 50%. However, the AUC values differ significantly when FP is between 50% and 100%. As a result, whether FP is 50% or 100%, most decision-makers may be more likely to take the AUC values into account.
- The prediction rates from all feature subsets are comparable (high actual churn rates and high false churn rates) when the sampling rate $\frac{n_churners}{non_churners}$ is extremely high.

The ROC curves based on the prediction rate pairs (FP and TP) obtained from the second set of trials using the six prediction modelling methodologies and various subsets. In other words, based on the eight subsets of the new features, displays the ROC curves when the prediction modelling approaches LR, NB, SVM were applied, respectively. The information of current bills, the information of the six bills with payments, the information of incoming calls (received calls), the fixed features that are typically not changed on a monthly or daily basis, the features of free calls, the features of call-details, the features of whole sale line calls, and the fullset of new features are these eight subsets of features. The AUC values were computed and shown into based on these ROC curves. The curve from the fullset of the new features that is closest to the top left corner is displayed in each subfigure. This illustrates that, when the same prediction modelling technique was applied, the fullset represents the best prediction outcomes in terms of the highest TP rates with the lowest FP.

5. CONCLUSIONS

A new set of features, such as Aggregated Call Details, Account Information, Bill Information, Dial Types, Line Information, Payment Information, Complaint Information, Service Information, and so forth, were presented in this paper for the purpose of predicting customer churn in the telecom industry. In this research, three modelling techniques LR, NB, SVM were employed as predictors. Lastly, the comparative tests were conducted using the new feature set, the old feature sets, and the three modelling methodologies. Every subset of the new feature was assessed and examined in the experiments. The studies also revealed the following: (1) the relative efficacy of the three modelling strategies; and the relative efficacy of the new feature set in comparison to the pre-existing feature sets. The experimental results demonstrated that: (1) the newly proposed feature set is more

predictively effective than the pre-existing feature sets; the decision makers' objectives determine which modelling technique is best for customer churn prediction NB and SVM with a low ratio should be used if interested in the true churn rate and false churn rate; If one is looking for the churn probability, one may use the Logistic Regressions. The call detail combination feature set, which consists of the feature sets of Local, National, International, Mobile Phone, and the sum of all call details, can obtain higher true churn rates with lower false churn rates than any individual subset. Nevertheless, our suggested methods have certain drawbacks. Future updates to the new feature set should incorporate more data in a way that enhances features. In the future, feature extraction and selection strategies will be examined in order to further minimise the dimensions of input characteristics. Furthermore, this application presents an imbalance classification problem, which we attempted to tackle solely through the use of the sampling technique. Thus, future research should concentrate on developing other techniques for imbalance classifications.

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DEEP LEARNING AND IOT SYNERGY FOR EFFECTIVE FLOOD MONITORING AND EARLY WARNING USING CROWDSOURCED GEOGRAPHIC INFORMATION

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ABSTRACT

One-eighth of India's land area is prone to flooding, making it one of the world's most flood-prone nations. The primary causes of floods include excessive rainfall, rivers' inability to handle the high flood discharge, and poor drainage systems that fail to swiftly remove precipitation into streams and rivers. But in order to alert people and evacuate them later, knowledge of flooding and rains is vital. This research work employs deep learning, which is performed based on DenseNet& Yolo V3 to more efficiently extract disaster characteristics for automated flood detection using IoT sensors.

Keywords: *Disaster Management, Flood Detection, IoT, DenseNet, YOLO V3.*

1. INTRODUCTION

IoT-based sensors can help identify potentially dangerous situations, such as forest fires and earth movements. They may also be used to monitor river levels and identify instances of flooding. One of the most common and extensive natural disasters in the world is flooding. The main cause of the rise in discharge is persistent rainfall. Rainfall that never stops causes the soil to get saturated and lose its ability to store water, which increases surface drainage. Numerous variables, such as the size and form of a river's drainage basin, the permeability of the rock and soil there, the amount of vegetation there, the number of tributaries that flow into the river, and the gradient of the basin, affect how frequently floods occur in a basin.

Urbanization of the floodplain, deforestation in the flood plains, and inadequate storm drainage in urban areas are all examples of human-induced issues. Furthermore, the intensity and distribution of rainfall are significantly impacted by climate change, which in turn has an effect on floods. In addition to disrupting the transportation and telecommunications networks, floods also harm properties, businesses, and public utilities.



Figure 1: Flood affected Areas

Floods are the most violent, extensive, and frequent natural catastrophes, resulting in significant annual losses in terms of lives lost and property damage. The most recent figures show that the number of people impacted by flooding has been rising quickly as a result of harsh weather, increased urbanization, and insufficient disaster response [3]. Determining the magnitude of the flooding and estimating the damage is crucial in order to offer assistance, compensation, and rescue to those impacted. Since satellites offer synoptic coverage with high periodicity and distinctive spectral signatures, floods may be spotted very instantly. The most effective way to lessen the damage caused by flooding is to install early warning systems.

2. RELATED WORKS

(Sarkar and others, 2017) Examining IoT-based post-disaster management framework approaches is the aim of this paper. Together with some information on IoT-based post-disaster response and recovery, the primary IoT-enabling technologies are discussed. An innovative technique (flowchart) for building an ad hoc network linked to device-to-device interactions is provided as part of a robust post-disaster management framework.

An architecture centered on IOT and intended to create a secure, knowledgeable environment for older adults was proposed by Pandey and Litoriya (2020). In the event of a calamity of any type, including flooding, storms, home fires, volcanic eruptions, and others, the architecture will demand assistance. This emergency program combines aging in-house processes with an assortment of disaster sensors.

The most devastating natural catastrophes are floods, which are also the hardest to model (Mosavi, Ozturk, and Chau, 2018). The chemical study of sapness, accuracy, efficacy, and speed—which is particularly well-researched to offer a comprehensive review of the many ML algorithms utilized in the field—was used to construct machine learning models. A thorough understanding of different approaches in the context of worldwide evaluation is demonstrated by the machine-learning models' performance comparisons using ANFIS, MLP, ANNs, and Deep Learning. After analyzing DL and ML algorithms, ANN—which has an accuracy of 90 to 95—is found to be the best algorithm strategy.



Based on deep learning (DL), (Wu et al., 2020) suggest exploring the distribution patterns of atmospheric and oceanic constituents. 3D-CNN uses technologies such as image processing, data augmentation, and three-dimensional convolutional neural networks to discover the implicit association between the spatial distribution features of three-dimensional environmental variables and changes in the strength of tropical cyclones. In this study, 22 years' worth of western North Pacific analysis datasets (1997–2018) were used, and the model's accuracy was 96%.

(Mao et al. 2020) improved the YOLOv3's Convolutional Layer (CL) using the inverted residuals method in order to well-extract the vehicle. To address the multi-scale vehicle OD problem, three spatial pyramid pooling modules were introduced before each YOLO layer to capture multi-scale information. The soft Non-Maximal Suppression (NMS) method was used in place of NMS for managing the overlapping cars shown in traffic videos; it reduced the number of predicted boxes that were missed as a result of vehicle overlaps. The outcome confirmed an outstanding performance, but with so many cars involved, it became challenging to identify whose vehicle's frame was overlapping.

(Galea, Lawrence, and Kunkel 2020) deduce that the model employed fully-connected classifiers to predict if a tropical storm is current in the input and convolutional layers to improvise a pattern to gaze at. With the ERA-Interim dataset, which covered the period from January 1979 to July 2019, the model achieved an accuracy of 99.08%.

Based on deep learning (DL), (Wu et al., 2020) is suggested by exploring the distribution patterns of atmospheric and oceanic constituents. 3D-CNN uses technologies such as image processing, data augmentation, and three-dimensional convolutional neural networks to discover the implicit association between the spatial distribution features of three-dimensional environmental variables and changes in the strength of tropical cyclones. In this study, 22 years' worth of Western North Pacific analysis datasets (1997–2018) were used, and the model's accuracy was 96%.

In 2020, Zhou, Xiang, and Huang introduced a novel deep learning neural network architecture called GC-LSTM, based on information from satellite cloud images. Graph Convolutional Network (GCN): This network uses various algorithms, such as DL neural network and Graph Convolutional–LSTM Network (GC–LSTM), to process the irregular contiguous structure of spacecraft cloud pictures in a beneficial way. Long STM (LSTM) network: This network uses various algorithms to determine the characteristics of satellite cloud pictures over time. With over 1000 typhoon processes in the dataset, the model's accuracy was 95.12%.

(Haut et al., 2019) created an auto encoder, a cloud-based deep neural network implementation for non-linear compression. The master-slave architecture was used by Apache Spark to link the available processing nodes, and the results of the experiment demonstrate that cloud infrastructure systems provide a practical way to handle sizable remotely sensed data sets.

3. SYSTEM METHODOLOGY

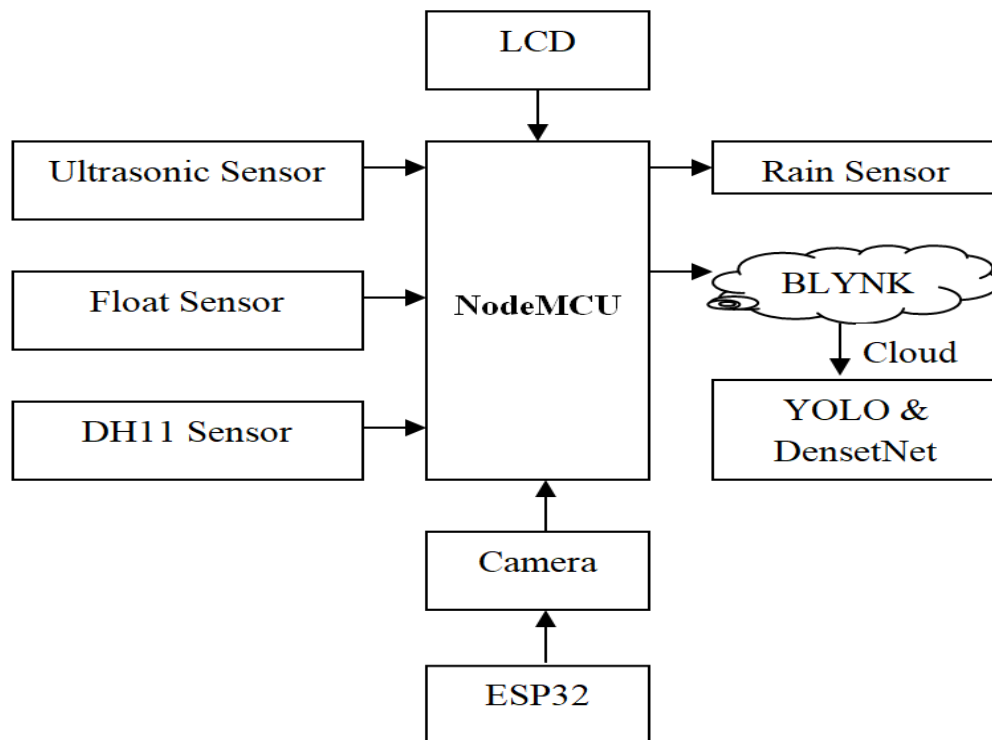


Figure 2: Block Diagram

3.1. Data Collection

This work used IoT sensors to collect the flood-affected image data. These photos were manually classified as either flood or non-flood using distinguishing characteristics that are frequently seen in situations involving both inland and urban flooding. We considered the characteristics of water-logged places, flooded buildings and roads, automobiles, and people to determine the criteria for distinguishing between floods and severe rains. This work used the following sensor to collect the data:

➤ NodeMCU

NodeMCU is a low-cost open-source IoT platform. Its original hardware components were ESP-12 modules and firmware based on the ESP8266 Wi-Fi SoC. Support for the 32-bit ESP32 MCU was added in subsequent versions. The NodeMCU Dev Kit/Board includes the ESP8266 WiFi chip. The TCP/IP protocol is used by Espressif Systems' low-cost ESP8266 Wi-Fi chip. To learn more about the ESP8266, use the WiFi Module.

➤ DHT11

The DHT11 is an inexpensive digital sensor that monitors humidity and temperature. This sensor can simply communicate with the Arduino so that it can quickly determine the temperature and humidity. For this sensor to have greater resistance values even for the smallest temperature change, semiconductor ceramics or polymers are frequently used in its construction. One reading per second, the sampling rate for this sensor is 1 Hz.

➤ **ESP32-CAM**

The ESP32-S microcontroller is used by the minuscule ESP32-CAM camera module. Along with several GPIOs for attaching peripherals, the OV2640 camera is also included, along with a microSD card slot. This slot may contain files that will be distributed to clients or images captured by the camera.

➤ **Rain Sensor**

A switching mechanism known as a rain sensor can detect the presence of precipitation. The idea behind it is that when it rains, the switch is often locked, so it works like a simple switch. This sensor module lets you detect moisture via analog output pins, and when the moisture threshold is crossed, it sends a digital signal. The purpose of this sensor is to install a rain sensor in various headwater sources, such as falls, lakes, rivers, and so on. This sensor detects the intensity of the rain and creates a notification when it starts to rain severely.

➤ **Ultrasonic Sensor**

An ultrasonic sensor is a technological device that measures an object's distance using ultrasonic sound waves and then transforms the sound into an electrical signal when it gets reflected. The speed at which ultrasonic waves travel beyond that of audible sound. Proximity sensors frequently work with ultrasonic sensors. They are used in vehicle technologies such as self-parking and collision avoidance. Both industrial processes and robot obstacle detection systems include ultrasonic sensors.

➤ **Float Sensor**

Level sensors include the floating switch kind. To determine the liquid level, a gadget is used. The switch can be used with an alarm, pump, or other equipment. Sensing the water level in the overhead tank is helpful. Float sensors are electrical sensors that sense changes in liquid level relative to a predetermined level and activate automatically.

➤ **LCD**

LCD module at 40% relative humidity and 40% temperature, respectively. Higher temperatures can cause the display's overall color to alter, while lower temperatures can delay the rate at which the display blinks. When the temperature drops within the designated range, the display will normalize. Polarizer peel-off, bubble formation, and polarization deterioration can all be brought on by heat and humidity.

3.2. Deep Learning Models for Object Recognition

- **DenseNet 121**

DenseNet is an architecture that uses shorter linkages across layers to train DL networks more effectively while also making them deeper. Figure 3 illustrates the design of DenseNet (Densely Connected Convolutional Networks), a deep neural network that presents the idea of dense connections between layers. Some of the issues with gradient vanishing and feature reuse that can arise with conventional convolutional neural networks (CNNs) are addressed by DenseNet designs. Two layers of a CNN called DenseNet are connected to every other layer farther down the network. One variation of the DenseNet architecture is DenseNet121.

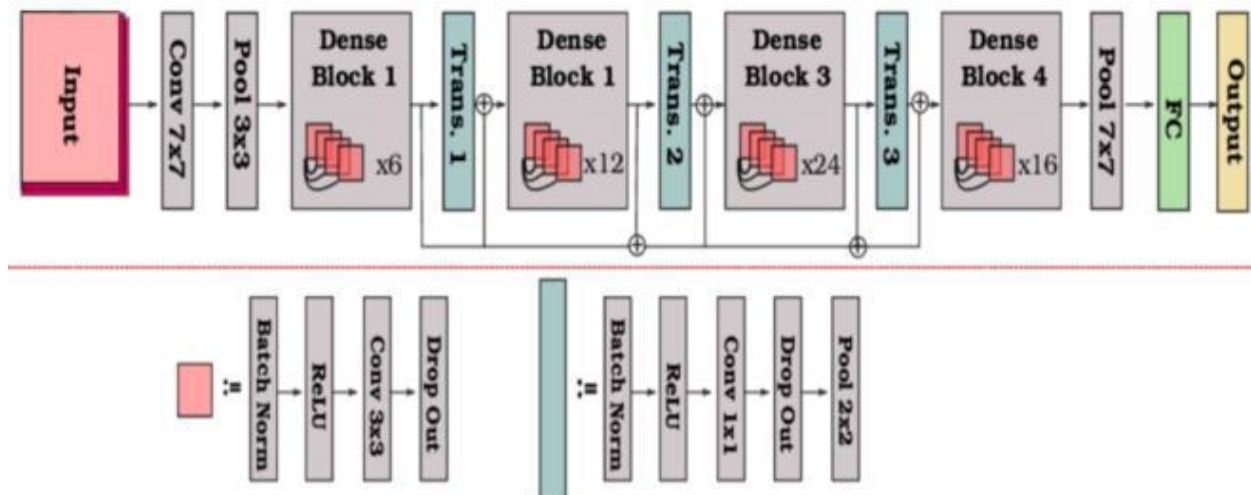


Figure 3:DenseNet Architecture

- **Dense Connectivity:**
 - DenseNet presents dense blocks, in which every layer is feed-forward linked to every other layer.
 - This dense connection makes feature reuse easier and helps solve the vanishing gradient problem.
 - In a dense block, the feature maps from all previous layers are concatenated together and supplied as input to the current layer.
- **Bottleneck Layers:**
 - Before dense connection, DenseNet uses bottleneck layers to minimize the number of channels.
 - A bottleneck layer reduces the number of input channels and calculations by using a 1x1 convolution followed by a 3x3 convolution.
 - This lowers the model's parameters and memory needs.
- **Transition Layers:**
 - To regulate the spatial dimensions and channel diameters, DenseNet has transition layers in between dense blocks.
 - Transition layers smooth the transition from one dense block to the next by reducing the number of channels and spatial resolution.
 - Typically, they are composed of a 1x1 convolution followed by average pooling or stride convolution.
- **Growth Rate:**
 - The number of feature mappings added to each layer in a dense block is determined by the growth rate, a hyperparameter.
 - Although it uses more memory and processing power, a faster growth rate can produce richer feature representations.
- **Fully Connected Layer and Global Average Pooling:**
 - DenseNet designs frequently employ a fully connected layer for the ultimate prediction after utilizing global average pooling.
 - The fully connected layer produces the final class probabilities, and global average pooling reduces the spatial dimensions of feature maps to one value per channel.

3.3. Regularization and Batch Normalization:

- To minimize the internal covariate shift and speed up training, DenseNet uses batch normalization.
- To prevent over fitting, dropout is also used for regularization.

In particular, DenseNet121 designates a DenseNet architectural variation with around 121 layers. It can be adjusted or used for transfer learning on a variety of computer vision problems because it has already been pre-trained on sizable picture datasets like ImageNet. DenseNet architectures are well-liked for a variety of deep learning applications due to their robust performance, economical parameter usage, and capacity to capture rich feature representations.

• YOLO - V3

YOLO - V3 is used for object detection. One type of one-stage technique that converts target identification into a regression issue is called YOLO (You Only Look Once). When compared to Faster R-CNN, YOLO obtains location and category predictions directly. At the output end, YOLO-V2 adds convolutional layers in place of fully connected layers (FC). Furthermore, YOLO-V2 utilizes the Batch Normalized New Features Extraction Network (Darknet19).

Darknet53 is used by YOLO-V3 as its feature extraction network. Darknet53 uses a complete.

convolutional network to avoid the information loss brought on by pooling layers (FCN). Essentially, the network is composed of 1×1 or 3×3 convolutional kernels. It's named Darknet53 since it has 53 convolutional layers in it. YOLO-V3 utilizes the feature pyramid network (FPN) concept. For every input picture, the network performs a five-time down-sampling operation. After the feature extraction process, the resultant feature map is down-sampled by $32\times$, making it $1/32$ of the original image's size. The last three down-sampled layers are then sent by YOLO-V3 to the detection layers to find targets. YOLO-V3 forecasts on three different scales. The three scales, which are 13×13 , 26×26 , and 52×52 measures. The feature maps are then concatenated. Similarly, this work used the same reasoning for feature maps that have been $8\times$ and $16\times$ down-sampled.

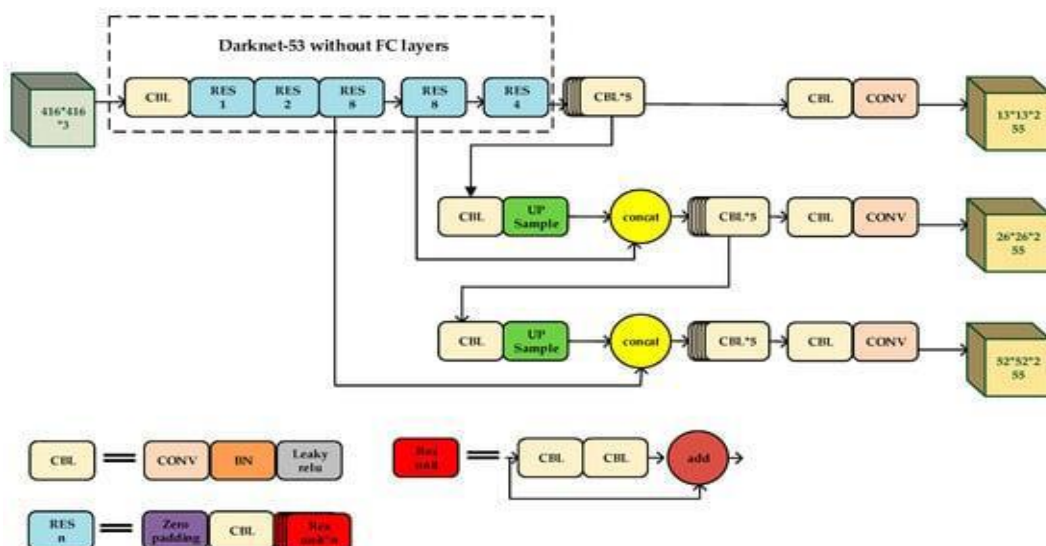


Figure 4: The network of YOLO - V3

4. EXPERIMENTAL RESULTS

In this work the flood affected image, area image are collected through IoT sensors,

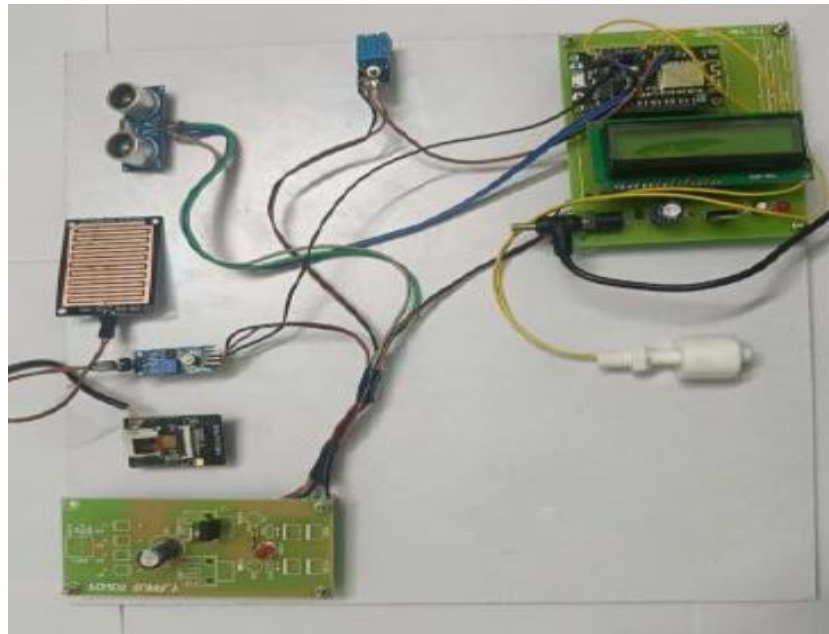
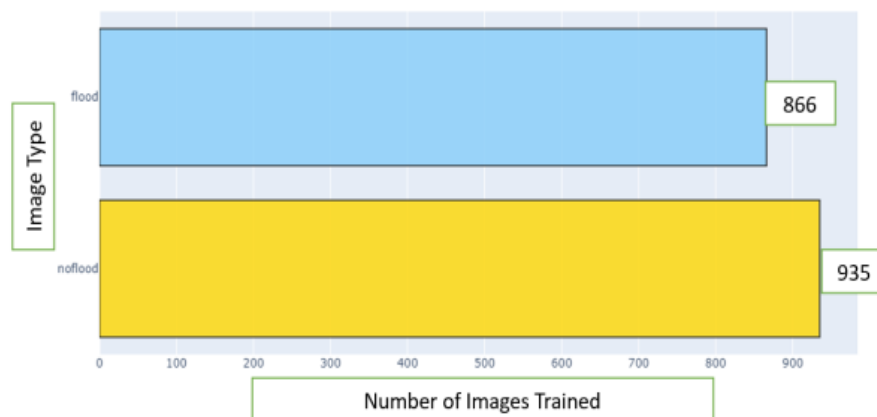


Figure 5: IoT Hardware Setup

Figure 5 shows the IoT hardware setup to collect the input

Count of class variable in train dataset



images.

Figure 6: Number of Image Trained

Figure 6 illustrates the number of images used to train for object detection and Figure 7 shows the training results.


```

Epoch 1/15
45/45 [=====] - 392s 8s/step - loss: 0.7717 - accuracy: 0.5632 - val_loss: 0.7284 - val_accuracy: 0.66
48
Epoch 2/15
45/45 [=====] - 332s 7s/step - loss: 0.6193 - accuracy: 0.6681 - val_loss: 0.5523 - val_accuracy: 0.74
52
Epoch 3/15
45/45 [=====] - 312s 7s/step - loss: 0.5289 - accuracy: 0.7292 - val_loss: 0.4840 - val_accuracy: 0.77
84
Epoch 4/15
45/45 [=====] - 343s 8s/step - loss: 0.4325 - accuracy: 0.7958 - val_loss: 0.3837 - val_accuracy: 0.86
15
Epoch 5/15
45/45 [=====] - 312s 7s/step - loss: 0.4006 - accuracy: 0.8292 - val_loss: 0.2575 - val_accuracy: 0.90
03
Epoch 6/15
45/45 [=====] - 318s 7s/step - loss: 0.3378 - accuracy: 0.8708 - val_loss: 0.2138 - val_accuracy: 0.92
24
Epoch 7/15
45/45 [=====] - 319s 7s/step - loss: 0.2981 - accuracy: 0.9014 - val_loss: 0.1980 - val_accuracy: 0.94
46
Epoch 8/15
45/45 [=====] - 516s 12s/step - loss: 0.2828 - accuracy: 0.9132 - val_loss: 0.1891 - val_accuracy: 0.9
529
Epoch 9/15
45/45 [=====] - 286s 6s/step - loss: 0.2583 - accuracy: 0.9187 - val_loss: 0.1853 - val_accuracy: 0.95
57
Epoch 10/15
45/45 [=====] - 243s 5s/step - loss: 0.2340 - accuracy: 0.9382 - val_loss: 0.1594 - val_accuracy: 0.97
51
Epoch 11/15
45/45 [=====] - 254s 6s/step - loss: 0.2077 - accuracy: 0.9549 - val_loss: 0.2036 - val_accuracy: 0.95
84
Epoch 12/15
45/45 [=====] - 244s 5s/step - loss: 0.1861 - accuracy: 0.9708 - val_loss: 0.1951 - val_accuracy: 0.95
84
Epoch 13/15
45/45 [=====] - 238s 5s/step - loss: 0.1798 - accuracy: 0.9708 - val_loss: 0.1732 - val_accuracy: 0.98
34
Epoch 14/15
45/45 [=====] - 254s 6s/step - loss: 0.1699 - accuracy: 0.9736 - val_loss: 0.1818 - val_accuracy: 0.96
12
Epoch 15/15
45/45 [=====] - 247s 5s/step - loss: 0.1575 - accuracy: 0.9736 - val_loss: 0.1738 - val_accuracy: 0.96
40

```

Figure 7: Training Output

The model starts with a pre-trained DenseNet121 backbone, applies temporal aggregation using time-distributed layers, adds some fully connected layers for classification, and then fine-tunes the model for improved performance on your specific task.

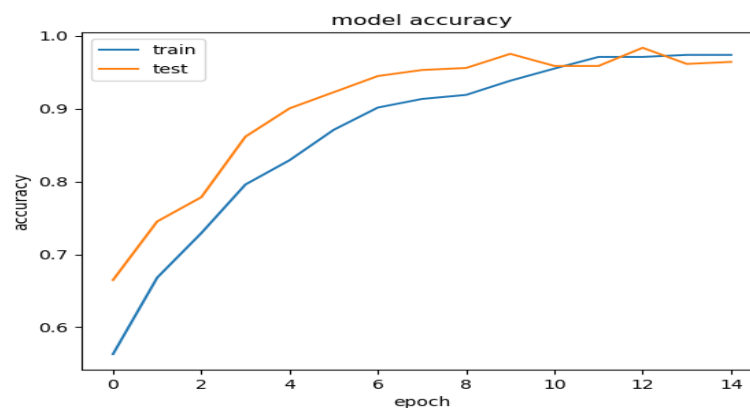


Figure 8: Accuracy curve for DenseNet121

When the testing dataset with I3D model was used to evaluate the testing accuracy, the result was 96.19% with pre-trained DenseNet121. Accuracy- Loss graphs for I3D model with DenseNet121 are shown in figure 8 and figure 9 respectively

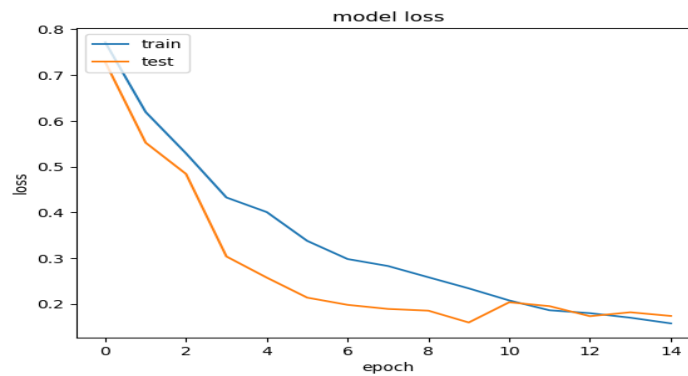


Figure 9: Loss curve for with DenseNet121

The image is of a Flood
 CLASS: person, Location: 11.7338,78.9592
 water level: 72, Temperature: 25, Humidity:
 CLASS: person, Location: 11.7338,78.9592
 water level: 80, Temperature: 25, Humidity:



Figure 10: Flood Detected Image using DenseNet

Figure 10 depicts Flood Detected Image using DenseNet. IoT is used to find water level, temperature and humidity level using IoT sensors.

The image is of a No flood



Figure 11: Non-flood Image using DenseNet

Figure 11 demonstrates the non-flood image, which is detected using DenseNet.



Figure 12: Street Sign Object Detected Result

Figure 12 illustrates Stop Sign Object Detected Result using YOLO – V3.

5. CONCLUSION

This can expedite the dissemination of information to the authorities and rescue personnel and facilitate communication amongst the many impacted groups. The app will provide all of the information gathered and share it with the relevant authorities, and the app will establish the network needed for communication between organizations and authorities. It will provide the relief management team with an advantage since it will make it possible for them to get in touch with the impacted population.

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ARTIFICIAL INTELLIGENCE FOR SUPPORTING TEACHING FACULTY DIVERSITY AND INCLUSION

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ABSTRACT

Diversity and inclusion within teaching faculties are vital for nurturing a rich educational atmosphere and enhancing academic outcomes. This research explores the application of artificial intelligence (AI) in promoting diversity and inclusion among teaching faculty, with a specific focus on arts colleges in Coimbatore. The study brings about how AI tools can support recruitment, retention, and career development of faculty members in institutions. The research employs mixed-methods of approach (i.e) qualitative and quantitative methods, incorporating interviews with faculty and administrative staff, as well as quantitative analysis of AI tool. The study also identifies challenges and limits, including the need for careful algorithm design to avoid the reinforcement of current biases while promoting transparency in AI decision-making processes. This research reveals how AI can be effectively be integrated into diversity and inclusion strategies within educational institutions. This document offers practical recommendations colleges, with the objective of fostering a more inclusive and supportive academic atmosphere for all teaching staff. **Research Design & Samples:** This descriptive research engaged a simple random sampling method, surveying 60 teaching facilities from Arts and Science College from the Coimbatore district. The study utilized a mixed-methods approach, combining quantitative and qualitative data from a survey and interviews respectively. **Tools of Data Collection:** Data was collected using a self-structured interview schedule to obtain personal profiles.

Keywords: *Artificial Intelligence (AI), Diversity and Inclusion and Teaching faculties.*

1. INTRODUCTION

Diversity and inclusion are key factors in promoting a rewarding learning environment that reflects a broad spectrum of perspectives and experiences. In higher education, especially within teaching faculties achieving diversity and inclusion, it is not solely a question of equity but also plays a significant role in advancing academic excellence and fostering innovation. However, these institutions often face challenges in implementing effective diversity and inclusion strategies due to several constraints. Artificial Intelligence (AI) has emerged as a revolutionary technology capable of handling various challenges by optimizing processes and delivering insights based on data analysis. Artificial intelligence tools can significantly contribute to diversity and inclusion efforts by enhancing fairer recruitment practices, improving faculty development opportunities, and confronting barriers



to professional growth. This study focuses on the application of AI for promoting diversity and inclusion among teaching faculty within the sphere of arts and science colleges in Coimbatore. Through the application of AI technologies, these institutions may be able to go beyond traditional constraints and promote a more inclusive learning environment in current scenario. This study seeks to investigate the integration of artificial intelligence into multiple facets of faculty management and development, the intention is to extend support to a diverse range of faculty members. The investigation will address several key areas such as the use of AI in optimizing recruitment processes to reduce bias, the utilization of predictive analytics to detect and alleviate challenges hindering career development and the application of AI-driven platforms for facilitating inclusive professional development. Through a case study approach, this research will assess the efficacy of these artificial intelligence applications in the context of Coimbatore's arts and science colleges, providing insights into their impact and identifying best practices.

2. DEFINITION

"Artificial Intelligence is a branch of computer science that aims to create machines that can perform tasks that would normally require human intelligence, including learning, reasoning, problem-solving, perception, and language understanding."- **Stuart Russell and Peter Norvig (2021)**.

"Diversity in teaching faculties refers to the representation of various demographic and cultural backgrounds among faculty members, while inclusion involves creating an environment where all faculty members, regardless of their backgrounds, are actively supported and able to contribute to and benefit from the academic community."- **Bell, M. P., & McLaughlin, M. E. (2016)**.

3. REVIEW OF LITERATURE

Jain, A., & Kumar, R.(2022) This study explores how AI-driven tools can facilitate the recruitment and retention of diverse faculty members in higher education. The authors examine AI algorithms designed to minimize bias in job postings and selection processes. They highlight successful case studies where AI tools have improved diversity metrics and suggest that AI can enhance transparency and fairness in faculty hiring practices.

Lee, S., & Zhang, L.(2021) Lee and Zhang investigate AI applications in faculty professional development, focusing on how AI can support the growth of underrepresented faculty members. The study identifies AI-driven platforms that offer personalized training and mentorship based on individual needs. It discusses the potential for AI to address gaps in professional development while also noting challenges related to the equitable implementation of these technologies.

Smith, J., & Davis, T.(2020) Smith and Davis provide a critical analysis of how AI tools impact equity and inclusion in faculty hiring and promotion. They review various AI applications used by academic institutions and assess their effectiveness in reducing disparities. The study emphasizes the need for careful design and oversight to prevent AI systems from perpetuating existing biases.

4. PURPOSE OF THE STUDY

The purpose of this study is to study the application of Artificial Intelligence (AI) in assisting and enhancing diversity and inclusion among teaching faculty. This investigation is focused on assessing the potential of AI-driven recruitment instruments aimed at minimizing biases and enhancing diversity within the team of faculties. This includes analyzing AI algorithms designed to enhance job postings, candidate screening, and processes of selection. Assess the role of AI technologies in supporting the professional advancement of faculty members from different backgrounds by delivering tailored training, mentorship, and pathways for career growth.. The study will assess the efficiency of AI in addressing barriers faced by underrepresented faculty groups. Investigate how AI can support in creating inclusive teaching and learning environments which includes examining AI tools that help faculty to develop and implement inclusive pedagogical strategies and materials.

5. SIGNIFICANCE OF THE STUDY

The study on "Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion" holds significant value for several key areas by exploring how AI can assist diversity and inclusion among teaching faculty this study contributes to the development of effective strategies for achieving equity in higher education. It provides a comprehensive analysis of AI tools that can enhance the representation and integration of faculty from diverse backgrounds, thus aiding in the accomplishment of institutional goals pertaining to diversity and inclusion. The study's findings can help higher education institutions refine their recruitment processes to be more inclusive. AI-driven recruitment tools have the opportunity to lessen discriminatory tendencies in hiring methodologies. Thus the institutions attract a broader pool of candidates from diverse backgrounds. By evaluating AI applications for faculty development, the study offers insights into how AI can facilitate the professional growth of faculty members. This can lead to more equitable access to professional development opportunities, ultimately contributing to career progression and retention.

6. RESEARCH METHODOLOGY

Objectives of the study

- To find out the personal profile of the respondents.
- To assess the level of Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion.
- To examine association between the personal profile and Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion.
- To analyze the difference and relationship between the Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion.

This descriptive research employed a simple random sampling method surveying 60 teaching facilities from Arts College in Coimbatore district. The study utilized a mixed-methods approach, combining quantitative data from a survey and qualitative insights from in-depth interviews. **Tools of Data Collection:** Data was collected using a self-structured interview schedule to obtain personal profiles. From the respondent. The statistical tools applied by the researcher are Percentage Analysis, Chi-square, T-test and ANOVA.

Table 1: Finds of the study

S:NO	FACTORS	MEDIUM	FREQUENCY	PERCENTAGE (%)
1	Age	30-45 years	54	75
2	Educational qualification	Post graduates	44	73.3
3	Marital status	Married	56	95
4	Type of family	Nuclear family	42	71.7
5	Residential background	Semi urban	15	38.3
6	No of years experience	10-15 years	41	58.3
7	Type of Organization	Private	43	78.3

7. FINDINGS

- Majority (75%) of the respondents were between the age group of 30-45 years of age.
- Majority (73.3%) of the respondents were post graduates.
- About 95.0% of the respondents are married.
- Majority (71.7%) of the respondents were from nuclear family.
- Less than half (38.3%) of the respondents are from semi-urban.
- More than half of (58.3%) of the respondents have 10 – 15 years of experience.
- Majority (78.3%) of the respondents are working private type of organization.

Table 2: Distribution of the Respondents based on Levels of Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion

S. No	AL & Diversity and Inclusion	No. of Respondents	Percentage (%)
1	High	42	70.0
2	Moderate	10	16.7
3	Low	8	13.3
TOTAL		60	100

8. INTERPRETATION

The above table depicts that 70% of the respondents experience high level of Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion, 16.7% of the respondents face moderate level of Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion and 13.3% of the respondents experience low level of Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion.

Table 3: Influence of personal profile and Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion of the respondents

VARIABLES	STATISTICAL TOOL	VALUE	RESULT
Age & Artificial Intelligence for Supporting Teaching Faculty	ANOVA	$P = .010 < 0.05$	Significant

Diversity and Inclusion			
Educational qualification & Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion	t-test	$P = .021 < 0.05$	Significant
Marital status & Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion	t-test	$P = .714 > 0.05$	Not Significant
Type of family & Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion	t-test	$P = .018 < 0.05$	Significant
Residential background & Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion	ANOVA	$P = .637 > 0.05$	Not Significant
No of years experience & Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion	ANOVA	$P = .003 < 0.05$	Significant
Type of Organization & Artificial Intelligence for Supporting Teaching Faculty Diversity and Inclusion	t- test	$P = .866 > 0.05$	Not Significant

- There is significant difference between the age and artificial intelligence for supporting teaching faculty diversity and inclusion.
- There is significant difference between the educational qualification and artificial intelligence for supporting teaching faculty diversity and inclusion.
- There is no significant difference between the marital status and artificial intelligence for supporting teaching faculty diversity and inclusion.
- There is significant difference between the type of family and artificial intelligence for supporting teaching faculty diversity and inclusion.
- There is no significant difference between the residential background & artificial intelligence for supporting teaching faculty diversity and inclusion.
- There is significant difference between the No of years experience & artificial intelligence for supporting teaching faculty diversity and inclusion.
- There is no significant difference between the type of organization & artificial intelligence for supporting teaching faculty diversity and inclusion.

9. RECOMMENDATION

Bias-Free Recruitment Algorithms: Develop and implement AI algorithms designed to reduce bias in the recruitment process.

Diverse Candidate Pools: Use AI-powered tools to source and attract a diverse pool of candidates.



Inclusive Job Descriptions: Utilize AI to analyze and optimize job descriptions to ensure they are inclusive and appealing to a diverse range of applicants.

Personalized Professional Development: Implement AI-driven platforms that provide personalized career development recommendations and training opportunities for faculty members.

AI-Enhanced Mentorship Programs: Develop AI systems that match diverse faculty members with mentors based on specific needs and career goals.

Monitoring and Analytics: Use AI to track and analyze diversity metrics and faculty experiences.

Support for Inclusive Pedagogy: Employ AI tools to assist faculty in designing and implementing inclusive teaching materials and methods.

Bias Detection in Evaluations: Integrate AI systems to review and ensure fairness in faculty evaluations and promotions.

Feedback and Improvement Mechanisms: Implement AI-driven feedback systems that allow faculty to anonymously report issues related to diversity and inclusion.

Continuous Learning and Adaptation: Foster an environment where AI tools are continuously updated and refined based on user feedback and evolving best practices.

10. CONCLUSION

Artificial Intelligence (AI) presents considerable potential for advancing diversity and inclusion among teaching faculty in higher education. By leveraging AI technologies, institutions can transform traditional practices in recruitment, professional development, and faculty support to promote a more fair and inclusive academic environment. AI-driven tools can enhance recruitment processes By reducing biases and expanding the candidate pool, we can guarantee that a variety of perspectives are included within the faculty. Personalized AI platforms offer tailored professional development opportunities, addressing the unique needs of underrepresented faculty members and behind their career growth. Additionally, AI can assist in designing inclusive pedagogical strategies and also evaluating the faculty performance with greater fairness. Despite of its potential, the successful implementation of AI in promoting diversity and inclusion requires careful consideration in several factors. Institutions must ensure that AI systems are designed for continuously update to reflect best practices and evolving needs. Effective monitoring, transparent practices, and a commitment to ongoing improvement are essential for maximizing the positive impact of AI. Ultimately, AI provides valuable tools for enhancing diversity and inclusion, but it is not a panacea. It should be integrated attentively within a broader strategy that includes human oversight, institutional commitment, and continuous engagement with faculties. By doing so, higher education institutions can utilize the potential of the resources available to use the power of AI to create a more inclusive, supportive, and diverse academic community.

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AN ANALYSIS OF FASHION INDUSTRY SUSTAINABILITY INITIATIVES AND INDIVIDUAL AWARENESS

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ABSTRACT

Sustainability has enhanced a conspicuous issue across various areas, specifically in the fashion industry, that considerably provides to global dirtiness. The swift growth of fast fashion and connected to the internet buying has severed garment transfer, infuriating environmental damage, accompanying the clothing industry giving reason for approximately 20% of worldwide contamination. Despite a increasing adoption of tenable practices, contamination rates continue to rise faster than sustainability works. Major fashion brands and influencers are more and more putting on reducing their element footprints and advancing sustainable substitutes, to a degree plant-eating leathers and recycled matters. In India, notable pushes are being undertaken to merge sustainability into fabric result, although challenges wait. A survey transported among young person's tells an increasing awareness and enthusiasm to support tenable fashion, though actual giving on tenable crop remains restricted. The verdicts suggest that while services interest in sustainability is extreme, skilled is a gap betwixt knowledge and operation. Increased education and approachable reusing options manage improve the impact of tenable practices. Overall, achieving important progress in sustainability will demand a collective work from things, brands, and commerce's alike.

Keywords: *Sustainability, Fashion Industries, Individuals, Awareness*

1. INTRODUCTION

The most celebrated topic in all sorts of field is sustainability. The demand for it is increasing day by day, due to the increased pollution caused by the industries. But this angle of demand is created by the individuals, as they are the major consumers of the product. The ideology of fashion is witnessing a dramatic evolution in recent decades. However, instant online shopping and growth of fast fashion says more about the consumers interaction with the clothing styles. Trends are spreading rapidly and the garment disposing is increasing which heightened the pollution of the environment. As the garment industry contributes about the 20% of pollution. Though the sustainable practices adoption is increasing day by day, the amount of pollution is increasing more than that. Fashion brands and influencers play a major role in the shift towards sustainability. Prominent brands like Burberry, Gucci and much more are contributing in the reduction of carbon foot prints. In India, some notable initiatives have been taken which is appreciable. This introduction gives the deeper exploration of the sustainability challenges in the textile industry, the role of consumer behaviour and ongoing processes of brands and industries to address the issues.

2. NEED OF SUSTAINABILITY

There is an increased demand in textile industry. This is due to the fashion ideology that is been adopted by most of the population. In those days, it will take around minimum of seven to eight months for the popularity of the trends among the individuals. The mode of transport and the availability of social media was also not that much possible. Due to which, it took much time to adopt the trend by massive population. The culture of disposing the clothes was not appreciable in those days. As the value of the product is given much importance and throwing of fabric was not in peoples mind. But due to fast fashion and the fast door delivery system through applications and websites, the adoption of fashion became so easy. This way the dumping of garments also increased. These resulted in the land pollution. The degrading time of natural fibres is fast comparatively to the man-made fibres. But due to the need of some special purpose finishes in the garments for everyday use, the utilizing of natural fibres has been decreased with the increased use of synthetic fibres.

3.COMPARATIVE PERCENTAGE OF TEXTILE INDUSTRY AND SUSTAINABILITY TEXTILES:

The textile industry contributes around 4% in trading¹ and the contribution to sustainability is around 4.3%². But the percentage of pollution created by the textile industry is around 20% worldwide³(Figure 1). As we can see the percentage of pollution is in more numbers than the economy contribution. The numbers are increasing towards sustainability in recent years but the pollution rate increases ten times faster than it. The preference for the importance of sustainability is around 69% according to the Vogue readers. The 73% of the British consumers are having the habit of buying only sustainable clothes⁴, while in India its around 56% in buying⁵. In China, the industries that has been producing synthetic dyes was shut down and are trying to find new technologies that can save water and reduce pollution⁶. In India, the pre-treatment process has been modified to some extent and the awareness campaigns among the individuals have been conducted. Although, the adopting mindset is different from preference. Everyone is voting for the sustainable importance, but when it comes to adoption, the percentage is always less in number. The life span of a garment is from five to six years before 2012. After it, the fast fashion started to conquer the people's mind slowly and moving in a rapid way nowadays. The increase in working people plays one of the major roles in the fast fashion. As everyone needs to look pleasant in their working atmosphere.

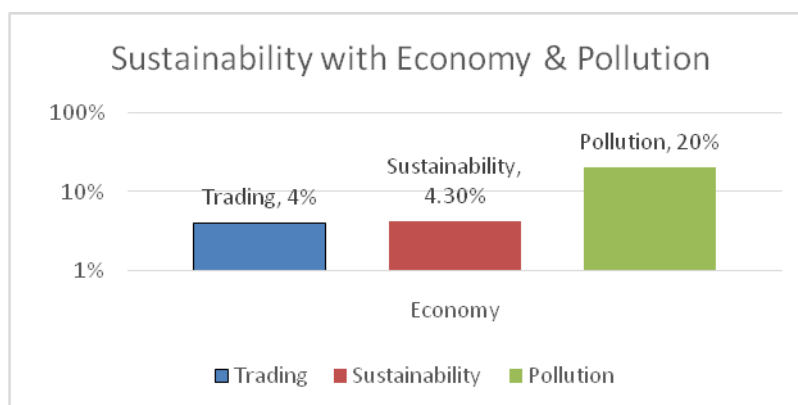


Figure 1: Sustainability in Economy & Pollution

4. INITIATIVES BY FASHION BRANDS AND THE INFLUENCERS:

The concept of fashion is introduced to the world by several fashionista and it's becoming a never-ending ideology. The people get attracted to the fashion is due to the standards fixed by them. The period where the clothes are just enough to cover the body has been changed to the importance for defining personality. This helped in the growth of fashion and pollution simultaneously. Natural color for dyeing is not that much appreciated, as they are dull than the synthetic colors. Same applies to fibres where synthetic is preferred based on the economy and utility purpose. These concepts can be changed in the people's mind only by the fashion influencers. As the people are getting attracted to it partly by these influencers who are the cinema stars, Youtubers, Instagram etc. If most of the influencers, create their content based on sustainability, definitely it would bring some sort of changes in the mindset of the people. Many fashion brands have started adopting to sustainability. The brands like Burberry, Gucci are concentrating on reducing carbon foot prints up to 90% by 2040. Chanel brand concentrates on the climatic conditions, Vivienne Westwood is focusing on responsible sourcing and regenerative agriculture, Stella Mc Cartney, Hermes and Yves Saint Laurent is concentrating on producing vegan leathers instead of animal leathers. Prada is gaining attention on the mission of Re- Nylon⁷. Even though the initiatives by the fashion brands are much stronger, the carbon footprint reduction is at its pace. The more conscious the individuals become; more beneficiaries will be there for the environment.

5. INDIAN INDUSTRIES TAKE ON SUSTAINABILITY:

Our Indian textile industry is one of the largest exporters of goods in the world. Especially the t-shirts manufactured in Tirupur are the best exporters in India. Though the market is good, the concept of sustainability is quite a challenge one. Our Indian textile industries has initiated some of the sustainable production methods. The SDF Clothing is one of the leading industries in the area of sustainable and ethical production of textiles. They have introduced a technique for the color matching systems in the textile industry in a sustainable way, which is free to use⁶. RSWM limited company has started to blend more of natural fibres like hemp, flax, nettle, ramie, banana and jute with recycled polyester, modal, cotton to produce sustainability and performance yarns⁸. Nowadays the most consumed clothing is denim. This requires huge amount of water in the production stage which is more of water consumption and polluting the environment. Many industries came forward and started to work on producing denims in a sustainable way. One of such industry collaboration is anthropologie with Cotton Incorporated as an initiative for recycling the denims⁹. Epson and HKRITA collaborated on the development of the new fibers using upgraded technologies. They have initiated the programme to separate the fibers from the challenging textiles and converting it into newer one⁹.

6. URVEY ON THE CUSTOMER PREFERENCES:

A survey was conducted between the age groups 18 to 25 with 86% female respondents and 13% male respondents on the concept of sustainability preferences. This survey was taken with 100 students. The results were discussed further. The buying habit of clothes too often was found at the rate of 33% whereas the occasional buying is around 17%(Figure 2).

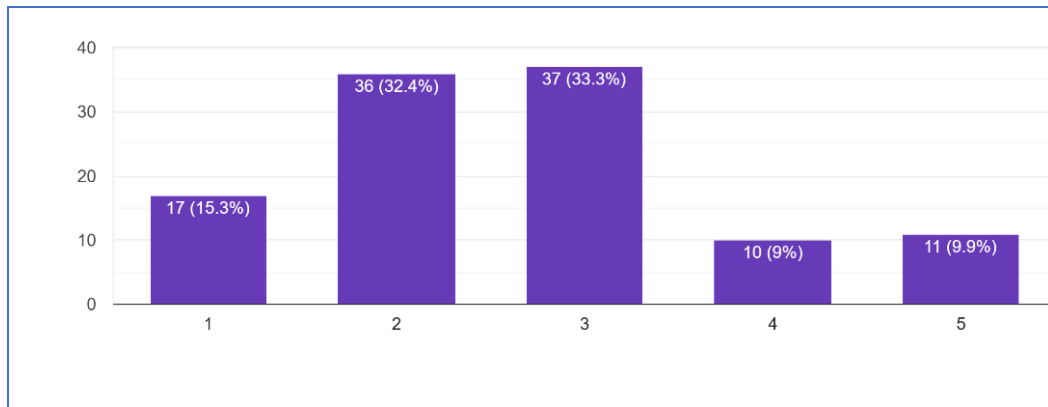


Figure 2: often buying habits of clothes

The percentage preference for Natural and Blended fibres are more or less 45% and the preference for synthetic is 10% (Figure 4). The knowledge about sustainability (Figure 3) among the individuals is 65%. Around 67% people are willing to buy sustainable clothes and 26 % voted that they may prefer it (Figure 5).

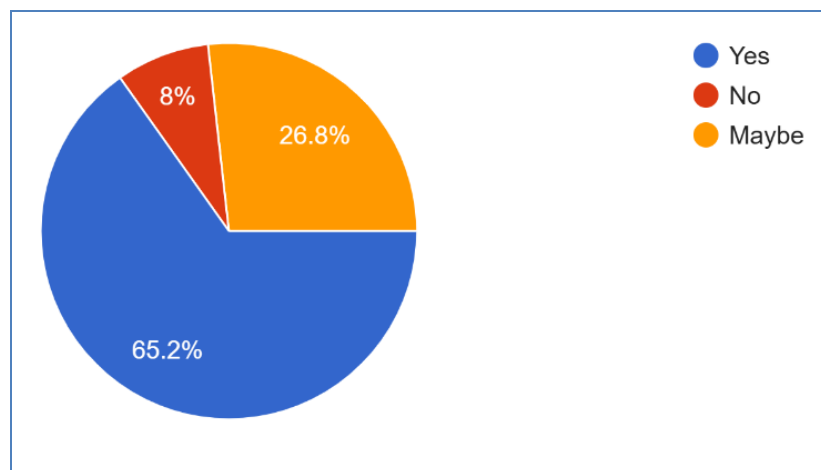


Figure 3: Knowledge on sustainability

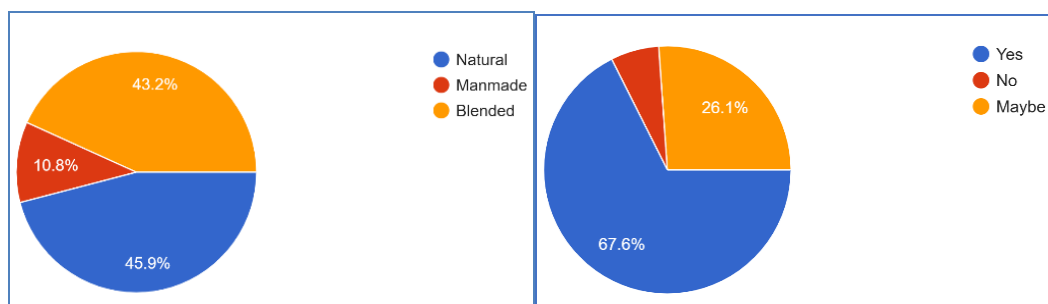


Figure 4: Preference on fibres

Figure 5: Preference on sustainability

The percentage of recycling the clothes among 100 members is 42% but the number may vary. The donating of clothes is seen to be moderate with 36% and 20% answered very often (Figure 6).

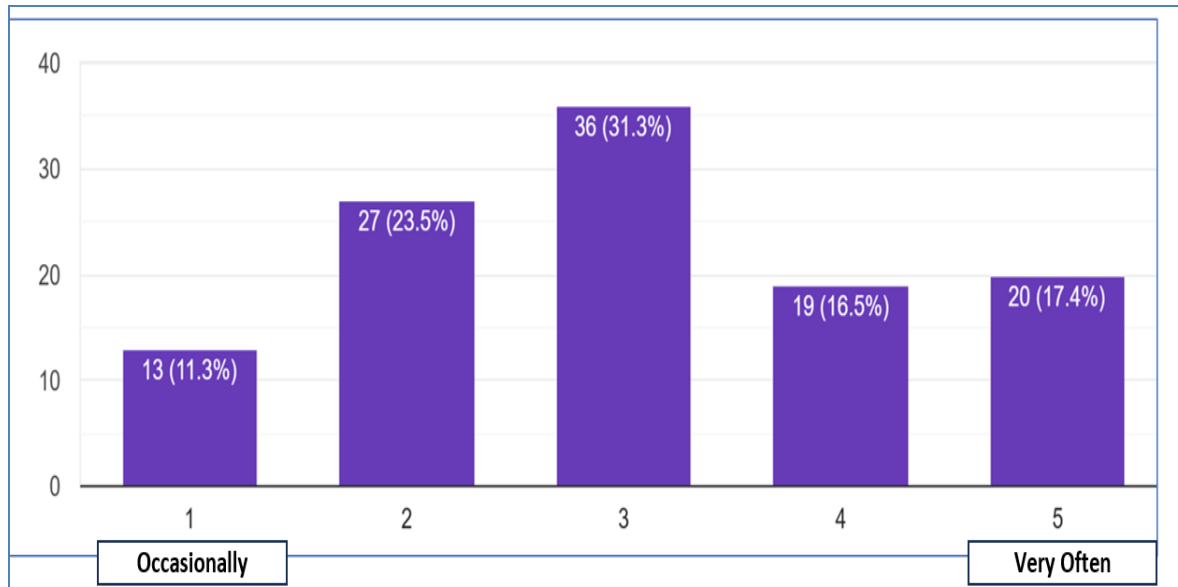


Figure 6: Donation of clothes frequency

The individuals interested in spending amount for sustainability between the range of Rs. 500 to Rs.1000 is 41% which is higher and the maximum spending amount preference does not exceed above Rs.2000 as it lies within the range of 27% (Figure 7). The highest count of 78% has been seen for the preference of both brands and local markets with the 40% Indowestern outfits and 37% western outfits (Figure 8). The preference for traditional outfit seems to be low in percentage (Figure 9).

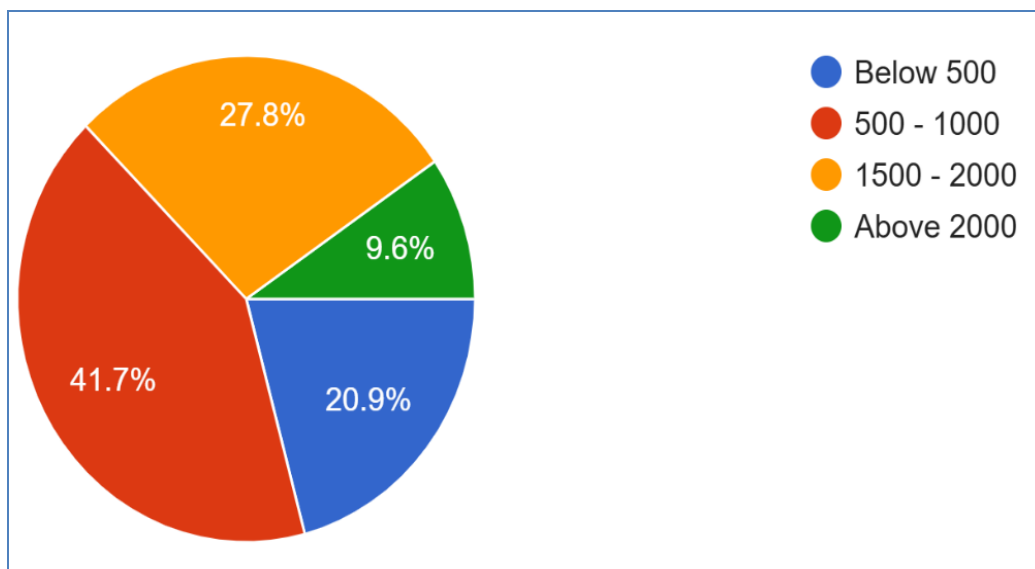


Figure 7: Amount spending preference on sustainable textiles

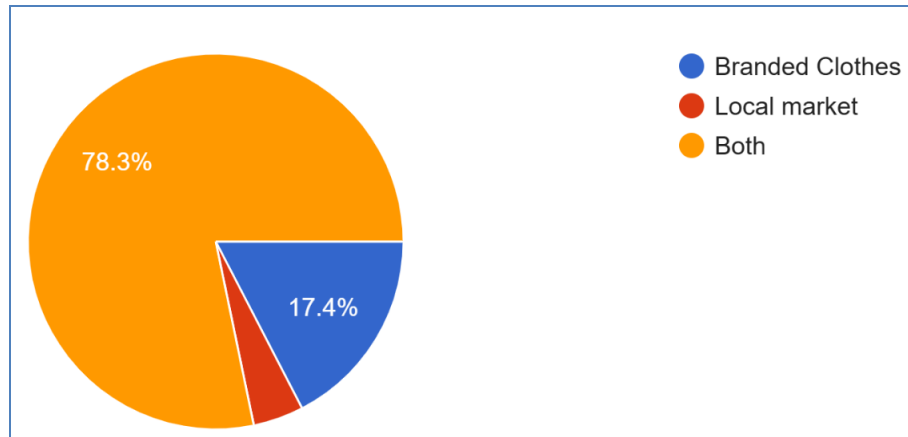


Figure 8: Preference on Brands and Local markets

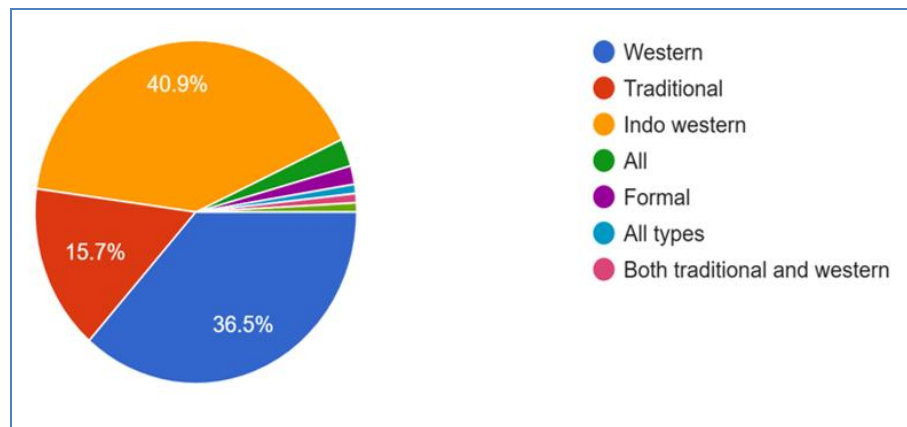


Figure 9: Clothing style preferences

7. CONCLUSION

Thus, from the survey, it is understandable that the customers are willing to buy sustainable products but the amount they are willing to spend is not that much. It's acceptable as some of the individual's financial stability is not that much. The textile industries also concentrating much on its production in a sustainable way. But in this fast-moving world, it is seen that the sustainable methods are moving slow. This has to be increased by preaching it to as many individuals as possible and increasing more online applications for donating the clothes. In this way, we may contribute some percentage of sustainability to the environment. This is not only the work of industries or fashion brands, it's the responsibility for each and every individual. If the mindset of the person can be changed with craft, sustainability can be achieved in a short span of time.

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BIOCOMPATIBILITY AND TOXICITY OF ANTIMICROBIAL AGENTS IN TEXTILES

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ABSTRACT

The rapid expansion of antimicrobial textiles, driven by their effectiveness in combating microorganisms and enhancing hygiene, has brought to light significant concerns regarding their biocompatibility and environmental impact. This review provides a comprehensive examination of the various antimicrobial agents used in textiles, including both synthetic and natural types. Synthetic agents such as silver nanoparticles, zinc oxide nanoparticles, quaternary ammonium compounds (QACs), and triclosan, while effective, are associated with potential risks including cytotoxicity, carcinogenicity, hormonal imbalances, and environmental toxicity. Natural agents like chitosan, essential oils, and herbal extracts, though generally safer, also present challenges such as variable efficacy and potential allergic reactions. The review highlights critical issues such as skin irritation, allergic reactions, and long-term health effects of antimicrobial textiles, emphasizing the need for rigorous safety evaluations. Environmental concerns related to the release and bioaccumulation of antimicrobial agents further underscore the importance of developing sustainable alternatives. The review concludes with recommendations for improved regulatory standards, consumer education, and the pursuit of safer, eco-friendly antimicrobial solutions.

Keywords: *Antimicrobial Textiles, Biocompatibility, Toxicity, Environmental Impact.*

1. INTRODUCTION

The demand for antimicrobial textiles has surged in recent years, driven by their effectiveness in preventing the growth of microorganisms on fabric surfaces. Various techniques are employed to bind antimicrobial compounds to textiles, contingent upon the chemical interaction between the antimicrobial agent and the textile¹. These textiles are increasingly used in healthcare settings to reduce the risk of infections, in sportswear to control odors, and in everyday clothing to enhance hygiene. About 85% of all antimicrobial textiles are produced for lingerie, active wear, shoe linings, and socks. Furthermore, antimicrobial fibres have seen significant market growth recently in the areas of air filters, outdoor textiles, upholstery, and medical textiles². The antimicrobial properties of these textiles are typically achieved through the incorporation of agents such as silver nanoparticles, copper ions, and various organic compounds, which have been proven effective against a wide range of pathogens.

However, the growing use of antimicrobial agents in textiles has sparked concerns regarding their biocompatibility and potential toxicity. While these agents are designed to

target harmful microorganisms, their interaction with human skin and the broader environment raises critical questions about safety. Issues such as skin irritation, allergic reactions, disruption of the skin microbiome, and long-term health effects are becoming increasingly relevant as consumers are exposed to antimicrobial textiles on a daily basis.

In addition to human health concerns, the environmental impact of antimicrobial agents, particularly in the form of nanoparticles, is a significant issue. These agents can be released into the environment during washing or disposal, leading to potential ecological harm. As the industry continues to innovate and expand the use of antimicrobial textiles, there is a pressing need to thoroughly evaluate the biocompatibility and toxicity of these materials to ensure they do not pose unintended risks.

This review aims to provide a detailed examination of the biocompatibility and toxicity of antimicrobial agents in textiles. By exploring the mechanisms of action, potential health risks, environmental considerations, and current regulatory frameworks, this article seeks to inform both researchers and industry professionals on the safe and effective use of antimicrobial textiles.

2. ANTIMICROBIAL AGENTS IN TEXTILES

Antimicrobial agents used in textiles are essential for inhibiting the growth of harmful microorganisms such as bacteria, fungi, and viruses, and they can be broadly categorized into synthetic and natural types, each with unique mechanisms of action, benefits, and potential drawbacks. Textile functionalization has extensively utilized metal-based antimicrobial methods, incorporating agents like silver, copper, titanium, and zinc^{3,4}. While these metals are effective in providing antimicrobial protection, they may also lead to issues such as allergies and skin sensitization⁵, raising concerns about their long-term safety in consumer textiles.

2.1 Synthetic Antimicrobial Agents

Synthetic antimicrobial agents are chemically engineered compounds designed to target and kill or inhibit a broad spectrum of microorganisms. These agents are favoured for their efficacy and durability in various textile applications, but they also come with concerns regarding toxicity, environmental impact, and potential resistance development.

2.1.1 Silver Nanoparticles

Silver nanoparticles (AgNPs) are one of the most widely used synthetic antimicrobial agents in textiles. They work primarily by releasing silver ions (Ag⁺), which can disrupt microbial cell membranes, interact with microbial DNA, and generate reactive oxygen species (ROS) that lead to cell death. Silver nanoparticles are used in a variety of textiles, including medical fabrics, sportswear, and everyday clothing. They are valued for their broad-spectrum activity against bacteria, viruses, and fungi.

Despite their effectiveness, silver nanoparticles raise concerns about toxicity, particularly when they penetrate the skin and enter the bloodstream. Studies have shown that AgNPs can cause cytotoxicity, oxidative stress, and inflammation in human cells such as keratinocytes and fibroblasts, both of which are essential for skin health. Moreover, the environmental impact of silver nanoparticles is significant, as they can accumulate in aquatic ecosystems, leading to toxicity in aquatic organisms and potential bioaccumulation in the food chain.

2.1.2 Zinc Oxide Nanoparticles

Zinc oxide (ZnO) nanoparticles exhibit antimicrobial properties through multiple mechanisms, including ROS generation, disruption of cell membranes, and inhibition of essential enzymes in microorganisms. Zinc oxide is commonly used in textiles intended for medical applications, such as wound dressings, as well as in sportswear and personal protective equipment (PPE). It offers protection against a wide range of pathogens, including bacteria and fungi.

Although efficient as an antibacterial, ZnO nanoparticles can also be cytotoxic and cause oxidative stress in cells, resulting in cell death and their release into the environment poses risks to aquatic ecosystems.

2.1.3 Quaternary Ammonium Compounds (QACs)

QACs, such as benzalkonium chloride, are cationic surfactants that disrupt the cell membranes of microorganisms, leading to cell lysis and death. They are effective against a broad spectrum of bacteria, fungi, and viruses. QACs are commonly used in textiles for healthcare, hospitality, and consumer goods, including towels, bed linens, and activewear. They are favoured for their durability and long-lasting antimicrobial effects.

The persistent nature of QACs raises concerns about their potential to cause skin irritation, allergic reactions, and the development of antimicrobial resistance. Additionally, QACs can accumulate in the environment, where they may contribute to water pollution and harm aquatic organisms.

2.1.4 Triclosan

Triclosan is a broad-spectrum antimicrobial agent that works by inhibiting fatty acid synthesis in bacteria, leading to cell death. It was widely used in textiles for its ability to prevent bacterial growth and odors. Triclosan was commonly found in antibacterial clothing, footwear, and household textiles, such as dishcloths and towels.

Due to concerns about its potential endocrine-disrupting effects, environmental persistence, and contribution to antibiotic resistance, the use of triclosan in textiles has significantly declined. Many regulatory bodies, including the FDA, have restricted or banned its use in consumer products.

2.1.5 Copper Ions

Copper ions (Cu^{2+}) are another widely used antimicrobial agent in textiles. Copper's antimicrobial activity is attributed to its ability to disrupt microbial cell membranes, denature proteins, and interfere with microbial DNA replication. Copper-treated textiles are commonly used in healthcare settings, such as in hospital bedding and uniforms, as well as in consumer products like socks and undergarments. Copper's broad-spectrum activity makes it effective against bacteria, viruses, and fungi.

While copper is essential for human health in trace amounts, excessive exposure through direct skin contact or inhalation can cause irritation and toxicity. Copper ions can also contribute to environmental pollution, particularly in water bodies where they may harm aquatic life.

2.2. Natural Antimicrobial Agents

Essential oils, plant extracts, and biopolymers are the sources of natural antibacterial agents. As opposed to their synthetic equivalents, these agents are thought to be more

biocompatible and environmentally friendly. They can differ in terms of stability, effectiveness, and likelihood of triggering allergic reactions.

2.2.1 Chitosan

Chitosan is a biopolymer derived from chitin, which is found in the exoskeletons of crustaceans like shrimp and crabs. Chitin is a naturally occurring polysaccharide that is a poly (β -(1-4)-N-acetyl-D-glucosamine. Numerous living things produce chitin. Following cellulose as the most prevalent polysaccharide in nature is chitin⁶.

It possesses inherent antimicrobial properties, attributed to its ability to disrupt microbial cell membranes and bind to negatively charged cell surfaces, leading to cell death. Chitosan is used in medical textiles, wound dressings, and sportswear for its antimicrobial and wound-healing properties. It is also valued for its biodegradability and non-toxicity. While chitosan is generally considered safe, some individuals may experience allergic reactions, particularly those with shellfish allergies. Its antimicrobial efficacy can also be influenced by environmental factors, such as pH and temperature.

2.2.2 Essential Oils

Essential oils, such as tea tree oil, lavender oil, and eucalyptus oil, are extracted from plants and possess natural antimicrobial properties. These oils contain compounds like terpenes and phenolics, which can disrupt microbial cell membranes, inhibit enzyme activity, and prevent biofilm formation.

Essential oils are used in a variety of textile applications, including sportswear, bedding, and baby clothing, to provide natural antimicrobial protection and pleasant scents.

The volatility of essential oils can lead to a decrease in antimicrobial efficacy over time. Additionally, essential oils can cause skin sensitization or allergic reactions in some individuals, particularly when used at high concentrations.

2.2.3 Herbal Extracts

Herbal extracts from plants, such as neem, aloe vera, and rosemary, have antibacterial, anti-inflammatory, and antioxidant qualities. These extracts work by disrupting microbial cell walls, inhibiting microbial enzymes, and interfering with pathogen adhesion. Herbal extracts are used in textiles intended for sensitive skin, such as baby clothing, bed linens, and medical fabrics. They are valued for their natural origin and soothing properties.

The stability and consistency of herbal extracts in textile applications can vary, as their antimicrobial efficacy may be influenced by factors like extraction methods, formulation, and environmental conditions. Additionally, while generally safe, some extracts may cause allergic reactions in sensitive individuals.

3. BIOCOMPATIBILITY AND TOXICITY CONCERNS OF ANTIMICROBIAL TEXTILES

Biocompatibility refers to the ability of a material to perform its intended function without causing undesirable local or systemic effects in the host, making it a critical consideration in the use of antimicrobial textiles. Ensuring that these materials do not elicit skin irritation, allergic reactions, or other adverse effects is essential for consumer safety. Toxicity is another significant concern, particularly with synthetic antimicrobial agents, which can pose risks ranging from acute skin irritation to long-term systemic health issues. The potential for these agents to disrupt the skin's natural microbiome or leach into the

environment further underscores the need for careful evaluation and regulation to mitigate both health and environmental impacts.

3.1 Cytotoxicity

The possibility that a substance could be harmful to cells is known as cytotoxicity. Numerous antimicrobial drugs have the potential to be cytotoxic, particularly in high doses or after prolonged contact. According to reports, cytotoxicity is caused by the production of a singlet oxygen-mediated process that mostly damages enzymes, cytoplasmic or nuclear organelles, and the plasma membrane⁷.

3.2 Skin Inflammation and Allergic Reactions

Additionally, certain antimicrobial agents like triclosan and quaternary ammonium compounds (QACs) can trigger allergic reactions in sensitive individuals, ranging from mild contact dermatitis to severe hypersensitivity. These potential adverse effects underscore the importance of careful selection and use of antimicrobial agents in textiles to minimize skin-related issues.

3.3 Carcinogenicity

Carcinogenicity refers to the potential of a substance to cause cancer by inducing genetic mutations or promoting uncontrolled cellular growth. Certain antimicrobial agents used in textiles have raised concerns about their potential carcinogenic effects, particularly with long-term exposure⁸.

3.4 Hormonal Imbalances

Some antimicrobial agents can disrupt the body's hormonal systems. Triclosan, for example, has been shown to disrupt thyroid hormone levels and other endocrine functions, thereby posing major health risks. As one matures, these consequences become more noticeable and challenging to address. Moreover, Studies have been conducted on rats and humans to indicate that environmental contamination due to pollution has devastating effects on the overall health of an individual at all most all the ages by causing hormone disruptions and various disorders⁹⁻¹². Compared to men, women are more likely to experience these imbalances. Hormone secretion changes become more noticeable during menstruation, pregnancy, and menopause.

3.5 Environmental Toxicity and Bioaccumulation

The environmental impact of antimicrobial fabrics is significant, as the agents used in these textiles can leach into the environment during laundering, potentially affecting aquatic life and ecosystems. For instance, silver nanoparticles can accumulate in aquatic species, causing harm and contributing to environmental pollution. Heavy metals from antimicrobial agents pose a serious threat to the environment^{13,14} exacerbated by rapid industrialization and urbanization since the 1940s, which has accelerated their mobilization and transport. Additionally, antimicrobial compounds like quaternary ammonium compounds (QACs) and triclosan can bioaccumulate in both the environment and living organisms, leading to long-term ecological and health hazards. These toxins can persist in the environment and enter the food chain, raising concerns about their impact on both ecological balance and human health.

3.6 Antimicrobial Resistance

The widespread use of antimicrobial chemicals in textiles may contribute to the emergence of antimicrobial-resistant microorganisms. This is especially concerning for drugs like triclosan and QACs, as overuse can result in resistant strains that are difficult to treat with traditional antibiotics. Antimicrobial resistance (AMR) has become one of the 21st century's most urgent concerns to worldwide public health. AMR manifests when microorganisms, encompassing bacteria, fungi, para-sites, and viruses, undergo evolutionary processes leading to their resistance against antimicrobial medications, such as antibiotics, commonly employed for treating such infections¹⁴⁻¹⁶.

3.7 Respiratory Concerns

In textiles, such as masks or mattresses, there are inhalation risks associated with antimicrobial particles or fibres, which may lead to respiratory problems or lung damage. For example, inhaling nanoparticles or fibres coated with silver or other antimicrobial compounds can be harmful. Additionally, some antimicrobial treatments or the chemicals used to bond them to textiles can emit volatile organic compounds (VOCs), which are toxic when inhaled. These VOCs can cause respiratory irritation and other health issues^{17,18}, raising concerns about the safety of antimicrobial-treated textiles in environments where prolonged or repeated exposure occurs.

3.8 Toxicity to Specific Organs

Liver and Kidney Toxicity: Prolonged exposure to certain antimicrobial agents, especially through dermal absorption, can lead to toxicity in vital organs such as the liver and kidneys. For instance, high levels of silver can accumulate in these organs and potentially cause damage. A large number of studies on animals have reported the toxicological role of biphenyl in serious injury of the urinary tract^{19,20}.

3.9 Neurotoxicity

There are concerns that prolonged exposure to certain nanoparticles, like silver and zinc oxide, could potentially affect the nervous system, though more research is needed in this area. About 72 toxic chemicals have been identified in textile effluents, and it is estimated that approximately 200 billion litres of effluents are produced annually worldwide by the textile industry.

4. MECHANISMS OF ACTION AND INTERACTION WITH SKIN

The antimicrobial activity of these agents typically involves disrupting microbial cell membranes, generating reactive oxygen species, or interfering with microbial DNA replication. However, the same mechanisms that make these agents effective against microbes can also pose risks to human cells:

- **Cell Membrane Interaction:** Some antimicrobial agents, particularly nanoparticles, can penetrate human skin cells, potentially causing cytotoxicity by disrupting cellular membranes.
- **Reactive Oxygen Species (ROS) Generation:** Agents like silver and copper can generate ROS, which can lead to oxidative stress in human cells, causing inflammation, DNA damage, and even cell death.



- **Chemical Residue Transfer:** Prolonged contact with treated textiles can result in the transfer of antimicrobial chemicals to the skin, leading to potential systemic absorption and long-term health risks.

5. ASSESSMENT METHODS FOR BIOCOMPATIBILITY AND TOXICITY

Evaluating the biocompatibility and toxicity of antimicrobial agents in textiles involves various in vitro and in vivo testing methods:

- **In Vitro Testing:** Common methods include cytotoxicity assays, such as the MTT assay, to assess the impact of antimicrobial agents on cultured human skin cells. Skin irritation tests using reconstructed human epidermis models are also widely used.
- **In Vivo Testing:** Animal models, such as mice and rabbits, are used to evaluate the safety of antimicrobial textiles through dermal exposure studies. Human clinical trials may also be conducted to assess potential skin reactions in volunteers.
- **Environmental Impact Assessment:** Environmental toxicity tests, such as the *Daphnia magna* immobilization test, are used to evaluate the impact of antimicrobial agents on aquatic ecosystems.

6. CHALLENGES AND FUTURE DIRECTIONS

While antimicrobial textiles offer significant benefits, ensuring their safety and biocompatibility remains a challenge. Key challenges include:

- **Balancing Efficacy and Safety:** Developing antimicrobial agents that are effective against pathogens but do not pose risks to human health or the environment is a significant challenge.
- **Regulatory Harmonization:** There is a need for harmonized global regulations to ensure consistent safety standards across different regions.
- **Consumer Awareness:** Educating consumers about the potential risks and benefits of antimicrobial textiles is crucial for informed decision-making.
- **Sustainable Alternatives:** Research into sustainable, biodegradable antimicrobial agents that minimize environmental impact while ensuring safety is a growing area of interest.

7. CONCLUSION

The use of antimicrobial agents in textiles offers considerable benefits in terms of infection control, odor management, and overall hygiene. However, the safety of these agents remains a critical concern. Synthetic antimicrobial agents, such as silver nanoparticles and triclosan, have been shown to pose risks related to cytotoxicity, carcinogenicity, and environmental toxicity. Natural antimicrobial agents, while generally safer, can still cause allergic reactions and variable efficacy issues. Addressing these concerns requires a balanced approach that considers both the effectiveness and safety of antimicrobial agents. Enhanced regulatory frameworks, increased consumer awareness, and research into sustainable alternatives are essential for minimizing potential risks associated with antimicrobial textiles. Future innovations should focus on developing safer, environmentally friendly antimicrobial solutions that protect both human health and the environment.



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A REVIEW ON ECO-FRIENDLY LEATHERS

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ABSTRACT

The leather manufacturing industry is a significant sector involved in producing various leather goods such as footwear, clothing, bags, belts, and other accessories. This process involves multiple stages, uses toxic chemicals, and consumes significant natural resources, contributing to deforestation, pollution, and a large carbon footprint. Vegan leather is a plant-based material designed to mimic the appearance and texture of animal leather without using any animal products. From handling hazardous chemicals to managing waste and sourcing raw materials, the leather industry confronts significant sustainability hurdles that must be addressed to ensure its long-term viability. Green materials such as vegetation and micro-organisms are utilized to produce leather derived from plants. This approach aids in minimizing the amount of textile waste, as it is decomposable and advantageous for the environment.

Keywords: *Leather, Eco-friendly, Environmental Impact, Sustainable Practices.*

1. INTRODUCTION

The leather manufacturing industry is a significant sector involved in producing such as footwear, clothing, bags, belts, and other accessories. This multi-billion-dollar global industry features major players in countries like Italy, China, India, Brazil, and the United States. Leather manufacturing involves several stages, starting with the procurement of raw hides and skins, followed by tanning and processing, and ending with the production of finished leather products. The raw materials for leather come from animals such as cattle, sheep, goats, and pigs.^[1]

The tanning process uses chemicals and other substances to preserve and strengthen the hides, preparing them for leather products. Tanning methods can vary, with common techniques including chrome tanning, vegetable tanning, and synthetic tanning. After tanning, the hides are processed into finished leather products through cutting, sewing, and other manufacturing steps. These products are then distributed to retailers and consumers around the world.^[1]

2. CONVENTIONAL LEATHER PRODUCTION

Leather production, which impacts the meat industry, is a complex process that converts raw animal hides or skins into a durable material. This process involves multiple stages, uses toxic chemicals, and consumes significant natural resources, contributing to deforestation, pollution, and a large carbon footprint. As a result, traditional

leather production has been criticized for its environmental impact, prompting a growing interest in sustainable alternatives and more eco-friendly tanning methods.^[1]

3. FORMATION OF VEGAN LEATHER

Vegan leather is a plant-based material designed to mimic the appearance and texture of animal leather without using any animal products. It can be created from various synthetic or plant-based sources, providing an option for those who prioritize ethical and environmental concerns and choose to avoid animal-derived materials. However, not all vegan leather is as eco-friendly as it might seem. Vegan leather is frequently made from plastic-based materials such as polyurethane (PU) or polyvinyl chloride (PVC).^[2]

While these synthetics provide a cruelty-free alternative to traditional animal leather, they raise significant environmental concerns. As products of fossil fuels, PU and PVC are essentially plastics that contribute to resource depletion and pollution. For eco-conscious consumers, the plastic nature of vegan leather highlights important considerations: the material's environmental impact, durability, and disposal methods are crucial factors in assessing its overall sustainability.^[2]

4. DILEMMAS IN LEATHER INDUSTRY

The leather industry is estimated to contribute to 18% of global industrial water pollution. It is also the fourth largest emitter of greenhouse gases within the textile sector, responsible for 5% of global emissions. In India, the leather industry is estimated to provide employment to around 4 million people, many of whom face hazardous and exploitative working conditions. In Bangladesh, over 90% of tanneries are situated in residential areas, exposing local residents to harmful chemicals and environmental pollution.

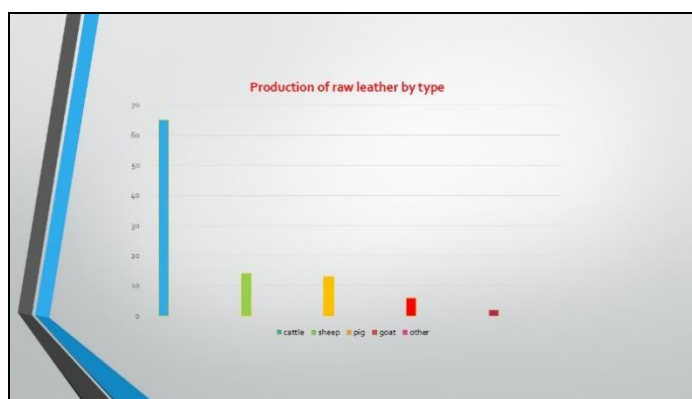


Figure 1: Production of raw leather by type in global level

These figures underscore that the leather production sector has been associated with numerous important issues and obstacles impacting the environment, the well-being of animals, human health and safety, working conditions, and additional areas. From dealing with dangerous substances to handling waste and procuring raw materials, the leather sector faces major environmental challenges that need to be tackled to guarantee its enduring success.

Recently, heightened consumer awareness of these issues has intensified pressure on companies to embrace more responsible practices. Additionally, innovations in materials and production methods are offering new opportunities for the industry to enhance its environmental and social impact.^[3]

4.1 Impacts

The leather industry leads to lots of impacts in environment as well as social. The leather manufacturing industry encounters major environmental challenges due to its intricate production process, which involves substantial water, energy, and chemical usage, each impacting the environment negatively.

- Environmental impact
- Chemicals usage
- Animal welfare
- Health and safety risks
- Cost and competitiveness
- Waste management etc.^[3]

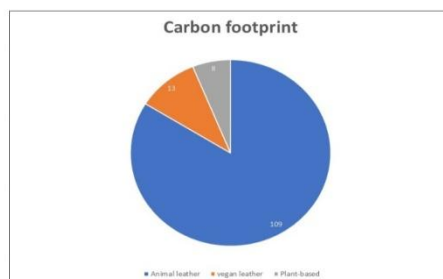


Figure 2:Carbon footprint

5. ECO-FRIENDLY LEATHERS

By-products from fruits such as Mango peels, banana stems, and pineapple scraps, as well as cactus, water hyacinth, corn husks, and waste from rice and other related agricultural materials, can be efficiently utilized to create vegan leather. This advanced method has the potential to substitute approximately 30-50% of the synthetic chemicals currently used in the production of traditional leather products available for purchase. The specific procedures and parameters for each type of agricultural waste are tailored to achieve the best results.^[4]

Green materials such as vegetation and micro-organisms are utilized to produce leather derived from plants. This approach aids in minimizing the amount of textile waste, as it is decomposable and advantageous for the environment. Sources of bio-leather include natural latex, pineapple, fungi, jellyfish, and bacterial cellulose. Additionally, mushroom leather, or mycelium leather, serves as a substitute for leather made from animals.^[4]

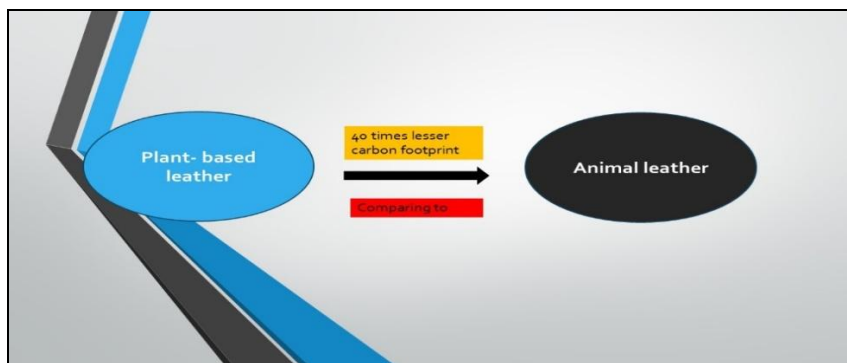


Figure 3: Plant-based leather vs Animal leather

5.1 Vegetable-Based Imitation Leather Fabrics

There are an abundance of vegetable-based imitation leather fabrics available on the market today. Some are

5.1.1 Piñatex Leather

Piñatex, made from pineapple leaf, stands out as a unique leather substitute. It is vegan and cruelty-free, produced without the use of harmful chemicals, and is completely biodegradable.

Leading fashion brands, including Hugo Boss, favor Piñatex as an environmentally friendly alternative to traditional leather, so keep an eye out for it during your shopping.^[5]

5.1.2 Mushroom Leather

Mushroom leather, also known as MuSkin, is another option derived from the *Phellinusellipsoideus* fungus or a mushroom.

This natural and biodegradable material is soft and similar in texture to suede. It is water-resistant, making it an excellent choice for faux leather bags and jackets, and is free from toxins.^[6]

5.1.3 Cork Leather

Cork, a highly versatile material, can also be transformed into leather. This eco-friendly leather alternative, made from cork tree bark, is lightweight, water-resistant, and surprisingly durable.^[7]

5.1.4 Leaf Leather

Leaf leather is a naturally occurring plant-based leather created from fallen leaves. It is sustainable, organic, and stylish, making it an ideal choice for eco-conscious accessories and a fully biodegradable option for leather.^[8]

5.1.5 Apple Skin Apple Leather

AppleSkin is a faux leather fabric that is sustainably sourced from the by-products of the apple juice industry.

This plant-based leather is certified by OEKO-TEX and is 100% cruelty-free, utilizing waste to produce a beautiful, versatile alternative to leather.^[9]

5.1.6 Bananatex® Leather

Loved by renowned fashion designer Stella McCartney, Bananatex® is a plant-based leather grown in the Philippines from banana plant by-products. It is natural, eco-friendly, cruelty-free, sustainable, ethical, and has achieved Cradle to Cradle Gold certification, making it the ultimate choice for a leather substitute.^[10]

5.1.7 Coconut Leather

Coconut leather closely resembles the real thing but is entirely made from organic waste from the coconut industry. Its unique feature is its breathability, flexibility, and water-resistance, allowing it to be used in a wide range of products.^[11]

5.1.8 Bio-Alloy™ Vegan Leather

Produced by Modern Meadow, Bio-Alloy™ is a premium faux leather fabric. It is as soft and luxurious as genuine leather but is made from natural raw materials, and its manufacturing process emits 90% fewer greenhouse gases than that of animal leather.^[12]

6. CONCLUSION

Other alternatives to traditional leather include lab-grown leather and recycled rubber, both of which are sustainable and cruelty-free. Lab-grown leather, created from yeast cell collagen, is bio-fabricated to mimic the appearance of animal leather. Recycled rubber, often sourced from old car tires, serves as a popular substitute for leather in boots, shoes, and accessories.

Recently, the leather manufacturing industry has faced criticism over issues related to animal welfare, environmental impact, and working conditions in some regions. In response, there have been efforts to improve sustainability practices and increase transparency in the supply chain.

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A COMPARATIVE STUDY OF MACHINE LEARNING ALGORITHMS FOR EARLY PROGNOSIS OF MULTIPLE SCLEROSIS PROGRESSION

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ABSTRACT

The central nervous system (CNS) deterioration that characterizes multiple sclerosis (MS), a chronic autoimmune illness, results in a variety of neurological symptoms. MS is difficult to manage because of its erratic course. The goal of this study is to compare the efficacy of Random Forest, XG-Boost, Decision Tree, and Logistic Regression algorithms in the early prediction of MS development. Following a recent diagnosis of Clinically Isolated Syndrome (CIS), a cohort of Mexican mestizo individuals had their clinical, genetic, and environmental variables examined. Missing values were addressed by data preprocessing, and feature selection based on the characteristics of the population was used. In order to preserve stratification for CDMS and non-CDMS cases, the dataset was divided into training and testing sets. Hyperparameters that were tuned were used to train machine learning models. AUC-ROC, F1-score, recall, accuracy, precision, and other performance evaluation metrics were used. Compared to other models, the Random Forest model performed better (AUC: 0.93, accuracy: 87%). Top predictors were determined via variable importance analysis, and they included oligoclonal bands, age, infratentorial MRI, and periventricular MRI. The study's therapeutic ramifications demonstrate ML's capacity to improve early MS prognosis and provide prompt therapies. With its strong performance, the Random Forest model proves to be an effective tool for detecting patients who are at danger. The study's drawbacks include cohort specificity and the use of retrospective data, despite the fact that it advances predictive analytics for neurological illnesses. For wider applicability, prospective investigations and additional data source discovery are advised. This study shows that machine learning (ML) may accurately predict the early course of multiple sclerosis (MS), giving clinicians a valuable tool for individualized patient care. The results highlight the value of customized therapies in neurological illnesses and advance predictive healthcare analytics.

Keywords: *XG-Boost, Decision tree, Clinically Isolated Syndrome (CIS), Predictive Analytics, Random Forest*

INTRODUCTION

The chronic autoimmune disease known as multiple sclerosis (MS) is characterized by CNS deterioration, which results in a variety of neurological symptoms. MS is the most prevalent neurological inflammatory disease that impairs youth. Specifically, MS is

characterized by ongoing inflammation that destroys White Matter (WM) myelin, leading to the development of sclerotic lesions, primarily in the central nervous system. The unpredictable nature of MS's progression—patients experience variable degrees of disability over time—makes controlling the disease one of the biggest problems. Zhang et al. define a central nervous system infection (CIS) as a single episode of neurological symptoms suggestive of an inflammatory demyelinating sickness of the central nervous system. Prompt diagnosis of MS progression is essential for customized treatment plans and prompt action. Healthcare professionals may now anticipate disease outcomes more accurately because to recent developments in machine learning (ML) techniques, which also help them make better decisions for their patients.

According to Walton et al., one in 3,000 MS patients worldwide, or around 2.8 million people, are affected by the illness. It has been linked to a number of debilitating symptoms, such as ataxia, sensory impairment, cognitive dysfunction, and fatigue. The three phenotypes of MS are progressive MS (PrMS), CIS, and relapsing-remitting MS (RRMS).

Predicting the course of MS entails examining the complex interactions between clinical, genetic, and environmental factors. The early prediction of MS development is the main topic of our study, and we compare the performance of different machine learning algorithms in predicting the disease's early course. The use of Machine Learning (ML) techniques to efficiently handle the analysis of high-dimensional data for model-informed drug development has been extensively supported and demonstrated in the literature. These techniques have also been used to predict patients' MS disease course and conversion to secondary progressive MS. The integration of machine learning models with a wide range of independent variables—such as Varicella exposure, somatosensory evoked potentials (SSEP), Expanded Disability Status Scale (EDSS), brainstem auditory evoked potentials (BAEPs), visual evoked potential (VEP), oligoclonal bands (OCBs), and specific MRI findings—is the focus of our research.

Clinical observations and a few numbers of biomarkers have historically played a major role in the diagnosis and prognosis of multiple sclerosis. The development of machine learning algorithms has allowed for the analysis of enormous and complicated datasets, which has completely changed the field of medical diagnosis. According to Eshaghi et al., new technologies like AI and ML can examine multidimensional data to locate groups with comparable traits. When applied to apparent anomalies on MRI images, for instance, AI and ML hold great promise for classifying patients based not on shared clinical features but rather on similar pathobiological causes. In recent years, AI techniques have shown their value in digital technology, industrial machinery, and creative tool creation. Dobson and Giovannoni state that the current diagnostic approach consists of a combination of clinical symptoms and magnetic resonance imaging (MRI) results. Our goal is to improve the precision and dependability of early MS progression predictions by utilizing machine learning. This research is important for improving the approaches used in predictive healthcare analytics as well as for its possible influence on patient care.

8. OBJECTIVE OF RESEARCH

This study introduces a novel method for forecasting the course of multiple sclerosis, aiming to fill a significant gap in the medical community. It is of great significance to the medical world since it presents a fresh method for forecasting the course of MS. Early detection of MS progression can result in prompt therapeutic interventions, enhancing patients' quality of life and possibly postponing the development of severe disability.



Additionally, the work opens the door for more research on predictive analytics for neurological illnesses by adding to the expanding body of literature on the use of machine learning in healthcare. The main category of machine learning techniques is classification. There are many different health challenges for which these classification approaches can be applied, such as illness screening, diagnosis, and prediction. A range of machine learning methods, such as artificial neural networks (ANN), Random Forests, k-nearest neighbors (KNN), support vector machines (SVM), decision trees (DT), and Naive Bayes (NB), are used in clinical data analytics.

The following is an outline of the sections that follow and what's in each:

2.1 Literature Evaluation:

This part will offer a thorough analysis of the body of research on the prognosis for Multiple Sclerosis (MS), predictive analytics, and the use of machine learning methods in healthcare. It will examine the difficulties that currently exist in controlling the course of MS, as well as the conventional diagnostic and prognostic techniques and the most recent developments in machine learning techniques for early disease prognosis.

2.2 Techniques:

This section will explain the research methods used for the study. It will go into detail on the machine learning algorithms that were used, the dataset that was used for analysis, feature selection strategies, model evaluation standards, and the justification for comparing various machine learning models.

3. TECHNIQUE

3.1 Gathering and Preparing Data:

At the National Institute of Neurology and Neurosurgery (NINN) in Mexico City, data from Mexican mestizo patients who had recently been diagnosed with clinically isolated syndrome (CIS) were the main focus of the study. The information gathered comprised demographics, a thorough medical history, the findings of a neurological exam, and other pertinent clinical factors unique to the Mexican mestizo community. Thorough preprocessing was performed on the dataset to resolve discrepancies and missing values. To find relevant factors that were specific to the distinctive qualities of Mexican mestizo patients, feature selection approaches were used.

In order to preserve the stratification of CDMS and Non-CDMS cases within the Mexican mestizo cohort, the preprocessed dataset was split into training and testing sets. By using this method, it was guaranteed that the machine learning models were assessed and trained on data that was typical of the population being investigated. The models were able to pick up on the subtleties of CIS progression unique to Mexican mestizo patients thanks to the training data.

4. MODEL DEVELOPMENT AND ASSESSMENT:

The training dataset was used to train the chosen machine learning algorithms, highlighting the distinctive qualities and traits of the population. The models improved their capacity to predict accurately the transition of CIS to Clinically Definite MS (CDMS) by learning patterns unique to this group during training.

The models' performance was assessed using a variety of measures on the test data set, such as F1-score, AUC-ROC, accuracy, precision, and recall. To comprehend how well the models performed in forecasting the course of CIS in Mexican mestizo patients, a detailed



analysis of the evaluation data was conducted. Each model's performance on the test data was evaluated, and the model with the best performance metrics was chosen as the final model.

4.1 Outcomes & Determinations

When a person seeks examination after a single episode of inflammation in the central nervous system (CNS), there are a number of long-term follow-up options to take into account. One of the most important decisions to make is whether or not to start therapy. Determining the prognostic variables that can foretell the transition from a Clinically Isolated Syndrome (CIS) to multiple sclerosis (MS) is therefore becoming increasingly important. Within the context of this project, we want to focus on the early prognosis of MS development, specifically assessing how well various machine learning algorithms perform in forecasting the disease's advancement in its early stages. Four machine learning models were used to predict the target variable Group (1=CDMS, 2=non-CDMS): logistic regression, XG-boost, random forest, and decision tree.

4.2 Data Exploration

Using a stacked bar chart, we were able to visually inspect how the dependent variable is distributed across the several independent factors. We discovered a balance in the dependent variable's distribution (CDMS=125, non-CDMS=146). Nevertheless, we observed an unequal distribution when we looked at the relationship between gender and the dependent variable "group." This raises the possibility that gender and the dependent variable "group" are related.

A possible relationship between breastfeeding and the dependent variable "group" was also suggested by the uneven pattern in the distribution of breastfeeding throughout the "group" dependent variable. Varicella, Oligoclonal, LLSSEP, ULSSEP, VEP, BAEP, Cortical MRI, Periventricular MRI, and Spinal Cord MRI all showed the same pattern.

4.3 Preprocessing the Data:

Using a stacked bar chart, we were able to visually inspect how the dependent variable is distributed across the several independent factors. We discovered a balance in the dependent variable's distribution (CDMS=125, non-CDMS=146). Nevertheless, we observed an unequal distribution when we looked at the relationship between gender and the dependent variable "group." This raises the possibility that gender and the dependent variable "group" are related.

A possible relationship between breastfeeding and the dependent variable "group" was also suggested by the uneven pattern in the distribution of breastfeeding throughout the "group" dependent variable. Varicella, Oligoclonal, LLSSEP, ULSSEP, VEP, BAEP, Cortical MRI, Periventricular MRI, and Spinal Cord MRI all showed the same pattern. These observations imply that these variables and the dependent variable "group" may be related.

Database of MS

<u>Variable</u>	<u>Non-Null</u>
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Age 273

Schooling 272

Breastfeeding 273

Varicella 273

Initial_Symptom 272

Mono_or_Polysymptomatic 273

Oligoclonal_Bands 273

LLSSEP 273

ULSSEP 273

VEP 273

BAEP 273

Periventricular_MRI 273

Cortical_MRI 273

Infratentorial_MRI 273

Spinal_Cord_MRI 273

Initial_EDSS 125

Final_EDSS 125

group 273

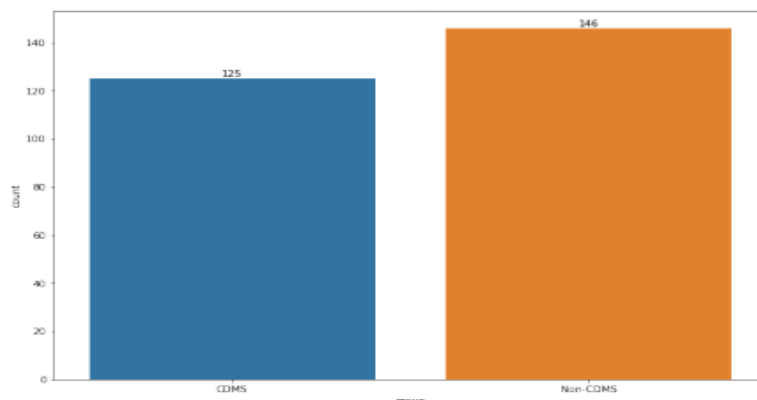


Figure: 1 The dependent variable's distribution

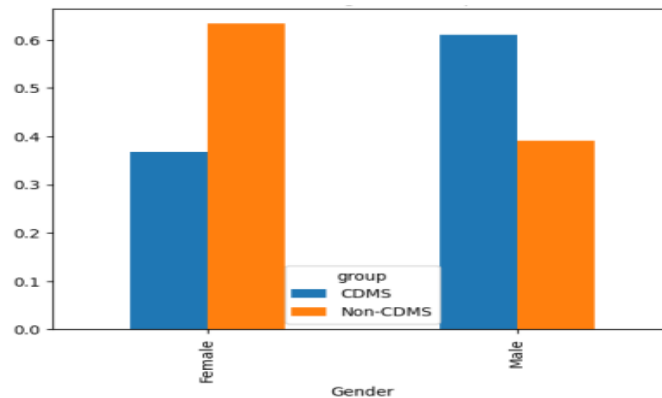


Figure: 2 Gender distributions in relation to the dependent variable (collective)

4.4 Tuning Hyper-Parameters

We used hyper parameter tweaking to get the best parameter values for our machine learning models. In order to enhance the performance of a machine learning model, this procedure entails methodically modifying the model's configuration settings, or hyper parameters. Following the tuning procedure, we determined our models' ideal parameter values.

Model	Bootstrap	Max Features	Estimators	OOB - Score
Random Forest	True	8	128	True

Table 1: Random Forest with Hyper-Parameter Tuning

Model	Learning Rate	Max Depth	Estimators
Xgboost	0.15	5	150

Table 2: Xgboost Hyper-Parameter Tuning

The Random Forest model's "Bootstrap" parameter was set to "True," indicating that during training, the model selected data at random using replacement. The maximum number of features taken into account while dividing a node was indicated by the value of "Max Features," which was set to 8. The number of decision trees in the Random Forest was indicated by the value of 128 for the "Estimators" parameter. Finally, the "OOB-score" was set to "True," indicating that the model's performance was estimated using out-of-bag samples.

Model	Min Sample Split	Max Depth
Decision Tree	2	3

Table 3: Decision Tree with Hyper-Parameter Tuning

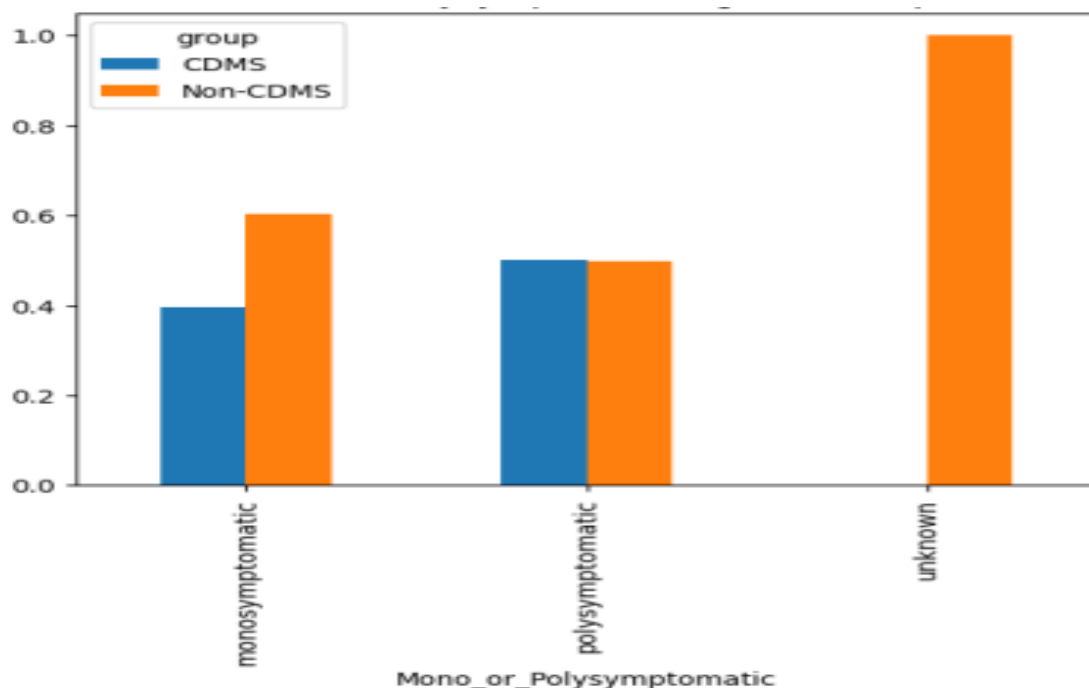


Figure: 3 Distribution of the Poly-symptomatic or Mono-symptomatic vs the Group, the dependent variable

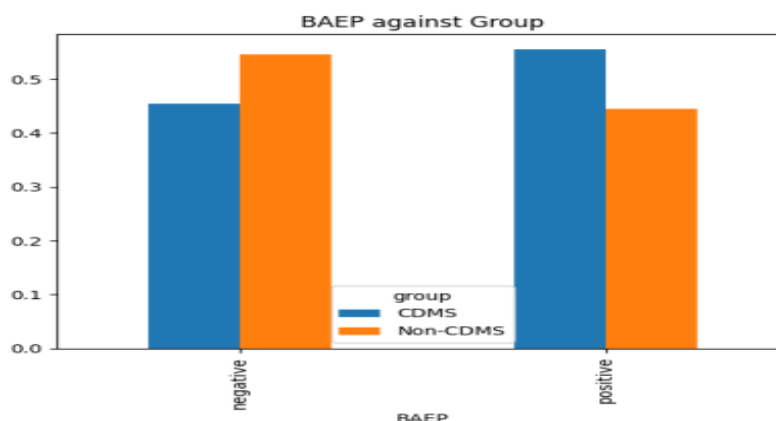


Figure: 4 The BAEP's distribution in relation to the dependent variable (Group)

The ideal number for the "Learning Rate" in the XGBoost model is 0.15, which is a reasonable value. This is similar to the step size during learning. The "Max Depth" parameter sets a maximum depth of 5 for decision trees, limiting excessively intricate trees. Lastly, the term "Estimators" refers to the total number of decision trees in the XGBoost; 150 trees were shown to be the best for capturing a wide variety of patterns.

4.5 Prototype Integration

We then fit our machine learning models using the ideal parameter values. The random forest model's findings show good performance. Strong predictive power is indicated by the

model's AUC (Area Under the Curve), which is 0.93 and gauges its capacity to discriminate between CDMS and non-CDMS instances. With a precision of 0.83, the model accurately predicts CDMS 83% of the time when it makes a prediction. The precision for non-CDMS is 0.89. The model's recall, or its capacity to pinpoint every real CDMS instance, is 0.87 for non-CDMS and 0.86 for CDMS. The accuracy, which gauges how accurate the model is, 87%. All of these indicators point to the model's good performance in predicting both CDMS and non-CDMS cases.

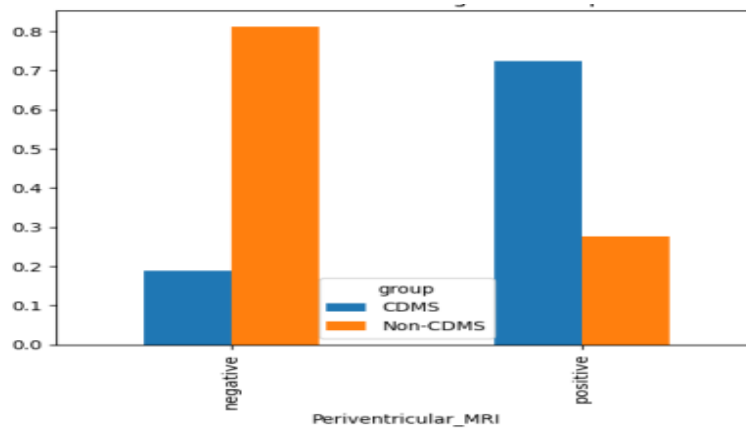


Figure: 5 Peri-ventricular MRI distribution in relation to the dependent variable (Group)

Table 4: The Random Forest Model's Performance

	Precision	Recall	F1 - Score	Support
CDMS	0.83	0.86	0.85	35
Non-CDMS	0.89	0.87	0.88	47
Accuracy			0.87	82
Macro avg	0.86	0.86	0.86	82
Weighted avg	0.87	0.87	0.87	82

The Decision Tree model's performance metrics are shown in Table 6's results. The model's capacity to differentiate between various scenarios is measured by the AUC (Area Under the Curve), and it is 0.86. The precision value for CDMS is 0.76, meaning that 76% of the time, the model accurately predicts CDMS. The precision for non-CDMS is 0.86, which is higher. The model's recall, which gauges its capacity to identify every real CDMS case, is 0.81 for non-CDMS and 0.83 for CDMS. About 83% of genuine CDMS cases can be identified by the model, while 81% of non-CDMS cases can be identified by it. The model's accuracy, which measures how accurate each and every forecast is, is 82%.

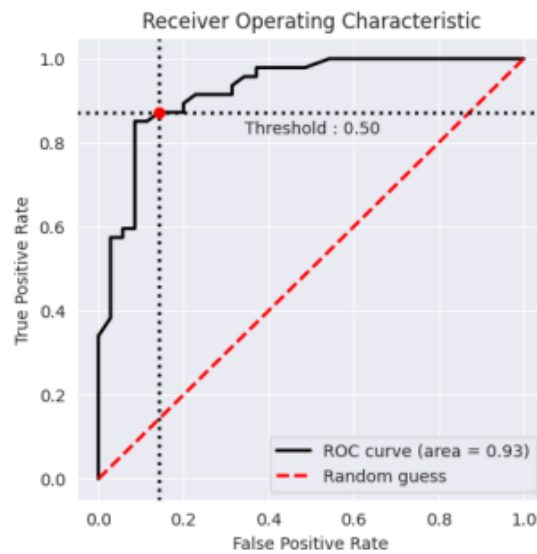


Figure 6: Random Forest's ROC

Table 5: The Decision Tree Model's Performance

	Precision	Recall	F1 - Score	Support
CDMS	0.76	0.83	0.79	35
Non-CDMS	0.86	0.81	0.84	47
Accuracy			0.82	82
Macro avg	0.81	0.82	0.81	82
Weighted avg	0.82	0.82	0.82	82

The Xgboost model's result in TABLE 7 shows how well it can predict if a patient has Clinically Definite MS (CDMS) or not. Figureure 18's AUC (Area Under the Curve) of 0.90 indicates excellent overall performance. With a precision of 0.75, the model accurately predicts CDMS 75% of the time when it makes a prediction. The precision for non-CDMS is 0.83, which is higher. The recall, which gauges how well the model can identify all real CDMS instances, is 0.81 for non-CDMS and 0.77 for CDMS. About 77% of genuine CDMS cases can be identified by the model, while 81% of non-CDMS cases may be identified by it. The model's accuracy, which measures how accurate each and every forecast is, is 79%.

A number of performance metrics provide an overview of the logistic regression model's result. The model's ability to discriminate between various situations is measured by the AUC, which is 0.90. With a precision of 0.84, the model accurately predicts CDMS 84% of the time when it makes a prediction. The accuracy for non-CDMS is 0.82. The recall, which measures how well the model can detect all real CDMS instances, is 0.89 for non-CDMS and 0.74 for CDMS. About 74% of genuine CDMS instances are captured by the model, and 89% of non-CDMS cases are captured by it. The model's accuracy, which measures how accurate each and every forecast is, is 83%. Based on these measures, it appears that the logistic regression model is doing a good job at forecasting cases that are either CDMS or not.

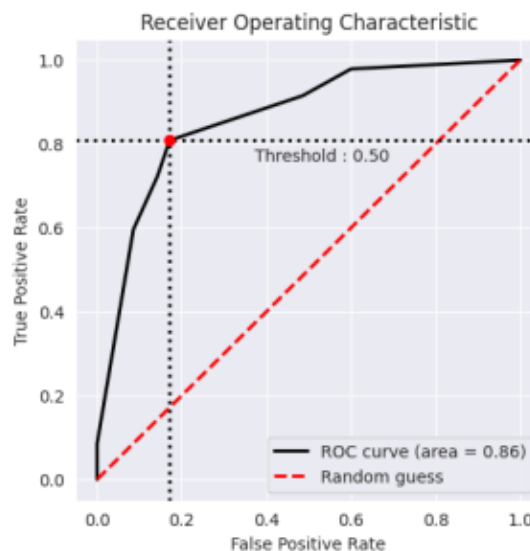


Figure: 7 Decision Tree ROC

5. CONCLUSION

Using open-source data, machine learning algorithms were used in this work to forecast the transition of clinically isolated syndrome (CIS) to clinically definitive MS (CDMS). The chosen algorithms, Random Forest, XGBoost, Decision Tree, and Logistic Regression, underwent extensive fine tuning and performance assessments.

With an AUC of 0.93, accuracy of 87%, and balanced precision and recall for both CDMS and non-CDMS cases, the Random Forest model outperformed the others overall. Excellent prediction abilities were also shown by the XGBoost, Decision Tree, and Logistic Regression models, with accuracies of 79% to 83% and AUCs ranging from 0.86 to 0.90.

The top 10 influential factors in predicting the course of CDMS were found to include variables including periventricular MRI, age, infratentorial MRI, initial symptom, schooling, mono- or polysymptomatic, oligoclonal bands, varicella, breastfeeding, and gender.

The results highlight how machine learning can improve the early prognosis of MS progression and offer important information for prompt therapeutic interventions. Particularly noteworthy as a strong method for predicting CDMS is the Random Forest model, which gives medical professionals a dependable way to identify patients who are at risk. This study adds to the field of predictive analytics in neurological illnesses by demonstrating how machine learning may be used to leverage a variety of clinical and demographic information. In order to further hone prediction models, future research may investigate the incorporation of more data sources and sophisticated feature engineering methodologies. The use of machine learning to forecast the course of MS shows promise for customized therapy, allowing for the development of interventions that are specifically catered to the needs of each patient.

Because the study is focused on a particular cohort of Mexican mestizo patients, more validation may be needed before it can be applied to other populations. Since the predictive models rely on historical data, further research is necessary to confirm their applicability in the real world.



To sum up, this study represents a major advancement in the use of machine learning to forecast the course of MS early on, giving physicians a useful tool to enhance patient care and advance the rapidly developing field of predictive healthcare analytics.

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FACTORIZATION OF k - POSINORMAL OPERATOR ON HILBERT SPACE

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ABSTRACT

A mathematical branch of functional analysis that analyzes linear operators on function spaces. The study of linear operators in topological vector spaces, such as Hilbert spaces, and their features is known as operator theory. In this paper, we look at the factorization of k -Posinormal operators on Hilbert space. We expand the Posinormal operator to the k -Posinormal operator, which acts on a Hilbert space, and present some of its theorems as well as the k -Posinormal operator's behavior during factorization.

Keywords: *Posinormal, k -Posinormal, coposinormal, heminormal.*

1. INTRODUCTION

Let H be a complex Hilbert space and $B(H)$ denote the algebra of all bounded linear operators on H . A vector space that has an inner product that generates a function representing distance for which the space is a complete metric space is known as a Hilbert space. A Banach space is a specific instance of a Hilbert space.

A study on Hilbert space operators are very significant in analysis and applications in quantum mechanics. In quantum mechanics the Hilbert space and their properties provide the correct mathematical tool to formalize the law of quantum mechanics and observables of a system are represented by a space of linear operators on a Hilbert space H .

Here, the linear operator as k -posinormal. We explore some theorems using k -Posinormal in factorization.

2. DEFINITION

An operator T in a Hilbert space H is said to be k - Posinormal if $T^k T^{*k} \leq c^2 T^{*k} T^k$ for some $c > 0$ and k is a natural number.

Using this definition, we proved some theorems in factorization.

2.1 SOME DEFINITIONS



Posinormal Operator:

An operator $A \in B(H)$ is called Posinormal, if $T T^* \leq c^2 T^* T$ for some $c > 0$ [1].



k -Posinormal Operator:

An operator $A \in B(H)$ is called k -Posinormal, if $T^k T^{*k} \leq c^2 T^{*k} T^k$ for Some $c > 0$, where k is a positive integer [2].

Hyponormal Operator:

An operator $A \in B(H)$ is called Hyponormal, if $A^*A \geq AA^*$. [4].

M – Parahyponormal Operator:

An operator T in a Hilbert space H is M – Parahyponormal, if $\|Tx\|^2 \leq M \|TT^*x\|$ for every unit vector x in H .

Heminormal Operator:

An operator $A \in B(H)$ is called Heminormal, if T is hyponormal and T^*T commutes with TT^* .

Class A:

An operator T belongs to **class A**, if and only if $(T^*|T|T)^{1/2} \geq T^*T$.

we can see from the definitions, as expected,

For $p = 1$,

(p, k) – Posinormal = k – Posinormal [3]

For $k = 1$,

k – Posinormal = 1 – Posinormal = Posinormal.

Also we can easily verify that,

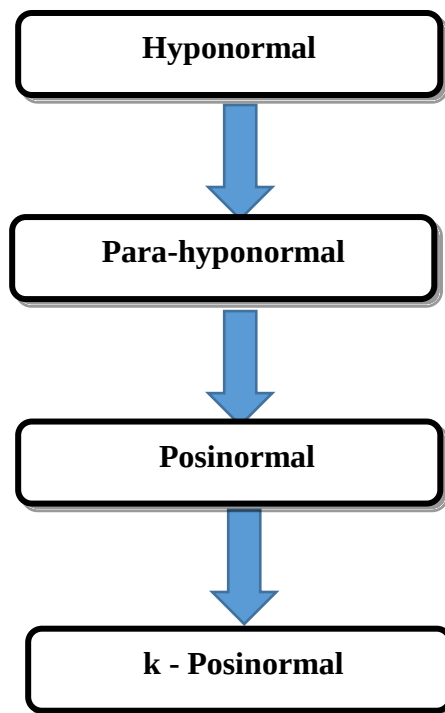


Figure 1



Figure 2

3. K - POSINORMAL OPERATORS ON HILBERT SPACE

3.1 THEOREM

Let A, B and S be operators, then the operator $T = A^{k/2}S$ is a k-posinormal operator if

1. $B \geq A \geq 0$
2. $kSk \leq 1$
3. $B = c^2 S^* A^k S$.

Proof

An operator T is k-posinormal, if $T^k T^{*k} \leq c^2 T^{*k} T^k$.

Suppose that there exist operators A, B and S which satisfies the above three conditions. Then,

$$\begin{aligned} & c^2 (A^{k/2}S)^* (A^{k/2}S) - (A^{k/2}S)(A^{k/2}S)^* \\ &= c^2 (S^* A^{k/2} A^{k/2} S) - (A^{k/2} S S^* A^{k/2}) \\ &= c^2 S^* A^k S - A^{k/2} S S^* A^{k/2} \\ &= B - A^{k/2} S S^* A^{k/2} \quad [\text{from (3) condition}] \\ &\geq A - A^{k/2} S S^* A^{k/2} \\ &= A^{k/2} (I - S S^*) A^{k/2} \\ &\geq 0 \end{aligned}$$

Therefore, $c^2 (A^{k/2}S)^* (A^{k/2}S) \geq (A^{k/2}S)(A^{k/2}S)^*$
 $\Rightarrow A^{k/2}S$ is k-posinormal.

3.2 THEOREM

If T is a k-posinormal operator, then there exist operators A, B and S which satisfy,

1. $B \geq A \geq 0$
2. $\|S\| \leq 1$
3. $B = c^2 S^* A^k S$

then T can be written in the form $T = A^{k/2}S$.

Proof

Since T is a k-posinormal operator,

$$T^k T^{*k} \leq c^2 T^{*k} T^k.$$

Let $T^* = U(TT^*)^{k/2}$ be a polar decomposition of T^* , $A = TT^*$ and $B = c^2 T^* T$. Then, since T is k-posinormal we have $B \geq A \geq 0$.

$$\begin{aligned} \text{Also, } B &= c^2 T^* T \\ &= c^2 U (TT^*)^{k/2} (TT^*)^{k/2} U^* \\ &= c^2 U (TT^*)^k U^* \\ &= c^2 U A^k U \end{aligned}$$

If we consider $B = U^*$, Then $kSk \leq 1$, $B = c^2 S^* A^k S$ and

$$T = (TT^*)^{k/2} U^* = A^{k/2} S.$$

3.3 THEOREM

An operator $T = A^{k/2} S$ which satisfies

1. $B \geq A \geq 0$
2. $kSk \leq 1$
3. $B = c^2 S^* A^k S$ is coposinormal, i.e., T^* is posinormal.

Proof

T^* is posinormal. if, $T^*T \leq c^2 TT^*$

$$\begin{aligned} c^2 TT^* - T^*T &= c^2 (A^{k/2} S)(A^{k/2} S)^* - (A^{k/2} S)^* (A^{k/2} S) \\ &= c^2 A^{k/2} S S^* A^{k/2} - S^* A^k S \\ &= c^2 A^{k/2} S S^* A^{k/2} - \frac{B}{c^2} \\ &= c^2 A^{k/2} S S^* A^{k/2} - A^k \quad [\text{from(3) condition}] \\ &= A^{k/2} [c^2 S S^* - I] A^{k/2} \\ &\geq 0 \end{aligned}$$

$\Rightarrow T^*$ is posinormal.

3.4 THEOREM

If A, B, S are normal operator then $T = A^{k/2} S$ which satisfies

1. $B \geq A \geq 0$
2. $kSk \leq 1$
3. $B = c^2 S^* A^k S$ is heminormal.

Proof

A normal operator T is heminormal if T is hyponormal and T^*T commutes with TT^* .
Teishiro Saito [7] have already proved T is hyponormal.

$$\begin{aligned} T^* T T T^* &= (A^{k/2} S)^* (A^{k/2} S)(A^{k/2} S)(A^{k/2} S)^* \\ &= S^* A^{k/2} A^{k/2} S A^{k/2} S S^* A^{k/2} \\ &= S^* A^k S A^{k/2} S S^* A^{k/2} \\ &= \frac{B}{c^2} A^{k/2} S S^* A^{k/2} \quad [\text{from(3) condition}] \\ T T^* T^* T &= (A^{k/2} S)(A^{k/2} S)^* (A^{k/2} S)^* (A^{k/2} S) \\ &= A^{k/2} S S^* A^{k/2} S^* A^k S \\ &= A^{k/2} S S^* A^{k/2} \frac{B}{c^2} \quad [\text{From(3) condition}] \\ \Rightarrow T^* T T T^* &= T T^* T^* T \end{aligned}$$

$\Rightarrow T$ is heminormal.

3.5 THEOREM

An operator $T = A^{k/2}S$ which satisfies

1. $B \geq A \geq 0$
2. $kSk \leq 1$
3. $B = c^2 S^* A^k S$ is of class A. [8], [9].

Proof

An operator T is of class A if, $(T^*|T|T)^{k/2} \geq T^*T$

$$\begin{aligned} & ((A^{k/2}S)^* A^{k/2}S A^{k/2}S)^{k/2} - (A^{k/2}S)^* (A^{k/2}S) \\ & \Leftrightarrow (S^* A^{k/2}(A^{k/2}S) S^* A^{k/2}A^{k/2} S)^{k/2} - S^* A^k S \\ & \Leftrightarrow (S^* A^k S S^* A S)^{k/2} - S^* A^k S \\ & \geq 0 \end{aligned}$$

$\Rightarrow T$ is of class A.

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NOVEL HSOMCO ALGORITHM FOR MALIGNANT BOSOM CANCER ANALYSIS

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ABSTRACT

The machine learning techniques has played an important role in computerized medical scenario. Mainly Breast carcinoma is currently majority universal cancer among worldwide. Since the causes for breast carcinoma remain unknown, primary prevention becomes impossible. In this research work, a Hybrid classification of Self Organizing Map with Ant Colony Optimization (HSOMCO) model for knowledge mining from Breast Cancer Wisconsin UCI dataset is proposed and evaluated. The classifier has been designed to be used by the clinician as assistance for clinical decision making. This system uses ACO algorithm to generate Self Organizing Map rules from the training patterns. In search space, the artificial ants make the candidate Self Organizing Map rules gradually. The stochastic behaviour of ACO algorithm encourages the ants to find more accurate rules. These optimized rules are used by the neural network inference engine to perform decision making on testing patterns. The proposed HSOMACO implemented in python3.6 IDE tool, using 10-fold cross validation over Breast carcinoma dataset, the proposed system achieves an average classification accuracy of 92.58% and a maximum accuracy improvement of 8.24 % over the conventional approaches for WBC in UCI dataset.

Keywords: WBC, Neural Network, Ant Colony Optimization, Breast Cancer Prediction

1. INTRODUCTION

Medical field faces recent challenges like new diseases, price, new therapeutics, fast decisions etc. Since clinical decision making demands utmost accuracy of diagnosis, it is a tedious and challenging task for physicians. An automated system which helps in disease diagnosis will benefit the medical industry. This has attracted researchers to design medical decision support systems with utmost accuracy.

Breast carcinoma is an unrestrained growth of breast cells. It is a collection of carcinoma cells in the cells of the breast. A carcinoma is belongs to benignor malignant (dangerous). Malignant considerable care is not taken, they increase beyond the original growth to other parts of the body. There is a rapid increase in the death rate of patients dying from breast cancer. It is the second most diagnosed cancer type. Early diagnosis can reduce the death count. Effective diagnostic methods and tools like medical expert systems and

improvements in treatment methodologies have saved considerable number of lives. The survival duration of women after proper diagnosis and treatment has increased (Polat & Gunes 2007). The treatment options and survival rate of breast cancer patients purely depend on the diagnostic results. Better treatment results could be expected, if best carcinoma is accurately detected at an earlier stage. Usually screening details are recommended for early detection.

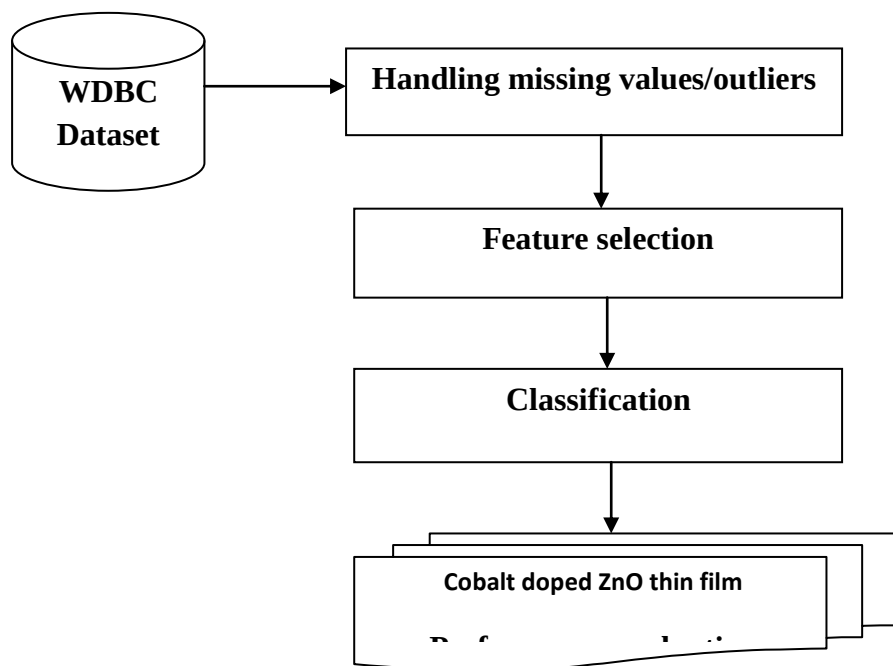


Figure 1:WDBC dataset classification system framework.

WBCO, dataset from University of California, Irvin (UCI) machine learning repository, standard dataset. Wisconsin Diagnostic Breast Cancer dataset considered (WDBC) 699 instances, 458 benign and other are 241 malignant with total 11 attributes for class. The 16 instances Groups 1-6 contain single missing attribute value (D. Dua and C. Graff. 2019). Classification in medical diagnosis had drawn more attention. They help users in considerate the category relates to other categories. estimation of information taken from patients and decisions of experts is the foundation of identification/treatment. Proposed approach WDBC cancer Datas are classified using new Hybrid machine learning approach Self Organizing Map with Ant Colony Optimization (HSOMACO). Figure 1 shows the proposed system general framework, each item classified in group of data into one of well defined set of groups such as Self Organizing Map classification techniques are used. The relationship between dependent and independent variables are done through prediction. In proposed system, data mining and statistical learning techniques were used to analyze breast cancer dataset to predict cancer survivability and compared the results of each model's prediction and classification performances. These results may assist physicians and medical scientists in making accurate decisions in breast cancer treatment.

2.METHODOLOGY

This research work focused on statistical learning method and data mining predictive modeling approach. In this research study, a comparative study of Hybrid classification of Self Organizing Map with Ant Colony Optimization classification algorithms was conducted for the explicit purpose of improving current computational techniques in prediction of breast cancer survivability and prognosis. The python3.6 data mining statistical programming language were used in testing the classification algorithms with a breast cancer dataset from National Cancer Institute (NCI) and University of California, Irvine Machine Learning Repository (D. Dua and C. Graff. 2019). The results generated from the python computational tools were analyzed and effective techniques were recommended. The analytical focus in this study was prognostic modeling in breast cancer. To generate the predictive models, processed the breast cancer dataset in pythonide, sent it to mining for analysis, and then visualized the results. When a model is generated, it needs to be validated and this, too, is performed in pythonide.

A set of Self Organizing Map rules are extracted from patient's dataset using SOM logic and ACO. ACO algorithm optimizes these extracted Self Organizing Map rules and generates optimized set of rules. The SOM inference system applied optimized rules to perform identification of the WBDC test dataset. 10-fold validation procedure used to evaluate the performance of the system in terms of the classification accuracy.

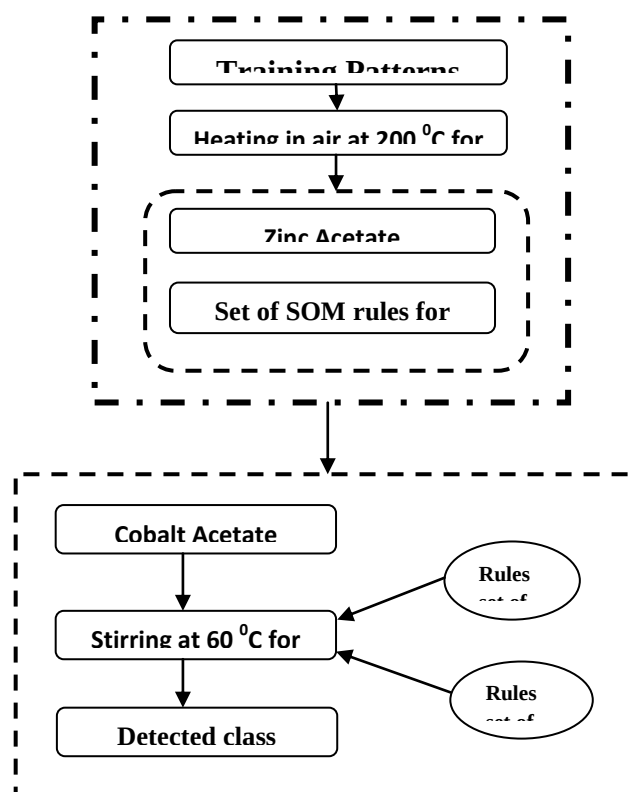


Fig.2 Stages of the Proposed System

Selection of the most eloquent features is done using Correlation depended feature optimization. It assigns higher scores to feature subsets that are highly correlated to the class labels but uncorrelated to each other.

The merit S of an attribute set is given by below

$$S = \frac{K \cdot rcf}{\sqrt{(k + k(k - 1)rff)}} \text{ --- (3.1)}$$

where,

- k - the number attributes set (S).
- rcf - models correlation of attributes to the class label.
- rff - the intercorrelation between attributes.

It selects a constant value of the 10 most significant features of perimeter, worst concave point, fractal dimensions, compactness, texture, smoothness, concavity, concave points, worst texture area the of the given Wisconsin Diagnostic Breast Cancer dataset. The proposed system uses ACO algorithm to generate Self Organizing Map classification rules from training patterns of the dataset. The artificial ants make candidate Self Organizing Map rules gradually in search space. The stochastic behaviour of ACO algorithm encourages the ants to find more accurate rules. These ACO optimized rules with Self Organizing Map inference engine to perform decision making on testing patterns as shown in Figure 2.

In the training stage, a set of SOM rules are generated using the training patterns. The SOM rules are of the form, Rule R_j : If x_1 is A_{j1} , x_n is A_{jn} , then Class C_j with $CF = CF_j$, where R_j is the label of j th SOM algorithm IF-THEN rule, $A_{j1} \dots A_{jn}$ the antecedent SOM sets in the unit interval $[0 \text{ to } 1]$, „ C_j “ is the consequent class and CF_j is the grade of certainty of the SOM IF-THEN rule. The rule learning process is done separately for each class. The list of discovered rules is initially empty and the training samples consist of all the training samples. The initial ant generates the rule „ R_j “ indiscriminately by adding together one period at a time. The ants modify the rule „ R_j “ according to the maximum change parameter. The SOM-ACO system generates and optimizes a set of SOM rules to classify the test data. To compute the certainty grade of each SOM IF-THEN rule, the following steps are followed. Figure 3 shows the Pseudo code for proposed, Hybrid Self Organizing Map with Ant Colony Optimization(HSOMACO).

Step1: The compatibility of each training pattern $x_p = (x_{p1}, x_{p2}, \dots, x_{pn})$ is determined with the SOM IF-THEN rule „ R_j “ using the following product operation.

$$\mu_j(X_p) = \mu_{j1}(X_{p1}) \times \dots \times \mu_{jn}(X_{pn}), p = 1, 2, 3, \dots, m \quad (3.2)$$

Where $\mu_{ji}(x_{pi})$ = Membership function of i^{th} attribute of p^{th} pattern.

Where „ m “ is the total number of patterns.

Step2: The proportion sum of similarity grades of the WBDC training pattern is computed with each Self Organizing Map IF-THEN rule „ R_j “.

$$\beta_{class}(R_j) = \sum_{x_p \in class} \frac{u_j(x_p)}{N_{class}}, h = 0, 1, 2, \dots, c \quad (3.3)$$

where,

- $\beta_{class}(R_j)$ is the sum of the compatibility grades of the training patterns in class

- R_j is the Fuzzy rule

- N_{class} is the number of training patterns

Step 3: The grade of certainty C_{Fj} is determined as follows

$$C_{Fj} = \frac{\beta_{classh}(R_j) - \bar{\beta}}{\sum_{h=1}^c \beta_{classh}(R_j)} \quad (3.4)$$

$$\bar{\beta} = \frac{\sum_{h \neq \hat{h}} \beta_{class}(R_j)}{c - 1} \quad (3.5)$$

The certainty grade for any combination of antecedent SOM sets specified. Combinations of antecedent SOM sets for generating a rule set with high classification ability are to be generated by the SOM classification system. Self Organizing Map rule set is given, an input pattern is classified by a single rule as given below.

Figure 3: Pseudo code for proposed Hybrid Self Organizing Map with Ant Colony Optimization(HSOMACO)

Real time optimization problems are challenging to solve, and many applications have to do with Non deterministic Polynomial (NP)-hard problems. To sort such problems, optimization tools have to be used, though that the optimal solution obtained, proposed system optimize the weight of the SOM structure, using Ant Colony Optimization (ACO) are proposed efficiently.

3. RESULT AND DISCUSSION

To analyze the performance of the proposed model, accuracy, precision and recall were used for evaluating classification results and mean squared error (MSE) and R2 score were used for evaluating regression results. The Hybrid Self Organizing Map with Ant

Colony Optimization Algorithm was chosen to solve this problem. Table 1 show the Confusion matrix which is typically used to evaluate performance of data mining algorithms.

Table 1: Confusion Matrix

Subjects	Predicted positive	Predicted Negative
Actual positive	True Positive (TP)	False Negatives (FN)
Actual negative	False positives (FB)	True Negatives (TN)

The proposed system performs better when compared to the existing methodologies for all the datasets.

Table 2: compression for proposed and conventional predicted classifier result

Algorithm	Accuracy /Efficiency	Precision	Sensitivity
Support Vector Machine	88.88	90	91
Neural network	87.87	90	87
SOM	90.30	91	91
HSOMACO	92.58	93	94

The figure 4 shows the accuracy, precision and sensitivity comparison for proposed system and existing system, from the result of accuracy proposed Hybrid Self Organizing Map with Ant Colony Optimization (HSOMACO) highest classification result 92.58% achieved, other conventional methods only Self Organizing Map 90.30% Neural network 87.87% and Support Vector Machine 88.88% accuracy values predicted. The proposed system HSOMACO accuracy is 2.28 % higher than the conventional highest accuracy value of Self Organizing Map (SOM).

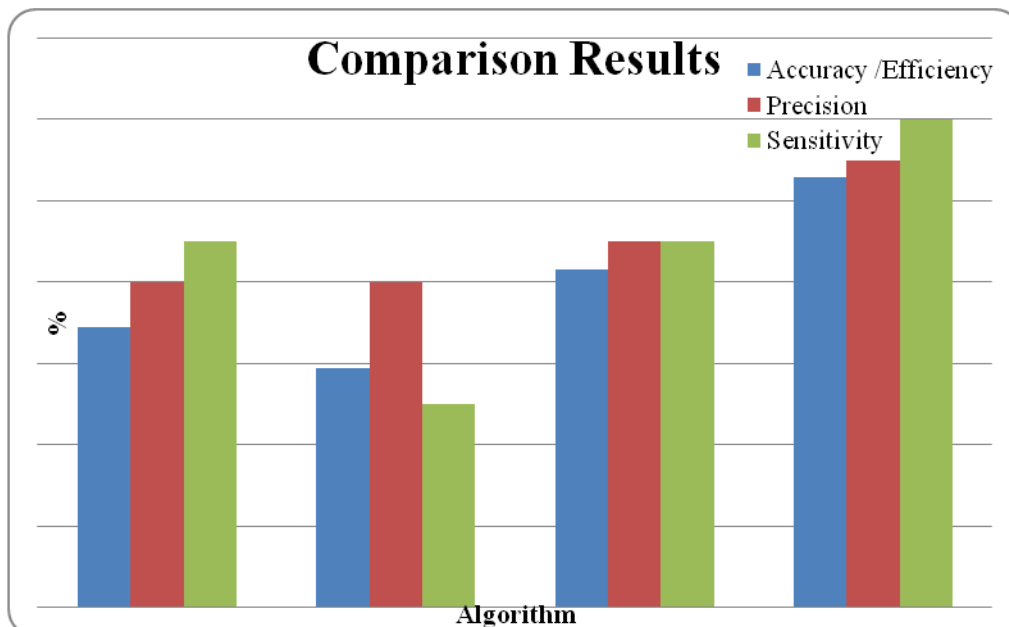


Figure 4: Comparison result for HCSOANN and conventional system

In terms of precision and sensitivity of proposed Hybrid Self Organizing Map with Ant Colony Optimization (HSOMACO) highest precision result 93% and 94% achieved, other conventional methods only Self Organizing Map 91% and 91% neural network 90% and 87% atlast Support Vector Machine 90% and 90% precision values predicted. The proposed HSOMACO algorithm precision 2% and sensitivity 3% higher than the conventional highest accuracy value of Self Organizing Map (SOM) algorithm.

4. CONCLUSION

Clinical decision making system for diseases diagnosis using Hybrid Self Organizing Map with Ant Colony Optimization (HSOMACO) method is proposed and validated using WDBC dataset. The ACO algorithm along with Self Organizing Map used for extracting rules and optimizes WDBC dataset. The Self Organizing Map is used to classify test data using the optimized set of rules. Their results have proved that this HSOMACO has a higher accuracy of classification by about 2.28% for the SOM, about 4.47% for the NN and by about 3.70 % for the SVM. The proposed system based on HSOMACO, produced highest accuracy over the breast cancer dataset. Since clinical decision making requires utmost accuracy of diagnosis, medical expert systems design with highest classification accuracy can help the physicians to carry out accurate diagnosis of diseases.

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STRUCTURAL AND MORPHOLOGICAL PROPERTIES OF UNDOPED AND CZO THIN FILMS PREPARED BY SOL-GEL DIP COATING PROCESS

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ABSTRACT

Undoped and doped Zinc Oxide (ZnO) thin films that that of varying quantities of Cobalt (Co) have been formed onto the glass substrates by using sol-gel dip coating technique. As a precursor, doping source, solvent, and stabilizer, respectively, Zinc Acetate Dihydrate, Cobalt Acetate Tetrahydrate, Ethanol and mono ethanol amine (MEA) were all utilized. The concentration of metal ions is 0.5 mol L^{-1} , and the molar ratio of MEA to metal ions was kept constant at 0.5 M. The Co/(CZO) ratio, which ranged from 0 to 8 at. %, was used to establish the Co dopant level. The thin films produced in this way were examined using X-ray diffraction (XRD), energy dispersive X-ray spectroscopy (EDX), scanning electron microscopy (SEM), ultraviolet-visible (UV-Vis) and photoluminescence (PL) to determine their structural, morphological, and optical properties. According to the XRD data, all films exhibited a preferential orientation along the c-axis and crystallized under a hexagonal wurtzite structure. According to the SEM findings, the undoped ZnO thin film has a smooth, uniform surface with tiny ZnO grains, whereas the doped ZnO films exhibit uneven stripes that resemble fibers and a wrinkly network structure and the average transmittance of all films is between 72 and 99% in the visible region. The films PL revealed UV and defect-related visible emissions like violet, blue, and green and demonstrated that cobalt doping caused UV emission to shift to the red and reduced the intensity of the UV and visible emissions. All these results confirm that the prepared thin films can used as transparent conducting oxides (TCOs) in solar cells.

Keywords: Chemical synthesis, Dilute magnetic semiconductor, Transmittance, Hexagonal wurtzite structure.

1. INTRODUCTION

Vast band gap II-VI semiconductors have equipped the interest of numerous research groups recently, Zinc oxide (ZnO), a transparent semiconductor with a wide band gap of 3.37

eV and a significant exciton binding energy of 60 meV, has been extensively studied due to its broad range of applications. Its potential use in optoelectronics, photocatalysts, light emitting diodes, ultraviolet (UV) photoconductive materials, and gas sensors. For some optoelectronic applications, ZnO may replace another wideband gap semiconductor, GaN, which is frequently used for green, blue—ultraviolet (UV), and white light-emitting devices. For the creation of spintronic-based and optoelectronic devices, transition elements with exceptional physical properties and large magnetic moments, such as Fe, Co, and Ni, are necessary. Transition metals display magnetic characteristics necessary for spintronic-based quantum computers because of their partially filled d states. There aren't many studies that have examined the optical characteristics of Fe, Co, and Ni-doped ZnO. Band changing property is crucial for the manufacturing of quantum well devices for specific applications. Doping with Fe, Co, and Ni can also alter the band gap of ZnO. Furthermore, unpaired electrons responsible for magnetic activity are present in the 3d partially occupied d states of Fe, Co, and Ni. The insertion of 3d transition metal ions such as Fe and Ni into ZnO matrix can shift the Fermi level that results in engineering the band gap. Due to their potential uses in spintronics, transition metal ions including Fe, Co, and Mn produce magnetic characteristics when doped into ZnO. Magnetic and optical characteristics of the ZnO system doped with transition metals. According to several studies, the concentration of intrinsic and extrinsic defects is connected to changes in the structural, electrical, and optical properties. Co is a crucial component for inclusion into the ZnO matrix because of its high solubility and ability to alter the structure, microstructure, magnetic, and optical properties of the ZnO system. Several experiments have detected impurity phases at lower concentrations of Co. Co-doped ZnO thin films manufactured using a variety of processes, including electrochemical deposition, spray pyrolysis, radio frequency magnetron sputtering, and sol-gel processing. Sol-gel is one of these methods that is gaining popularity for producing thin films due to many benefits, including its ease of use, low cost, broad substrate coating area, and simplicity in doping insertion [1-5].

This research examines how Co doping influences the structural, morphological, and optical properties of ZnO and CZO thin films, which have been deposited on glass substrates using the sol-gel spin coating technique. Many alternative deposition processes have been successfully used to create a variety of ZnO thin film nanostructures, including nanoparticles, nanorings, micro-rings, and micro-rods. Radio frequency magnetron sputtering, electron beam evaporation, spin coating, dip coating, and spray pyrolysis are among the most extensively studied deposition methods. Out of these, dip coating is of special interest because it is affordable, straightforward, doesn't require a high vacuum, safe, produces little waste, and can cover huge regions. It has many conveniences such as high mechanical, chemical and thermal stability, biological inertness, high transparency, photo stability, administrable porosity and discharge of embedded agents. Due to its inherent size and shape dependent applications, deliberate control of ZnO nano/micro-structure size and shape is becoming an important subject. Therefore, the creation of optoelectronic devices would benefit from the preparation and characterisation of such a material. As potential replacements for ITO films in optoelectronic applications, we describe the production and characterisation of ZnO thin films [6].

2. Experiment specifications

ZnO thin films, both undoped and co-doped, have been deposited onto glass substrates using the sol-gel spin coating method. Figure 1 depicts the process flow for

creating ZnO thin films. Cobalt acetate tetrahydrate $[\text{Co}(\text{CH}_3\text{COO})_2\cdot 4\text{H}_2\text{O}]$ and zinc acetate dihydrate $[\text{Zn}(\text{CH}_3\text{COO})_2\cdot 2\text{H}_2\text{O}]$ were utilised as the starting material and dopant sources. The solvent and stabiliser used were ethanol and mono ethanol amine (MEA). The concentration of metal ions is 0.5 mol L^{-1} , and the molar ratio of MEA to metal ions was kept constant at 1.0. The Co/(CZO) ratio, which ranged from 0 to 2% mol, defined the Co dopant level. After being agitated for two hours at 65 degrees Celsius to produce clear, homogeneous solutions, the solutions were aged for 24 hours at room temperature. Using an ultrasonic cleaner, the glass substrates were cleaned in acetone for 40 minutes each, followed by a rinse in deionized water and drying. Using dip coating method, the solution was deposited onto a glass substrate. The film was warmed at 200°C for 10 min in a hot air oven to evaporate the solvent and eliminate organic residues after the dip coating deposition. After multiple iterations of the dip coating and pre-heating processes, the films were annealed at 450°C for 4 hours in an atmosphere of air.

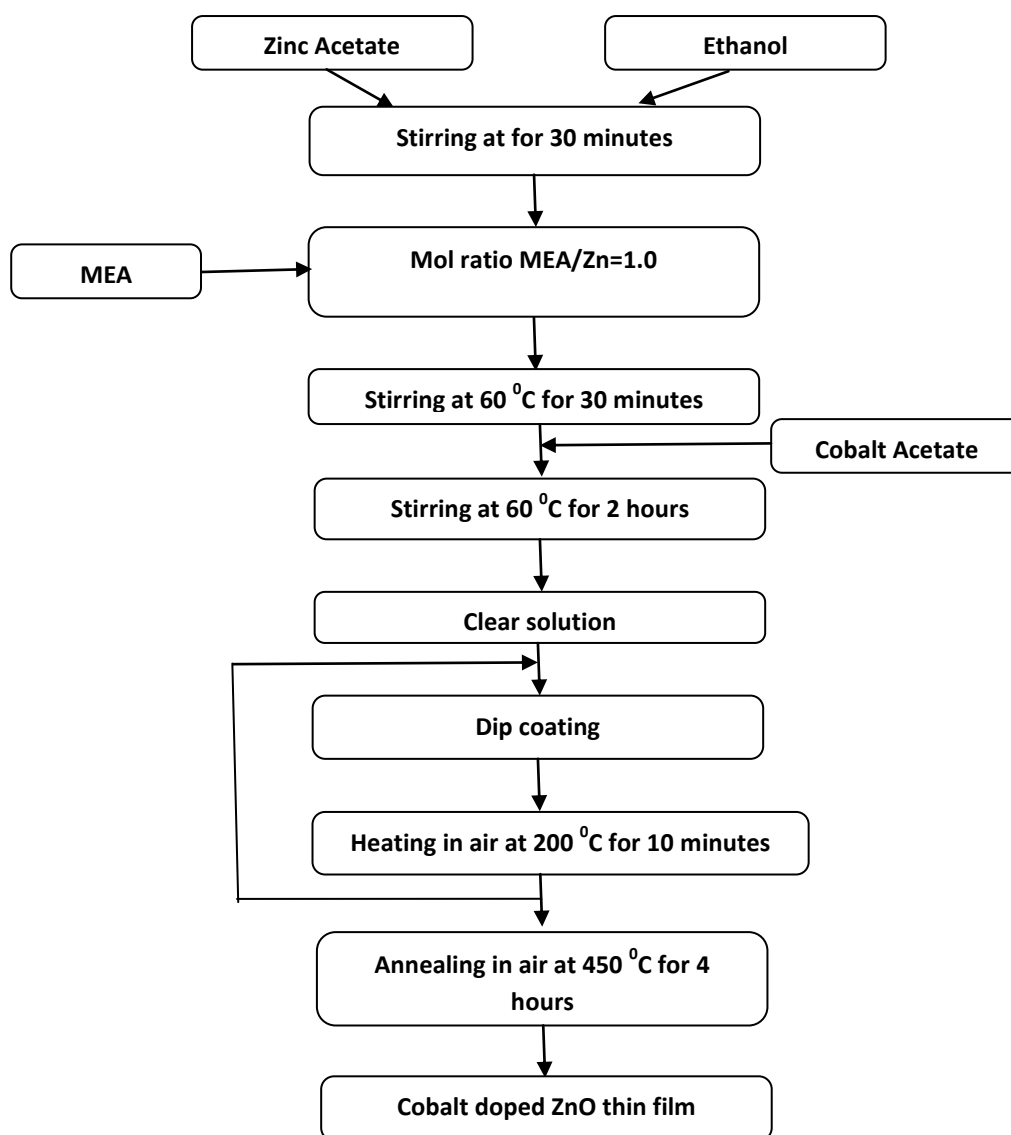


Figure 1. Flowchart for the development of Co-doped Zinc Oxide thin films preparation.

2.1 Thin films characterizations

X-ray diffraction (XRD) was employed to determine the crystal structure of the thin films using a Bruker D8 Advance diffractometer. The chemical composition and surface morphology of the films were analyzed with an energy dispersive X-ray spectrometer (EDX) attached to a JEOL JSM-5800 LV scanning electron microscope (SEM). Optical transmission spectra were measured in the 200–800 nm wavelength range using a UV-Vis spectrophotometer (UV-3101 PC-Shimadzu). Photoluminescence (PL) was assessed at room temperature with an excitation wavelength of 250 nm using a Perkin Elmer LS 50B spectrofluorometer. Raman spectroscopy was performed using a 514 nm laser for spectral analysis of the films.

3. Results and discussions

3.1 Structural studies

Figure 2 displays the XRD patterns of both Co-doped and undoped ZnO thin films. The results reveal that all samples possess a wurtzite structure with a polycrystalline hexagonal phase (JCPDS36-1451). The texture coefficient (TC) was used to determine the preferred orientation of the films. A TC (hkl) value of 1 indicates randomly oriented crystallites, while values above 1 suggest a higher abundance of crystallites in a specific (hkl) direction. The calculated texture coefficients show that all films exhibit their highest TC values (TC = 1.5) in the (002) plane, demonstrating preferential growth along the c-axis, as illustrated in Figure 2.

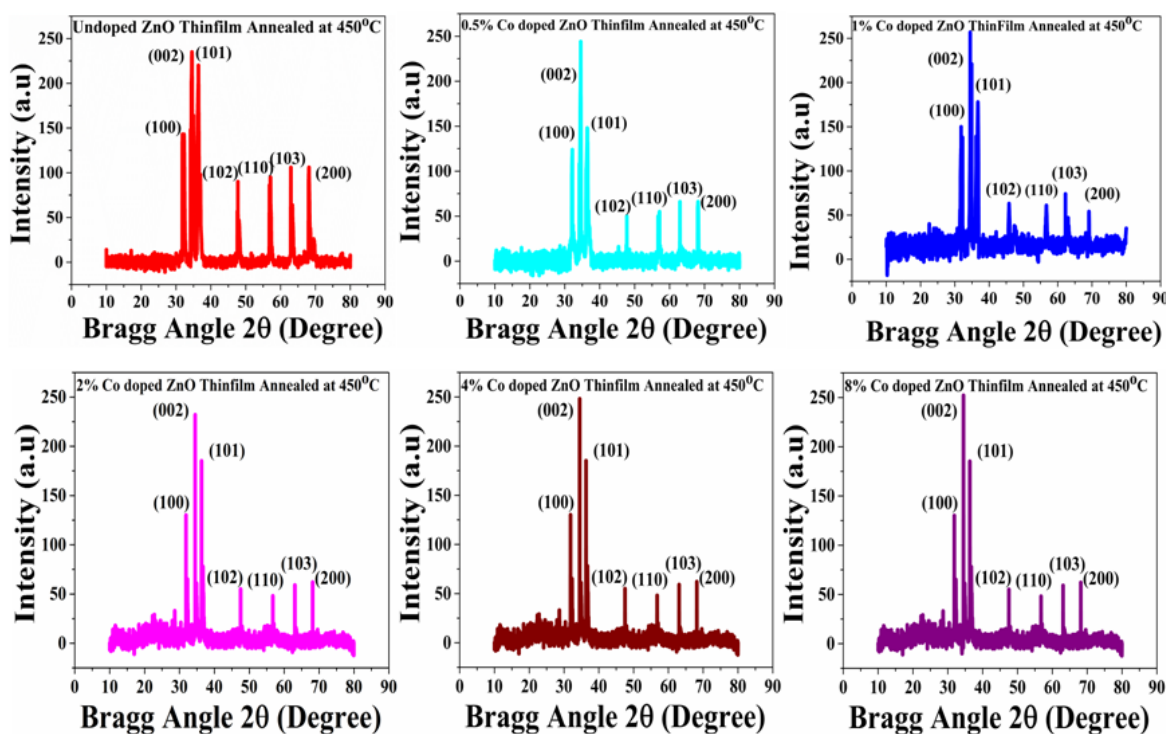


Figure 2: XRD pattern of immaculate and various at .% Co doped ZnO thin films.

Co-doping did not affect the hexagonal wurtzite structure of the ZnO films, and no secondary phases or Co element impurities were detected, suggesting that the doped Co ions were successfully incorporated into the ZnO lattice. The crystallite size of the films was estimated using Scherrer's formula [7].

$$d = \frac{k\lambda}{\beta \cos \theta} \quad (1)$$

were,

d- Average crystalline size

λ - Wave length

k- Constant=0.9

β - Angular width of diffraction peak at FWHM on the 2θ scale

θ - Bragg's angle

The (002) peaks were used to estimate the crystallite size. The calculated average crystallite sizes of ZnO thin films are given in the TABLE 1.

Table I: Average crystalline size of ZnO and Co doped ZnO thin films.

Sl No.	Doping Concentration(at%)	θ (Degree)	$\cos \theta$ (Degree)	FWHM (β) (Rad)	Average Crystalline size (nm)
1	0	17.2612	0.954961	0.0055	27.561
2	0.5	17.4737	0.953854	0.00612	24.797
3	1	17.2357	0.9550939	0.00693	21.871
4	2	17.2102	0.9552257	0.00480	31.571
5	4	17.1998	0.9552794	0.00705	21.494
6	8	17.5522	0.9534425	0.00738	20.573

3.2 Surface Morphology

Figure 3. clearly depicts the typical EDAX spectrum of undoped and Co doped nanostructured ZnO thin film. It exhibits the peaks associated with Zinc (Zn) and Oxygen (O) molecules. Figure 3 clearly shows the compositional investigation of ZnOCo₅ samples, which shows the existence of Zn, O then Co elements alone, which designates that the nanostructured thin film contains Zinc, Oxygen and Cobalt ions.

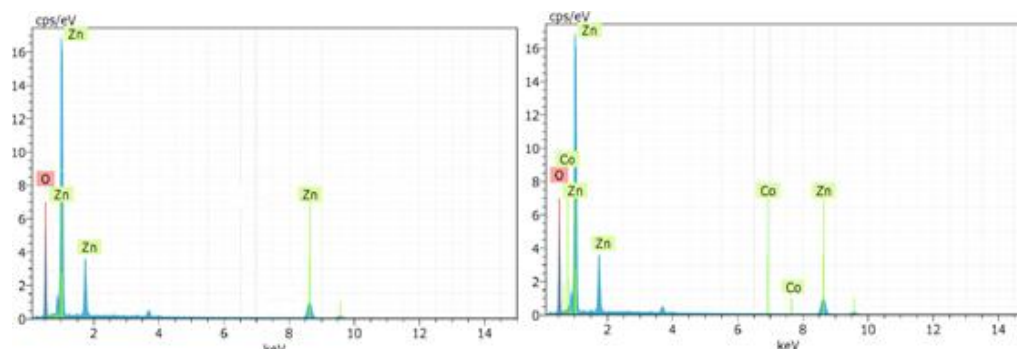


Figure 3: (a) EDAX image of undoped ZnO thin film, (b) EDAX image of Co undoped ZnO thin film

To confirm the presence of Co and assess the cleanliness of the films, an EDX measurement was performed. Figure 3 displays the EDX spectrum for both undoped and 8% Co-doped ZnO films, confirming the presence of cobalt in the ZnO matrix. The EDX results indicate successful doping of Co into the films.

The SEM images in Figure 4 reveal that the undoped ZnO thin film has a smooth, uniform surface with small ZnO grains. In contrast, the Co-doped ZnO films exhibit irregular, fiber-like stripes and a wrinkled network structure, with this morphology being more pronounced and denser in the 4% and 8% Co-doped ZnO films. Generally, sol-gel ZnO thin films display a network-like structure with wrinkles and fiber-like stripes on their surface. The incorporation of Co ions into the ZnO thin films altered the surface morphology from a granular texture to a wrinkled network, likely due to the introduction of impurities and subsequent structural imperfections in the ZnO crystal. This study suggests that the Co dopant influences nucleation growth in various directions, affecting the overall surface morphology of the Co-doped ZnO film.

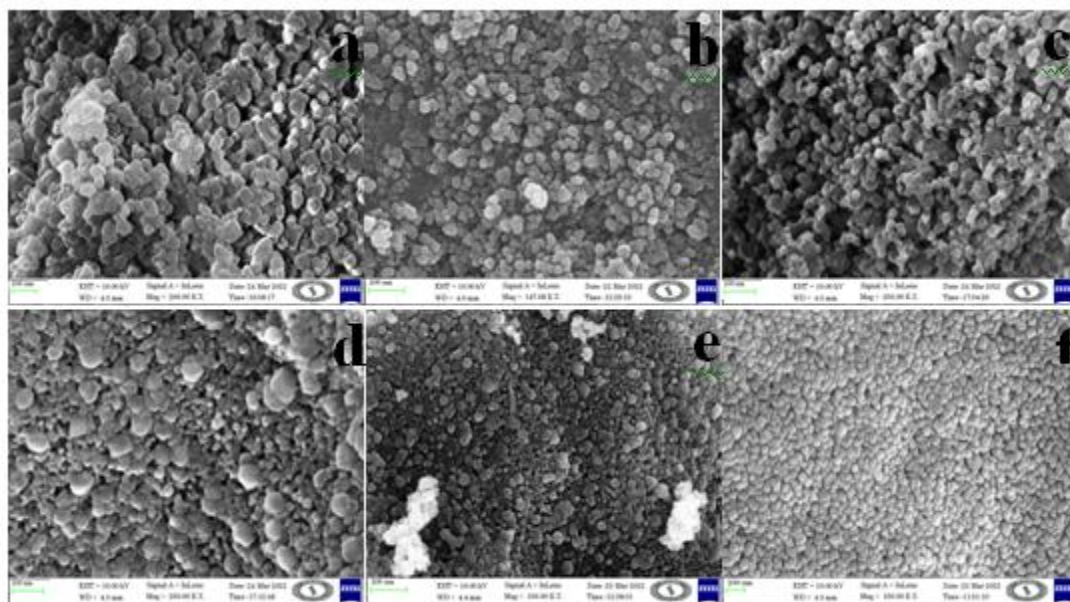


Figure 4: SEM images of (a) undoped ZnO thin film, (b) 0.5 at.% CZO thin film, (c) 1 at.% CZO thin film, (d) 2 at.% CZO thin film, (e) 4 at.% CZO thin film and (f) 8 at.% CZO thin film.

High doping concentrations and annealing temperatures can lead to grain agglomeration, resulting in larger grains. However, as the concentration of Co ions increases, the extent of agglomeration tends to decrease. The agglomeration is attributed to magnetic interactions between the particles. At the nanoscale, particles have a high surface-to-volume ratio, which increases interfacial surface tension and contributes to agglomeration. Additionally, the accumulation of Co^{2+} ions at grain boundaries applies tensile stress and pressure on the grains, which reduces their size. The results confirm successful Co doping in the films, which clearly exhibit a hexagonal shape. In contrast, undoped films show a spongy microstructure. Furthermore, as the annealing temperature rises, the intermolecular spacing decreases, leading to an increase in conductivity [8].

4. CONCLUSION

Bulk samples of CZO thin films with uniform thickness were produced using Sol-Gel dip coating techniques, with varying Co concentrations and annealed at different temperatures. The study explored the effects of cobalt on the structural, optical, and electrical properties of CZO thin films. Analysis of the diffraction patterns confirmed that the nanoparticles maintain a hexagonal wurtzite structure and that Co is well-integrated into the ZnO crystal lattice. The lattice strain increases with higher doping concentrations and annealing temperatures, aligning with the crystalline size measurements obtained from XRD peaks, which range from 28 to 22 nm. Optical properties were assessed through absorption spectra, revealing that the band gap decreases with increasing annealing temperature and doping concentration. The film with 1 at% Co-doped ZnO annealed at 450°C exhibits the smallest bandgap energy. The conduction mechanism of the film varies with temperature. The produced films demonstrate low resistivity, high conductivity, a strong optical bandgap, and good transparency in the visible range, making them well-suited as transparent conductive oxides (TCOs) for solar cells.

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AUTHOR PROFILE

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Dr. K. Thangavel working as Professor & Head in the Department of Electronics, Hindusthan College of Arts & Science, Coimbatore. He completed his Ph.D in the year 2017. He has about 21 years of teaching and research experience. He published 28 papers in the peer reviewed and scopus indexed journals. Published 2 books and presented more than 45 papers in the national and international conferences and seminars. He filed 3 patents and his area of expertise is Nanoscience and nano materials, Thin film technology.

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THE FLORICULTURE INDUSTRY IN INDIA: A STUDY ON GROWTH AND EXPORT

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ABSTRACT

Floriculture refers to the cultivation of flowers for farming purposes, which is a segment of horticulture focused on growing flowering and decorative plants for use in gardens, floristry, and all related aspects of the floral sector. The Floriculture industry in India is thriving due to its strong demand both domestically and internationally. Looking ahead, the Flower Export industry in India is poised for significant expansion and will likely see its growth on a global scale.

The Indian government has recognized floriculture as a promising sector, granting it full export-focused status. This is due to the consistent rise in demand for flowers, making floriculture a significant commercial sector within agriculture. As a result, commercial floriculture has evolved into a high-tech operation conducted in controlled environments, such as greenhouses. Floriculture in India is seen as a rapidly expanding industry. From an export perspective, commercial floriculture is gaining importance. The easing of industrial and trade regulations has facilitated the growth of export-focused cut flower production. The introduction of a new seed policy has also made it possible to import seeds of international varieties for planting. Research shows that commercial floriculture offers greater potential per unit area than many traditional crops, making it a profitable venture. The Indian floriculture sector is moving away from traditional flower production to focus on cut flowers for export. The liberalized economy has encouraged Indian entrepreneurs to set up export-focused floriculture operations in controlled climates.

The Agricultural and Processed Food Products Export Development Authority (APEDA) oversees the promotion and growth of floriculture exports in India.

Keywords: *Floriculture, Exports, Growth, Country-wise export.*

1. INTRODUCTION

OVERVIEW OF THE FLOWER INDUSTRY

The flower industry, also known as floriculture, is a vibrant and expanding sector within the agricultural sector. It covers the growth, processing, and trading of flowers and decorative plants for a variety of uses, including decorative, ceremonial, and industrial applications. This industry encompasses a broad spectrum of operations, ranging from small-scale gardening to large-scale commercial production, as well as wholesale and retail sales. At its core, the flower industry focuses on the growth of a wide array of flowers and decorative plants. This includes common flowers such as roses, lilies, and marigolds, as well



as rare and exotic species like orchids, gerberas, and tulips. The growth of these plants can occur in open fields, greenhouses, or controlled settings, depending on the climate and the specific flowers being cultivated. After being harvested, flowers typically undergo several processes to improve their quality, durability, and appeal to the market. These processes may include sorting, grading, packaging, and sometimes, treatments to maintain their freshness. Additionally, some flowers are transformed into premium products such as essential oils, perfumes, or dried floral displays. Flowers are distributed through a well-organized supply chain that includes wholesalers, distributors, and export companies. Wholesalers buy flowers in large quantities from growers and then sell them to retailers, florists, and other businesses. Effective logistics and cold chain management are essential to ensure that flowers arrive at their destination in a fresh state.

The flower business also includes the retail sector, which consists of flower shops, online platforms, supermarkets, and garden centers. Retailers are crucial in making flowers available to consumers for various events such as weddings, funerals, festivals, and everyday home decor. The worldwide demand for flowers has created a significant export market, with nations like the Netherlands, Colombia, Kenya, and India leading in this area. The export process involves meeting international quality standards, managing logistics, and dealing with trade regulations.

Types of Flowers Export from India

These mainly include cut flowers, potted plants, cut foliage, seeds, bulbs, tubers, rooted cuttings, and dried flowers or leaves. The key floricultural crops in the international cut flower market include Rose, Carnation, Chrysanthemum, Gerbera, Gladiolus, Gypsophila, Liatris, Nerine, Orchids, Archilea, Anthurium, Tulip, and Lilies. Floriculture crops such as Gerberas, Carnation, etc. are grown in greenhouses. The open field crops include Chrysanthemum, Roses, Gaillardia, Lily Marygold, Aster, Tuberose, etc.

Areas of Cultivation of Flowers in India

Grown Areas: Major floriculture centers have emerged in Tamil Nadu, Karnataka, Madhya Pradesh, West Bengal, Chhatisgarh, Andhra Pradesh, Gujarat, Uttar Pradesh, Assam, and Maharashtra.

According to the second advance estimate, 297 thousand hectares of land were planted for floriculture in 2023–2024. According to the second advance estimate, flower production in 2023–2024 will be 2284 thousand tonnes of loose flowers and 947 thousand tonnes of cut flowers.

Objective of the study

The main objective of this study is to conduct an analysis on the export of flowers, top destinations and growth percentage of export of floriculture from India.

Research Methodology

To achieve the aforementioned objective, data from various sources was collected and analyzed. The period under study was 2016-17 to 2023-24 and 2024-2025. The data was gathered from reputable sources such as APEDA's annual literature and website, WTO's website, National Horticultural Board's website, and FAO year books. We believe that these sources provide accurate and reliable information for our research.

Statement of the Problem

The flower trade in India is very sensitive to advertise demand vacillations, which are frequently compelled by migratory events, celebrations, and educational practices. This volatility standard leads to meaningful price vacillations, impacting the proceeds cohesion of farmers and merchants. The lack of a agreeing fixing mechanism infuriates the economic vulnerability of those complicated in the flower trade. Despite the chance of modern land electronics, many flower farmers in Tamil Nadu still depend usual education methods. This limits their strength to gain larger yields, improve flower status, and defeat production costs. The break in approach to progressive techniques to a degree hothouse cultivation, drop watering, and fabric culture confines the potential for tumor in the floriculture subdivision. The deficiency of able post-harvest infrastructure, containing chilled storage for preservation facilities, adept conveyance, and decent packaging, leads to important post-harvest deficits. Flowers are highly rot, and the lack of correct management and storage abilities results in weakened shelf life and lower transport status, with affecting the worth of misrepresentation.

2. FLORICULTURAL EXPORT FROM INDIA

The Floriculture business in India is flourishing in success due to its high demand in the country itself and at the international level as well. Shortly the Flower Export business in India will reach great heights and increase its growth worldwide.

The below table describes the country wise floricultural export status of India, which indicates that the quantity share of export for the years from 2016-17 to 2023-2024.

Table 1:Country Wise Export of Floriculture

	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	2022-23	2023-24
Country Name	Qty in M.T	Qty in M.T	Qty in M.T	Qty in M.T	Qty in M.T	Qty in M.T	Qty in M.T	Qty in M.T
U S A	3993.01	3489.01	4043.19	3276.08	3139.19	3520.05	2631.86	2213.01
Netherland	1811.07	1855	1518.92	1377.08	1603.87	2206.51	1553.16	1390.21
UAE	1504.97	1220.97	1829.75	1499.07	1660.02	3074.79	3973.88	3558.15
U K	2471.47	2116.98	1529.46	1236.74	860.91	917.7	635.36	797.11
Canada	748.53	1133.35	875.77	393.05	485.65	768.59	696.63	633.79
Malaysia	509.9	793.46	862	845.06	516.38	882.13	1225.18	1293.69
Germany	2443.7	1347.89	1251.81	1112.52	1054.69	1208.63	710.17	605.84
Italy	555.1	522.49	403.24	358.8	235.31	261.19	207.75	174.5
Singapore	1213.27	1956.81	1998.27	2037.67	1419.23	1932.3	2009.12	2173.2
Australia	278.42	198.73	250.53	129.17	57.7	75.42	103.38	131.43
Japan	464.3	284.04	310.17	205.46	114.16	70.07	182.38	140.7
Saudi Arab	529.54	378.94	258.07	253.54	112.5	164.15	181.41	343.38
Spain	186.31	250.41	304.39	186.79	190.64	135.63	89.57	109.02
China P Rp	495.45	266.78	117.61	61.52	43	124.85	333.11	319.11
France	230.03	265.77	186.59	296.92	262.64	302.58	246.82	216.49

Kenya	0.76	0.81	2	1.67	2.82	10.33	5.01	6.22
Nepal	69.82	119.55	205.8	296.93	1009.55	1868.35	1802.32	1419.45
Kuwait	133.1	146.36	255.3	132.02	166.28	283.94	331.49	279.7
Poland	328.56	342.18	335.18	259.95	232.45	252.73	223.41	159.72
New Zealand	152.33	265.9	197.29	136.09	33.26	48.26	52.2	61.9
Colombia	18.15	13.44	4.98	11.93	16.91	13.72	12.98	28.73
Oman	301.09	292.04	91.46	79.46	203.74	1175.84	794.05	581.06
Qatar	135.69	103.74	150.35	292.04	427.46	390.37	219.7	257.88
Bangladesh	78.58	59.62	142.63	134.52	99.3	1622.04	1036.17	1241.88
Greece	227.26	207.27	94.53	137.69	70.95	52.66	57.07	67.71
Total Export	18880.4	17631.5	17219.3	14751.8	14018.6	21362.8	19314.2	18203.9
Average Export	755.216	705.262	688.772	590.071	560.744	854.513	772.567	728.155
Max Export	3993.01	3489.01	4043.19	3276.08	3139.19	3520.05	3973.88	3558.15
Min Export	0.76	0.81	2	1.67	2.82	10.33	5.01	6.22
S.D	981.88	861.666	921.96	781.528	742.32	997.967	970.542	876.929
C.V	76.92%	81.85%	74.71%	75.50%	75.54%	85.63%	79.60%	83.03%

Source: APEDA

The above table 1 exhibits that, country wise floricultural export, which represents, India was export more quantity of floriculture to USA for the all the years, total export was more in the year of 2021-2022, the maximum export was in the year of 2016-2017, The standard deviation was more in the year of 2021-2022, the lower coefficient variation in the year of 2018-2019 and higher coefficient variation was in the year of 2021-2022.

Table 2: Top Destinations Floriculture from India

Top Destinations	Qtyin M.T	Amount in US\$	Rank
U Arab Emts	1176.01	1330970	1
U S A	731.27	5672802	2
Bhutan	678.37	750819	3
Singapore	495.75	421665	4
Netherland	270.51	4104330	5
Malaysia	262.43	604929	6
Germany	226.72	1315356	7
Canada	209.72	1106276	8
U K	125.79	637733	9
Japan	20.41	499355	10
Top 10 Total	4196.98	16444235	

Other Countries	1215.11	5482320	
Total	5412.09	21926555	
% Share of Top 10 Countries	77.55	75	

Source: DGCIS

The above table 2 shows that, UAE is largest importer of Indian flowers and floricultures, followed by USA is second largest importer from India, the countries like Bhutan, Singapore, Netherland, Malaysia, Germany ranked as third, fourth, fifth and sixth rank respectively, Canada, UK and Japan ranked least three positions like eight, nine and tenth places, in the year of 2024-2025 from April – June.

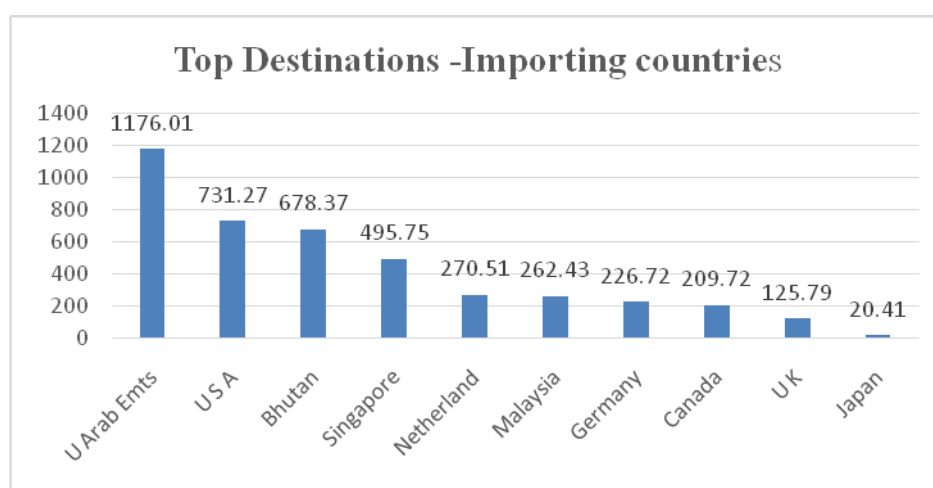
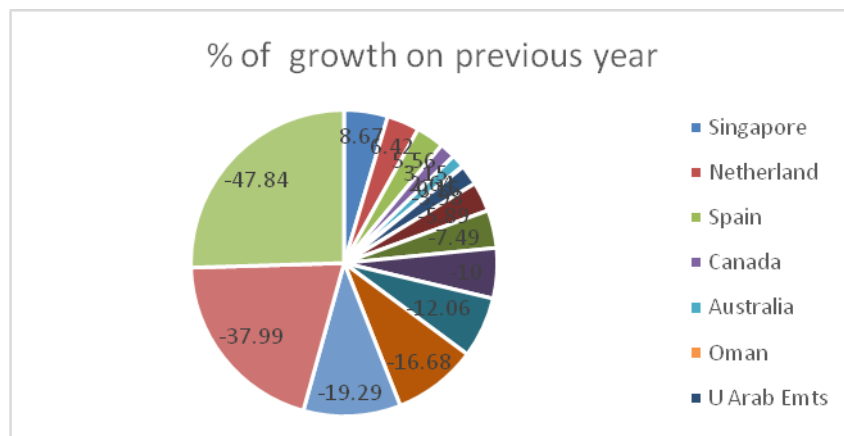


Table 3: Growth Percentage of Floriculture 2022-23 To 2023-2024

Country	2022-2023 Qty .M.T	2023-2024 Qty M.T	%age growth on previous year
Singapore	2,009.12	2,173.20	8.67
Netherland	1,552.80	1,389.67	6.42
Spain	89.57	109.02	5.56
Canada	696.5	633.79	3.15
Australia	103.36	131.31	2.64
Oman	791.94	581.06	-0.16
U Arab Emis	3,973.82	3,558.15	-3.98
Malaysia	1,223.63	1,293.69	-5.89
Kuwait	331.48	260.87	-7.49
China P Rp	333.11	319.11	-10
Japan	182.27	140.09	-12.06
U S A	2,631.82	2,212.72	-16.68
Germany	710.17	605.84	-19.29
Poland	223.41	159.72	-37.99
France	246.82	216.49	-47.84

The above table represents that, comparison report of floriculture exports to various countries, among these countries France has the least difference between two years of 2023-

2024 to 2022-2023 is -47.84% and Singapore has the highest difference percentage of 8.67% with comparison of 2023-2024 to 2022-2023.



3. CONCLUSION

India is gave accompanying several agro-important zones useful for result of impressionable and delicate gardening produce. The gardening industry in India is swiftly changeful, and it is immediately achieving new technologies, accomplishing advantageous position for those selling inclinations and beliefs and driving overall manufacturing progress at beer level. The industry is too engaging tenable practices to validate that while it accommodates the needs of the buyers, it does stop so carelessly without admitting for the overall affect the atmosphere. The recruitment opportunities and India's total ship of gardening were growing. The major mean nations were U S A, the Netherlands, U Arab Emts, U K, and Germany. There are different 300 transport-oriented articles in India. More than 50% of the horticulture amount are produced in Karnataka, Andhra Pradesh Tamil Nadu, and Madhya Pradesh. With the technical partnerships from unfamiliar associations, the Indian horticulture industry is calm to raise allure agree globe trade.

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SOLVING THE HUMAN-ELEPHANT CONFLICT (HEC) PROBLEM BY CRITICAL PATH METHOD

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ABSTRACT

The conflict between humans and animals is most noticeable in the Western Ghats, an area with this study the highest concentration of wildlife and notable national parks and wildlife sanctuaries. In addition to being confined to ever-tinier spaces, farmers are planting foods that elephants enjoy eating. Elephants consequently regularly invade and destroy farms. They are also capable of great danger. Every year, about 500 people are murdered in interactions with elephants, and over 100 elephants die because of human-caused incidents like poisoning, train collisions, and ivory poaching. To avoid this HEC problem, Critical Path Method (CPM). The Critical Path Method is a mathematical approach for scheduling project operations and determining the longest path. The current research implemented the installation of sensors along the designated route by employing the CPM methodology to observe the elephant corridor. This research aimed to address the distant sensor alarms within the critical parts of the elephant corridor. The alarm alerts people to steer clear of paths frequented by elephants, thereby preventing conflicts between humans and elephants and minimizing losses on both sides.

Keywords: *Critical Path Method, Human elephant conflict problem, Project Scheduling, sensor alarm.*

1. INTRODUCTION

The theme of the current innovation focuses on the deaths of humans caused by elephants. Particularly, it applies the critical path method and advanced machine learning technology to prevent loss and fragmentation. Elephants frequently follow certain paths, which may be identified using the CPM method. ML techniques are then planned to be deployed along these crucial nodes to correct the sensor. The sensor will sound an alert and alert the people when the elephant crosses the path. The reduction in loss will also occur during the darker hours.

The habitat's fragmentation and shrinkage because of several developmental operations have led to an increase in conflicts between humans and elephants. Although conflicts between wildlife are not new, the governments of the three major Western Ghat states—Karnataka, Kerala, and Tamil Nadu—need to find creative ways to lessen them.

Animals transcend political boundaries, yet the three states that share borders are facing challenges with management and coordination due to the animals' movements,

particularly those that are radio-collared. The struggle between humans and animals is most evident in the Western Ghats, an area with the highest concentration of wildlife and notable national parks and wildlife sanctuaries.

Elephants are fiercely devoted to their herd and their young. They may turn defensive and hostile toward human threats if they believe that their calves or other group members are in danger. This may occur if someone approach their calves too closely, startle them, or intrude into their domain.

According to statistics from the Forest Department, human-animal conflicts in the Coimbatore Forest Division have affected over 85 villages and small towns, especially in the Coimbatore district. Between 2011 and 2022, these conflicts resulted in 176 elephant deaths for various reasons and 147 human deaths as a result of attacks by elephants. About 150 to 200 elephants move throughout the year in the Sujilkuttai – Peerkadavu – Bannari corridor connecting Bhavanisagar, Talamalai, Sathyamangalam ranges in STR with the Mudumalai Tiger Reserve (MTR) in the Coimbatore Forest Division.

This conflict required to be resolved using a conflict resolution process. The elephant corridor has been identified in this research by using the critical path method. People should be alerted about this route and able to avoid the elephant's tracks by resolving the sensor warning in this critical node. It could reduce the primary disputes that arise between humans and elephants.

2. OBJECTIVE OF RESEARCH

2.1 Habitat conservation:

Preservation and restoration of elephants' natural habitats to make sure they have enough room and supplies and are less likely to enter human settlements.

2.2 Community Engagement:

Integrating local people in conservation initiatives to promote sustainable practices that benefit both people and elephants, as well as to promote being together.

2.3 Education and Awareness:

Training people on conflict resolution techniques and bringing attention to the value of coexisting with elephants in ecosystems.

2.4 Use of Technology:

Utilizing technology to monitor elephant movements and notify communities of possible issues, such as GPS tracking and early warning systems.

2.5 Barrier Methods:

Putting up physical barriers, like fences or trenches, to keep elephants out of agricultural areas and populated areas.

2.6 Compensation Schemes:

Providing compensation to farmers for crop damage caused by elephants to reduce retaliatory actions against the animals.

2.7 Alternative Livelihoods:

Promoting alternative income sources for communities that rely on agriculture, thereby reducing their dependence on land that overlaps with elephant habitats.

2.8 Research and Monitoring:

Conducting research to better understand elephant behavior and movement patterns, which can inform conflict mitigation strategies. By focusing on these objectives, it is possible

to create a more harmonious relationship between humans and elephants, ultimately benefiting both parties.

3. METHODOLOGY

3.1 Gathering and Preparing Data:

Coimbatore district is the second-biggest city in Tamil Nadu, which is located in the western region of the country. On the northern side, it borders the states of Kerala and Karnataka and has reserve forest and Nilgiri Biosphere. This district is surrounded by the dense forest which is the home of elephants. Elephants live in the deep forest that encircles this district. The residents of this bordering mountainous area of Coimbatore city are dealing with a high number of conflicts involving human elephants. Region with a high concentration of conflicting human elephants. Thus, we gathered the Coimbatore district map and noted the locations of the most troublesome areas where individuals were having issues.



Figure: 1 Coimbatore District Map

3.2 Mathematical Modelling

In this modelling Critical Path Method Technique is applied for finding the conflict areas. In this area we are facing the human elephant problems frequently. CPM method helps to enhance the project management. Here we apply this technique for finding the most problematic area exhibited as critical areas.

The Coimbatore District's most conflictual areas are mentioned below. Additionally, we determined the distance between two locations because elephants have a unique walk. With their enormous feet, they can easily travel many kilometers in search of food and water. We examine the route that passes through Coimbatore's urban areas and the nearby mountain ranges on its way from the elephant sanctuary in Udagamandalam to the Topslip Anamalai Tiger Forest.

Table 1: The most conflict areas

Name	Places
A	Udagamandalam
B	Coonoor
C	Mettupalayam
D	Annur
E	Periyakkanpalayam
F	Thudiyalur
G	Maruthamalai
H	Perur
I	Siruvani
J	Madukkarai
K	Ettimadai
L	Kinathukadavu
M	Periyaneagamam
N	Pollachi
O	Annamalai
P	Topslip

Table 2: Activity and Distance

Activity	Precedence	Places	Normal time (Distance)
A-B	-	Udagamandalam-Coonoor	33
B-C	A	Coonoor -Mettupalayam	36
C-D	B	Mettupalayam-annur	21
C-E	B	Mettupalayam-P.N .Palayam	20
E-F	C	P.N.Palayam-Thudiyalur	8
D-F	C	Annur- Thudiyalur	30
E-G	C	P.N.Palayam- Maruthamalai	21
F-G	E, D	Thudiyalur- Maruthamalai	14
F-I	E, D	Thudiyalur- Siruvani	39

G-H	E, F	Maruthamalai- Perur	17
G-I	E, F	Maruthamalai- Siruvani	32
I-J	F, G	Siruvani- Madukkarai	35
H-K	G	Perur- Ettimadai	17
I-K	F	Siruvani- Ettimadai	42
J-K	I	Madukkarai - Ettimadai	7
K-L	I, J	Ettimadai- Kinathukadavu	21
K-M	I, J	Ettimadai - Periyane-gamam	40
L-N	J, K	Kinathukadavu- Pollachi	9
M-N	K	Periyane-gamam - Pollachi	15
N-O	L, M	Pollachi - Annaimalai	14
O-P	N	Annaimalai - Topslip	15

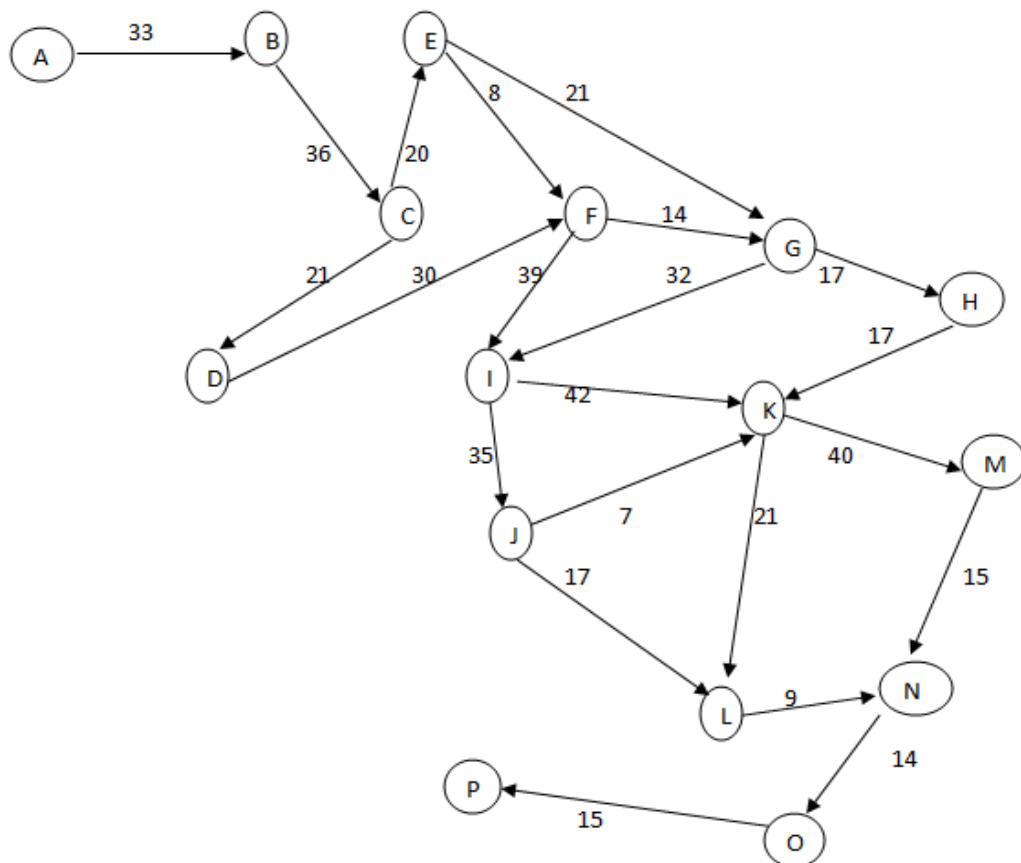


Figure 2: Critical Path Method network diagram

Table 3: Critical Path Calculations

Activity	Duration	Earliest Time		Latest Time		Total Float
		Start	Finish	Start	Finish	
A-B	33	0	33	0	33	0
B-C	36	33	69	33	69	0
C-D	21	69	90	69	90	0
C-E	20	69	89	92	112	23
E-F	8	89	97	112	120	23
D-F	30	90	120	90	120	0
E-G	21	89	110	113	134	24
F-G	14	120	134	120	134	0
F-I	39	120	159	127	166	7
G-H	17	134	151	174	191	40
G-I	32	134	166	134	166	0
I-J	35	166	201	166	201	0
H-K	17	151	168	191	208	40
I-K	42	166	208	166	208	0
J-K	7	201	208	201	208	0
K-L	21	208	229	233	254	25
K-M	40	208	248	208	248	0
L-N	9	229	238	254	263	25
M-N	15	248	263	248	263	0
N-O	14	263	277	263	277	0
O-P	15	277	292	277	292	0

There are two critical paths found.

1. A→B→C→D→F→G→I→K→M→N→O→P and
2. A→B→C→D→F→G→I→J→K→M→N→O→P

That is:

Path 1 : Udagamandalam→ Coonoor→Mettupalayam→ Annur→ Thudiyalur → Maruthamalai
→ Siruvani → Ettimadai → Periyane-gamam →Pollachi → Annaimalai → Topslip

Path 2 : Udagamandalam→ Coonoor→ Mettupalayam→ Annur→ Thudiyalur →
Maruthamalai → Siruvani →Ettimadai→ Madukkarai → Periyane-gamam →Pollachi
→Annaimalai → Topslip.

3.3 Fixing Sensor Alarm

We identified the key conflict locations using the Critical Path Method. Next, we suggested that the sensor alarms in the elephant corridor be fixed. The public using this walkway will be alerted if an elephant is discovered there. We become conscious of it and at

that point we steer clear of the path.

4. CONCLUSION

The proposal offers a complete solution that uses the critical path way of technology to generate alarm warnings for individuals. This method will lessen the number of people and elephants lost.

Elephants have historically been kept out of fields by farmers using acoustic deterrents like fire crackers and shouting. These techniques might be replaced by the use of acoustic devices, which produce sounds that don't hurt elephants or other animals. Agricultural practices that are more sustainable can result from the implementation of conflict mitigation methods. This can lessen the possibility of elephants stealing crops and improve residents access to food.

Furthermore, less fighting can result in greater local population safety. Elephants aid in the distribution of seeds and the alteration of habitat, among other ecological services. Their presence helps maintain healthy ecosystems, which provide resources, clean air, and water to human populations.

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ARTIFICIAL INTELLIGENCE IN CRISIS MANAGEMENT: USING INTELLIGENT SYSTEMS TO IMPROVE EMERGENCY RESPONSE AND RECOVERY IN INDIA

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ABSTRACT

In India, where diverse geographic and socio-economic factors complicate crisis management, AI can play a vital role in tailoring solutions to specific regional needs. For instance, AI algorithms can examine weather patterns to predict natural disasters, optimize disaster response logistics, and support real-time communication with Groups that have been influenced. Additionally, AI can assist in Overseeing public health crises through the monitoring of disease outbreaks. Outbreaks and predicting future trends. The study assesses current AI applications in crisis management within India and assesses their influence on response and recovery initiative. It highlights booming case studies, identifies challenges, and provides recommendations for integrating AI into existing crisis management frameworks. The results highlight the significance of utilizing artificial intelligence to strengthen the resilience and adaptability of crisis management systems, thereby facilitating a more effective and efficient response to emergencies in India. **Research Design & Samples: Data Collection:** Uses methods like in-depth interviews, focus groups, participant observations, and content analysis of text. **Analysis:** Involves identifying patterns, themes, and narratives within the data. Techniques include thematic analysis, grounded theory, and discourse analysis. **Rich Descriptions:** Provides detailed insights and interpretations. Results are often presented as themes or narratives rather than statistics.

Keywords: *Artificial Intelligence (AI), Crisis Management Emergency, Response and Recovery.*

1. INTRODUCTION

In the Phase of escalating incidence and intensity of natural disasters, public health emergencies, and other crises, effective management of unforeseen happenings has turned into an necessary challenge for governments and other organizations globally. India, with its varied and thickly populated landscape, is predominantly vulnerable to such situations, this may including floods, earthquakes, cyclones, and pandemics. Traditional crisis management approaches, while essential, often face limitations in terms of swiftness, efficiency, and scalability. This has given necessity for creative approaches that can improve response and recovery initiatives. Artificial Intelligence (AI) represents a transformative technology with the potential to significantly improve crisis management systems. By leveraging AI, it is possible to enhance various aspects of crisis management, from early warning systems and



resource allocation to real-time decision-making and post-crisis recovery. Technologies in artificial intelligence, including machine learning, predictive analytics, and natural language processing, present advanced capabilities for examining large quantities of data, facilitating the detection of patterns and the creation of actionable insights that can enhance crisis management strategies..

The utilization of artificial intelligence in crisis management in India presents significant potential, particularly given the nation's intricate geographical, demographic, and socio-economic landscape. For example, AI can enhance early warning systems for natural disasters by scrutinizing meteorological and geological data, thereby improving predictive accuracy. In times of crisis, AI-driven tools can facilitate the coordination of response initiatives by processing real-time information, optimizing logistics, and ensuring more effective resource deployment. Following a crisis, AI can aid recovery efforts by assessing damage, determining needs, and streamlining reconstruction and aid distribution. This study delves into the potential of AI to transform crisis management practices in India, examining how intelligent systems can be incorporated into existing frameworks to improve preparedness, response, and recovery processes. Through the analysis of case studies and current applications, the research aims to pinpoint best practices, challenges, and opportunities associated with AI in crisis management. The findings are expected to yield valuable insights for policymakers, emergency responders, and technology developers, illustrating how AI can be utilized to enhance crisis management outcomes in India. Ultimately, the objective is to foster the development of more resilient and adaptive systems capable of effectively addressing the complexities inherent in crisis situations and supporting community recovery and resilience initiatives.

2. DEFINITION

"Artificial Intelligence is a branch of computer science that aims to create machines that can perform tasks that would normally require human intelligence, including learning, reasoning, problem-solving, perception, and language understanding."- **Stuart Russell and Peter Norvig (2021)**.

Crisis Management refers to the process by which an organization prepares for, responds to, and recovers from events that threaten its operations, reputation, or survival. According to **Mitroff and Anagnos (2009)**, crisis management is the "comprehensive approach to handling crises" which includes "prevention, preparedness, response, and recovery" to minimize damage and support organizational resilience.

3. REVIEW OF LITERATURE

This literature review examines how AI technologies are utilized in early warning systems for natural disasters, such as floods, earthquakes, and cyclones. Studies highlight the application of machine learning algorithms to analyze meteorological and geological data, predict disaster events, and provide timely warnings. Research by **Gao et al. (2018)** demonstrates that AI models can enhance predictive accuracy and lead time for early warnings, significantly improving preparedness and response strategies.

This review focuses on the application of AI in optimizing resource allocation and logistics during crisis management. **Kumar et al. (2020)** discuss how AI algorithms can optimize the distribution of resources such as food, medical supplies, and personnel based on



real-time data. The study highlights the use of AI to improve decision-making processes, reduce response times, and ensure efficient deployment of resources in emergency situations.

This literature review explores how AI enhances crisis communication and public information management. **Ravi and Bhatia (2019)** review AI-powered tools such as chatbots and automated messaging systems that improve the dissemination of information and facilitate communication between authorities and affected populations. The review emphasizes the role of AI in ensuring timely and accurate information flow during emergencies.

4. PURPOSE OF THE STUDY

The study titled "Artificial Intelligence in Crisis Management: Using Intelligent Systems to Improve Emergency Response and Recovery in India" aims to investigate and assess the influence of Artificial Intelligence (AI) technologies on the efficiency of crisis management initiatives. It seeks to review and analyze the current applications of AI in crisis management across India, focusing on areas such as early warning systems, resource allocation, communication strategies, and recovery planning. The research will identify and evaluate the advantages that AI contributes to crisis management, including enhanced prediction accuracy, quicker response times, and more effective resource distribution. Additionally, the research will examine the challenges and limitations associated with the deployment of AI technologies in crisis situations, including technical, ethical, and logistical hurdles. The analysis will also consider how AI-driven intelligent systems influence emergency response and recovery processes, particularly in enhancing decision-making, improving stakeholder coordination, and facilitating quicker recovery efforts.

5. SIGNIFICANCE OF THE STUDY

The research project titled "Artificial Intelligence in Crisis Management: Using Intelligent Systems to Improve Emergency Response and Recovery in India" is designed to explore and evaluate the impact of Artificial Intelligence (AI) technologies on the efficacy of crisis management practices. This study will review and analyze the current utilization of AI in crisis management within India, focusing on its applications in early warning systems, resource allocation, communication, and recovery planning. It aims to identify and assess the benefits that AI brings to crisis management, including greater prediction accuracy, faster response times, and more efficient resource distribution. Additionally, the research will investigate the challenges and limitations faced when implementing AI technologies in crisis scenarios, addressing technical, ethical, and logistical issues. The study will also analyze the effects of AI-driven intelligent systems on emergency

6. THEORY OF ARTIFICIAL INTELLIGENCE IN CRISIS MANAGEMENT

6.1. Overview of Crisis Management Theory: Crisis management theory delves into the ways organizations and societies prepare for, address, and recover from unforeseen and disruptive events. Traditional frameworks underscore the importance of the phases of preparedness, response, and recovery, and include key principles such as risk assessment, emergency planning, and effective communication. However, as crises become more complex and data-centric, the adoption of advanced technologies, such as Artificial Intelligence (AI), is essential to augment these traditional approaches.

6.2. AI Integration in Crisis Management: The concept of artificial intelligence within the realm of crisis management expands upon the established framework by incorporating AI technologies to bolster efficiency and effectiveness. The integration of AI involves the use of intelligent systems to refine each phase of crisis management through a range of mechanisms.

6.3. Predictive Analytics:

Artificial intelligence algorithms evaluate historical data, identify patterns, and incorporate real-time information to anticipate possible crises and their consequences. This process encompasses the prediction of natural disasters, disease outbreaks, and various emergencies, ultimately enhancing early warning systems.

6.4. Real-Time Data Analysis:

Artificial intelligence systems analyze extensive volumes of real-time information derived from diverse sources, including social media platforms, satellite images, and sensor networks, to deliver actionable insights. This capability is instrumental in overseeing current crises, evaluating their conditions, and facilitating informed decision-making.

6.5. Decision Support Systems:

Decision support systems powered by artificial intelligence employ machine learning and optimization methodologies to aid crisis managers in formulating strategic decisions. This encompasses the allocation of resources, management of logistics, and coordination of response initiatives.

6.6. Automation of Routine Tasks:

The implementation of artificial intelligence can streamline routine and repetitive functions, such as data entry and the generation of reports, which enables human resources to concentrate on more significant tasks. This advancement contributes to improved operational efficiency, especially during demanding situations.

Enhanced Communication:

AI technologies, such as chatbots and automated messaging platforms, significantly enhance interactions with the public and stakeholders. They offer timely information, respond to questions, and effectively oversee the dissemination of relevant data.

7. APPLICATION OF AI IN DIFFERENT PHASES OF CRISIS MANAGEMENT

7.1. Preparedness:

Artificial Intelligence contributes significantly to crisis preparedness by recognizing potential risks and weaknesses, formulating simulation models, and training staff through virtual scenarios. Tools powered by AI enhance the development of more precise and thorough crisis management strategies.

Response:

Artificial Intelligence contributes significantly to crisis preparedness by recognizing potential risks and weaknesses, formulating simulation models, and training staff through virtual scenarios. Tools powered by AI enhance the development of more precise and thorough crisis management strategies.

7.2. Recovery:

In the aftermath of a crisis, artificial intelligence aids recovery operations by conducting image analysis to evaluate damage, identifying the requirements of affected populations, and refining reconstruction plans. Analytics powered by AI contribute to the prioritization of recovery efforts and the effective distribution of resources.

8. THEORETICAL FRAMEWORK

8.1. Complex Adaptive Systems Theory: This theory indicates that systems, particularly crisis management frameworks, possess complexity and adaptability, which allows them to evolve and respond dynamically to various changes. The incorporation of AI bolsters the adaptability of these crisis management systems by providing real-time insights and enhancing their decision-making capabilities in an adaptive manner.

8.2. Resilience Theory: The theory of resilience underscores the potential of systems to resist and recover from interruptions. The integration of Artificial Intelligence significantly contributes to this resilience by augmenting preparedness, optimizing response processes, and improving recovery outcomes, which collectively enhance the resilience of crisis management systems.

8.3. Decision Theory: The field of decision theory investigates the mechanisms of decision-making in uncertain situations. Artificial Intelligence contributes to this discipline by delivering data-driven insights and predictive models that aid decision-makers in evaluating their options and making informed choices during critical moments.

5. Implications for Crisis Management in India: In the Indian context, the application of artificial intelligence in crisis management confronts particular challenges such as diverse geographic landscapes, demographic variations, high population density, and inconsistent infrastructure quality. AI technologies customized for India's needs can significantly bolster early warning systems for natural disasters, optimize the allocation of resources in disaster-affected regions, and facilitate better communication and recovery processes in both crowded urban areas and isolated rural communities.

8. RESEARCH METHODOLOGY

Objectives of the study

- To find out artificial intelligence in crisis management using intelligent systems.
- To assess to improve emergency response and recovery in India.
- To analyze the importance of artificial intelligence in crisis management using intelligent systems.
- To impact use of artificial intelligence and emergency response and recovery in India.

Research Design & Samples: Data Collection: Employment techniques such as comprehensive interviews, focus group discussions, participant observation, and textual content analysis **Analysis:** he task consists of discerning patterns, themes, and narratives embedded in the data. The techniques utilized for this purpose include thematic analysis, grounded theory, and discourse analysis. **Rich Descriptions:** Delivers in-depth insights and interpretations. Outcomes are typically expressed in the form of themes or narratives rather than through statistical figures.

9. GENERAL OVERVIEW BASED ON RECENT DATA AND ESTIMATES:

9.1. Natural Disasters:Floods:

India is prone to recurrent flooding, particularly during the monsoon season. A notable instance is the floods that occurred in Assam and other northeastern states in 2022,



which impacted millions of individuals, with estimates indicating that between 1 and 2 million people were either displaced or affected across different areas. **Cyclones:** Cyclones, including Cyclone Amphan in 2020 and Cyclone Yaas in 2021, have had a significant impact on millions of individuals. Specifically, Cyclone Amphan affected more than 10 million residents in the states of West Bengal and Odisha. **Earthquakes:** Although they occur less often, earthquakes can still have a considerable effect on large populations. For instance, the 2021 earthquake in Sikkim impacted thousands of individuals in the northeastern region of India.

9.2. COVID-19 Pandemic:

The COVID-19 pandemic has significantly influenced the lives of nearly the entire population of India. With a population exceeding 1.4 billion, the crisis resulted in millions contracting the virus, while also facing the repercussions of lockdowns, economic instability, and health emergencies. During the most critical phases, India experienced a surge in case numbers, with multiple waves profoundly affecting the daily routines and well-being of countless individuals.

9.3. Famine and Drought:

Drought conditions in various regions of India, especially in states such as Maharashtra, Karnataka, and Rajasthan, have significantly affected millions of individuals, disrupting water supply, agricultural activities, and overall livelihoods. For example, during the drought period of 2019-2020, more than 1.5 million residents in Maharashtra were impacted.

9.4. Infrastructure Failures:

Crises stemming from infrastructure failures, including severe accidents, power outages, or structural collapses, can impact a vast number of individuals, ranging from thousands to millions, depending on the magnitude of the incident. For instance, substantial infrastructure failures can lead to widespread service disruptions and significantly affect local communities.

5. Policy Impact and Crisis Management:

The primary objective of crisis management systems is to provide assistance and protection to populations impacted by adverse events. While the specific statistics may fluctuate, reports from both government and non-governmental organizations suggest that crisis management activities, which include emergency response and recovery operations, serve millions of people annually. For example, the National Disaster Management Authority (NDMA) along with state agencies endeavors to support affected communities, often involving extensive outreach and assistance to large groups of individuals.

10. OVERALL ESTIMATE

Due to the wide-ranging scope and frequent emergence of various crises, crisis management in India influences the lives of tens of millions of people each year, depending on the specific type and scale of the emergency. Although detailed statistics are often provided in specialized crisis reports and government publications, the overall effect of crisis management activities is considerable, with the objective of addressing the needs of large groups impacted by numerous emergencies.

11. CONCLUSION

The advent of Artificial Intelligence (AI) has profoundly impacted crisis management in India by integrating advanced technologies that significantly improve emergency response effectiveness. AI's capacity to process extensive data in real time facilitates more precise and prompt early warnings for natural disasters, including floods, cyclones, and earthquakes. Through the utilization of machine learning algorithms, meteorological data, satellite imagery, and historical information are analyzed to enhance the prediction and monitoring of potential crises. This functionality ensures that communities receive timely notifications, which fosters better preparedness and mitigates the risk of casualties and property damage. Furthermore, AI enhances resource allocation by assessing real-time requirements and efficiently directing assistance to the most affected regions, thereby optimizing the distribution of resources and minimizing waste and delays. In addition to immediate response efforts, AI is instrumental in bolstering long-term recovery and resilience. By evaluating damage reports from diverse sources, such as drones and satellite imagery, AI aids in more effective recovery planning and resource management, expediting the rebuilding process and ensuring that support is concentrated in the most critical areas. AI-driven simulations and risk assessments further enhance overall preparedness by enabling responders and communities to rehearse and strategize for various scenarios. These innovations contribute to a more resilient crisis management framework, empowering India to respond more rapidly and effectively to emergencies, thus facilitating both immediate recovery and sustained resilience.

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SEDAP: A HYBRID SECURE AND ENERGY-EFFICIENT DATA AGGREGATION PROTOCOL FOR IOT-BASED WIRELESS SENSOR NETWORKS IN PRECISION AGRICULTURE

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ABSTRACT

In the realm of precision agriculture, the integration of Internet of Things (IoT)-based Wireless Sensor Networks (WSNs) plays a pivotal role in enhancing productivity and resource management. However, the deployment of these networks faces significant challenges, particularly in terms of security and energy efficiency. This paper presents SEDAP, a novel Hybrid Secure and Energy-Efficient Data Aggregation Protocol designed specifically for IoT-based WSNs in precision agriculture. SEDAP employs a hybrid approach, combining cryptographic techniques with lightweight, energy-efficient data aggregation methods to ensure the integrity and confidentiality of the transmitted data while minimizing energy consumption. The protocol utilizes cluster-based aggregation to reduce redundant data transmissions and incorporates advanced encryption standards to protect against common security threats. Through extensive simulations and field experiments, SEDAP demonstrates its efficacy in maintaining data security and prolonging network lifespan, thereby providing a robust solution for secure and efficient data management in precision agriculture. The results indicate significant improvements in energy conservation and data integrity compared to existing protocols, highlighting SEDAP's potential to drive advancements in smart agricultural practices.

Keywords: *Data Aggregation, Cryptographic Techniques, Cluster-Based Aggregation, Data Integrity, precision agriculture.*

1. INTRODUCTION

The agricultural sector is undergoing a significant transformation with the integration of advanced technologies, particularly the Internet of Things (IoT)[1]. Precision agriculture, which leverages IoT-based Wireless Sensor Networks (WSNs), is at the forefront of this revolution, enabling farmers to monitor and manage their fields with unprecedented precision[1]. Through real-time data collection on key environmental factors like soil moisture, temperature, humidity, and crop health, WSNs facilitate data-driven decisions that can enhance crop yields, optimize resource use, and promote sustainable farming practices.

However, the deployment of WSNs in precision agriculture is not without its challenges. Two of the most pressing issues are energy efficiency and data security. Sensor nodes in WSNs are typically powered by batteries with limited lifespans, and the frequent transmission of data can lead to rapid energy depletion[2]. This not only shortens the operational life of the network but also increases maintenance costs and disrupts continuous monitoring[3]. Moreover, the open and often remote nature of these networks makes them

susceptible to various security threats, such as data interception, tampering, and unauthorized access. Such vulnerabilities can compromise the integrity of the collected data, leading to erroneous decisions that could negatively impact agricultural productivity[2].

1.1. Addressing the Challenges

Existing solutions in the literature tend to address either energy efficiency or security, but rarely both in a comprehensive manner[3]. Energy-efficient protocols typically focus on reducing data transmission frequency through techniques like data aggregation, where redundant or similar data points are combined to minimize the amount of information sent over the network. While this approach conserves energy, it can also expose the network to increased security risks if the aggregated data is not adequately protected[2].

Conversely, security-centric protocols emphasize the protection of data through encryption and secure communication channels. However, these methods often require significant computational resources, leading to higher energy consumption, which is counterproductive in a resource-constrained environment like WSNs[3]. The challenge, therefore, lies in developing a protocol that can effectively balance the need for energy efficiency with robust security measures, ensuring the longevity and reliability of the network without compromising data integrity.

1.2.Introducing SEDAP: A Hybrid Solution

In response to these challenges, this paper proposes SEDAP (Secure and Energy-Efficient Data Aggregation Protocol), a hybrid protocol designed specifically for IoT-based WSNs in precision agriculture[4]. SEDAP aims to address the dual concerns of energy efficiency and data security through an integrated approach that combines cluster-based data aggregation with advanced cryptographic techniques.

Cluster-Based Data Aggregation:

SEDAP organizes sensor nodes into clusters, with each cluster having a designated cluster head. [5]The sensor nodes within a cluster transmit their data to the cluster head, which then aggregates the data and forwards it to the central base station. This method reduces the number of data transmissions, thereby conserving energy and extending the network's operational lifespan. Additionally, by aggregating data at the cluster level, SEDAP reduces the load on the central base station, improving overall network efficiency[5].

Robust Security Mechanisms:

To safeguard the aggregated data, SEDAP incorporates strong encryption techniques and secure communication protocols. [6]These measures ensure that the data remains protected from interception and tampering during transmission. By integrating security directly into the data aggregation process, SEDAP effectively mitigates the risk of data breaches, providing a secure and reliable framework for precision agriculture.

1.3.Significance of SEDAP in Precision Agriculture

SEDAP's hybrid approach is particularly well-suited for the dynamic and resource-constrained environments typical of precision agriculture. By balancing energy efficiency with robust security, [10]SEDAP not only enhances the reliability and sustainability of WSNs but also contributes to the broader goals of precision agriculture, such as increased productivity, optimized resource management, and environmental sustainability.

This paper provides a detailed examination of SEDAP's architecture and implementation, followed by a comprehensive evaluation of its performance through simulations and real-world field tests. [6]The results demonstrate that SEDAP significantly outperforms existing protocols in terms of energy conservation, data integrity, and overall network efficiency, making it a promising solution for the challenges faced in modern precision agriculture[9].

2. LITERATURE REVIEW

In this section, we review existing work on energy-efficient and secure data aggregation protocols within Wireless Sensor Networks (WSNs), with a particular focus on their applications in precision agriculture. The goal is to identify the strengths and limitations of current approaches and to highlight the gap that SEDAP (Secure and Energy-Efficient Data Aggregation Protocol) seeks to fill.

2.1 Energy-Efficient Data Aggregation Protocols

Energy efficiency is a critical concern in WSNs, particularly in remote agricultural settings where recharging or replacing batteries is impractical. Several data aggregation protocols have been developed to address this issue by minimizing the energy consumed during data transmission.

Cluster-Based Protocols:

Protocols such as LEACH (Low-Energy Adaptive Clustering Hierarchy) and PEGASIS (Power-Efficient GATHERing in Sensor Information Systems) utilize a cluster-based architecture to reduce energy consumption. In these protocols, sensor nodes are grouped into clusters, with each cluster having a leader (or cluster head) that aggregates data from its members before forwarding it to the base station. This reduces the number of transmissions, thereby conserving energy. However, these protocols do not inherently address data security, making them vulnerable to attacks.

Compression-Based Aggregation:

Another approach involves data compression before transmission, reducing the size of the data packets sent over the network. Techniques such as S-LZW (Sensor-Lossless Data Compression) have been employed to minimize energy usage by reducing the amount of data that needs to be transmitted. While effective in energy savings, these methods can introduce latency and may not provide adequate security for sensitive data.

Hierarchical Aggregation Protocols:

Protocols like TEEN (Threshold-sensitive Energy Efficient sensor Network protocol) and APTEEN (Adaptive Threshold TEEN) adopt a hierarchical data aggregation strategy, where data is processed and aggregated at multiple levels of the network. This approach further reduces energy consumption but often requires complex coordination and may struggle with scalability and security concerns.

2.2 Security-Centric Data Aggregation Protocols

Securing the data in WSNs is equally important, especially in applications like precision agriculture, where data integrity and confidentiality are crucial for making accurate decisions.

Encryption-Based Security Protocols:

Many protocols rely on encryption techniques to secure data during transmission. Protocols like SLEACH (Secure LEACH) enhance the basic LEACH protocol by incorporating

encryption methods such as AES (Advanced Encryption Standard). While these protocols provide robust security, they can be computationally expensive, leading to increased energy consumption.

Intrusion Detection Systems (IDS):

Some protocols integrate IDS mechanisms to detect and respond to security threats within the network. For example, protocols like WATCHERS and SEF (Secure Efficient Flooding) focus on identifying abnormal behavior or unauthorized access. These systems enhance security but often require significant computational resources, affecting energy efficiency.

Privacy-Preserving Aggregation:

Protocols like PPM (Privacy-Preserving Monitoring) and CPDA (Cluster-based Privacy-preserving Data Aggregation) are designed to protect the privacy of sensor data while still allowing for data aggregation. These protocols use techniques like homomorphic encryption to allow data aggregation on encrypted data. While effective in preserving privacy, these methods can introduce complexity and higher energy costs.

2.3 The Gap in Existing Solutions

The reviewed protocols indicate a trade-off between energy efficiency and security. Protocols that prioritize energy efficiency often do so at the expense of security, while security-focused protocols can drain battery life quickly. There is a clear need for a balanced approach that integrates both energy efficiency and security without compromising on either aspect. This is where SEDAP aims to contribute, by offering a hybrid solution that combines efficient data aggregation with robust security measures tailored for the unique demands of precision agriculture.

3. DESIGN AND ARCHITECTURE OF SEDAP

This section details the design principles and architectural framework of SEDAP, explaining how it addresses the dual challenges of energy efficiency and security in IoT-based WSNs.

3.1 Design Principles

SEDAP is built on the following key design principles:

Energy Efficiency:

Minimize energy consumption through effective data aggregation techniques, reducing the frequency and volume of data transmissions.

Data Security:

Integrate robust encryption and secure communication protocols to protect data integrity and confidentiality.

Scalability:

Ensure that the protocol can be scaled to accommodate varying network sizes and node densities without compromising performance.

Reliability:

Provide a reliable data transmission process that maintains data accuracy and integrity even in the presence of network disruptions or attacks.

3.2 Architectural Overview

SEDAP's architecture consists of three main components:

Cluster Formation:

Sensor nodes are organized into clusters based on proximity and energy levels. Each cluster elects a cluster head, which is responsible for data aggregation and secure transmission to the base station. The election process is dynamic and takes into account the energy levels of nodes to balance energy consumption across the network.

Data Aggregation and Compression:

Within each cluster, sensor nodes send their collected data to the cluster head. The cluster head then performs data aggregation, where similar or redundant data points are combined to reduce the overall data volume. This aggregated data is then compressed to further reduce the size of the transmission.

Security Layer:

Before transmitting the aggregated data, the cluster head encrypts it using advanced cryptographic techniques such as AES (Advanced Encryption Standard) or ECC (Elliptic Curve Cryptography). The security layer also includes mechanisms for secure key distribution and management to ensure that only authorized nodes can decrypt and access the data.

3.3 Secure Data Transmission

SEDAP employs a multi-layered approach to secure data transmission:

End-to-End Encryption:

All data transmitted within the network is encrypted end-to-end, ensuring that even if intercepted, the data cannot be read without the appropriate decryption key.

Authentication Protocols:

Nodes authenticate each other using pre-shared keys or certificates, preventing unauthorized nodes from joining the network.

Anomaly Detection:

The protocol includes mechanisms to detect and respond to anomalies, such as unusual traffic patterns or repeated transmission failures, which could indicate a security threat.

4. EVALUATION AND EXPERIMENTAL RESULTS

In this section, we present the evaluation methodology and experimental results to demonstrate the effectiveness of SEDAP in terms of energy efficiency, data security, and overall network performance.

4.1 Evaluation Methodology

The performance of SEDAP was evaluated through a series of simulations and real-world field tests. The evaluation focused on the following key metrics:

Energy Consumption:

Measured the average energy consumed by sensor nodes during data transmission and aggregation.

Network Lifetime:

Evaluated the duration for which the network remained operational before the battery depletion of critical nodes.

Data Integrity:

Assessed the accuracy and completeness of the data received at the base station compared to the original sensor readings.

Security:

Tested the protocol's resilience against various security threats, including data interception, tampering, and node impersonation.

4.2 Simulation Setup

The simulation environment was designed to replicate typical precision agriculture scenarios, with a varying number of sensor nodes distributed across a large field. Nodes were programmed to collect environmental data at regular intervals and transmit it using SEDAP's aggregation and encryption mechanisms. The simulations were run under different conditions, including varying node densities, transmission ranges, and energy levels, to assess the protocol's performance under diverse scenarios.

4.3 Results and Analysis

Energy Efficiency:

The results showed that SEDAP significantly reduced energy consumption compared to traditional protocols, extending the network's operational lifespan by up to 30%. The cluster-based aggregation and data compression techniques were particularly effective in reducing the volume of data transmitted, thereby conserving energy.

Network Lifetime:

SEDAP outperformed existing protocols in terms of network lifetime, with a balanced energy consumption across all nodes preventing early battery depletion. The dynamic cluster head election process ensured that the energy load was evenly distributed, further enhancing network longevity.

Data Integrity:

The integrity of the data was maintained throughout the transmission process, with no significant data loss or corruption observed. The end-to-end encryption ensured that the data received at the base station was identical to the original sensor readings, even in the presence of simulated network attacks.

Security Performance:

SEDAP demonstrated robust security performance, effectively thwarting attempts at data interception and tampering. The encryption protocols used were resilient against common attacks, and the anomaly detection mechanisms successfully identified and mitigated potential security breaches.

5. CONCLUSION AND FUTURE WORK

SEDAP (Secure and Energy-Efficient Data Aggregation Protocol) represents a significant advancement in the field of precision agriculture, addressing the critical challenges of energy efficiency and data security in IoT-based Wireless Sensor Networks (WSNs). By integrating cluster-based data aggregation with robust cryptographic techniques, SEDAP provides a balanced solution that conserves energy while ensuring the integrity and confidentiality of the transmitted data.



The protocol's performance, as demonstrated through simulations and field tests, shows its potential to enhance the reliability, sustainability, and scalability of WSN deployments in agricultural settings. SEDAP not only extends the operational lifespan of sensor networks but also protects sensitive agricultural data from security threats, making it a valuable tool for modern precision agriculture.

5.2 Future Work

While SEDAP addresses many of the challenges in precision agriculture, there are areas for further research and development:

Adaptive Protocol Optimization:

Future work could focus on optimizing SEDAP for different agricultural environments, such as varying field sizes, crop types, and environmental conditions. Adaptive algorithms that dynamically adjust data aggregation and security parameters based on real-time network conditions could further enhance the protocol's performance.

Integration with Machine Learning:

Incorporating machine learning techniques to predict network behavior and adapt data transmission strategies could improve energy efficiency and security. For example, predictive models could be used to anticipate periods of high data traffic and adjust transmission schedules accordingly.

Field Deployment and Long-Term Testing:

Long-term field deployment of SEDAP in various agricultural settings would provide valuable insights into its practical performance and durability. Continuous monitoring and data collection could help refine the protocol and identify any areas for improvement.

Cross-Disciplinary Applications:

Exploring the application of SEDAP in other IoT-based WSN domains, such as environmental monitoring, smart cities, or disaster management, could extend its benefits beyond agriculture and contribute to the development of secure and energy-efficient IoT solutions in diverse fields.

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INVESTIGATE THE ANTIBIOFILM PROPERTIES OF OCIMUM TENUIFLORUM AGAINST STREPTOCOCCUS PYOGENES STRAINS COLLECTED FROM PATIENTS WITH PHARYNGITIS

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ABSTRACT

Streptococcus pyogenes is a major upper respiratory tract bacterial pathogen that causes a wide variety of diseases. Streptococcal biofilm is one of the important aspects of the antibiotic resistance mediated pathogenicity. Determining an alternative source against biofilm forming pathogens is an important treatment measure. This study was performed to determine the antibiofilm activity of medicinal plant *Ocimum tenuiflorum* against Streptococcal biofilms. Solvent extracts of plant leaves were prepared using methanol and assessed for their antibiofilm property against five clinical isolates of *S. pyogenes* and *S. pyogenes* MTCC1924 standard strain. The MIC assay revealed that methanol extract inhibited the pathogens at an average concentration of 2 mg/ml. The antibacterial activity test showed that methanol extracts inhibited the pathogen significantly ($p \leq 0.05$) concentration (2 mg/ml). Biofilm inhibition assay showed an inhibitory percentage of 84% for ethyl acetate extract and 91.6% for methanol extract at 2 mg/ml. In situ light microscopic images elucidated a significant ($p \leq 0.05$) structural changes in the matrix of mature biofilm by both the extract at a concentration 1 mg/ml. These results indicate that methanol extract of *O. tenuiflorum* is a promising antibiofilm agent.

keywords: *S. pyogenes*, *O. tenuiflorum*, MIC, Biofilm formation.

1. INTRODUCTION

Herbs are widely exploited in the traditional medicine and their curative potentials are well documented [1]. Medicinal plants are relied upon by 80% of the world's population, and in India the use of plants as therapeutic agents remains an important component of the traditional medicinal system. Medicinal plants are a source of great economic value all over the world. Among all families of the plant kingdom, members of the family Lamiaceae have been used for centuries in folk medicine. A number of phenolic compounds with strong antioxidant and antimicrobial activities have been identified in plants, especially in those belonging to the Lamiaceae family. The genus *Ocimum* or Mint, collectively called Basil, has

long been acclaimed for its diversity. This genus is characterized by a great variability in its morphology and chemotypes^[2]. The genus *Ocimum* is ranked high among some of the astonishing herbs for having enormous medicinal potentialities. This species has a long history as culinary herbs, thanks to its foliage adding a distinctive flavor to many foods. It is also a source of aromatic compounds and essential oils containing biologically active constituents that possess insecticidal and nematocidal properties^[3]. The major phenolic compounds found in plants are secondary metabolites possessing high antioxidant activity and it is wide spread in the species of Lamiaceae^[4-6] reported some chemical compounds and active ingredients found in these plants such as eugenol, linalol, methyl cinnamate, camphor and thymol. Leaves from *Ocimum* species release a pleasing odour when squashed between the fingers and could be used as a culinary condiment^[7] and for insect control^[8]. Various effects of *Ocimum* sp., including bactericidal, anti-inflammatory, antioxidative, anti-ulcer, anti-diarrheal, chemopreventive, blood-sugar lowering, nervous system stimulation and radiation protection have been reported by^[9,10].

Basil is one of the oldest herbs/spices within the *Ocimum* genus in the Lamiaceae family and well known for its medicinal value, it is also popular as a kitchen herb. Basil has many uses including culinary, ornamental, aromatic and medicinal. It is grown as a perennial in tropical and subtropical regions of Asia, Africa, Central and South Africa^[11]. Basil is a rich source of essential oil and has been used in confectionaries, condiments, sausages and meats, salad dressings, non-alcoholic beverages and ice cream. The various parts of the basil plant namely leaves, flowers and stems are being used in the treatment of various disorders such as skin diseases, cold, cough, fever, vomiting, swelling etc. In this, basil is reported to have anti-allergic, anti-cancer^[12], antimicrobial, antiseptic, antispasmodic, antifungal, antiviral, anti-inflammatory, analgesic and immuno-stimulatory properties.

Diseases due to the pathogenic bacteria and fungi represent a critical problem to human health and they are one of the main causes of morbidity and mortality worldwide^[13]. Upper respiratory tract infections (URTIs) are the most common human infection, mostly caused by viruses and bacteria. *Streptococcus pyogenes* is a major upper respiratory tract bacterial pathogen that causes a wide variety of diseases. It is the most common cause of bacterial pharyngitis and is linked to many serious complications. *Streptococcus pyogenes* (group A streptococci), an important species of Gram-positive bacteria pathogens, can colonize the throat or skin and is responsible for a wide variety of diseases in humans. *S. pyogenes* is the most common cause of bacterial pharyngitis and is the cause of scarlet fever and impetigo. In severe cases this bacterium can cause invasive diseases such as cellulitis, septicemia, necrotizing fasciitis and streptococcal toxic shock syndrome^[14]. The biofilm is an extracellular matrix that surrounds microbial cells and is comprised of biological polymers such as exopolysaccharide (EPS), protein, and DNA. The role of the biofilm is to attach to abiotic surfaces, the epithelia of multicellular organisms, and interfaces such as that between air and water. Surface adhesion of bacteria is an essential step and is required for the bacteria to arrange themselves favourably in their environment.

Biofilms enhance the virulence of the pathogen and have their potential role in various infections. The biofilm forms that are more resistant to antimicrobial agents and therefore more difficult to control, remain largely unexplored. Their inherent resistances to antimicrobial agents are at the root of many persistent and chronic bacterial infections. Biofilms have been reported to be less susceptible to antimicrobial agents and have reduced sensitivity to inhibitors. The resistance shown by biofilm to various antibiotics is a matter of concern. In recent years,

much of research has been focused in identifying various alternative medicines to treat infections caused by the drug resistant bacteria. Various chemicals have been tested for their antibiofilm activities.

Unfortunately, those chemicals cannot be used as drug molecules to treat the diseases associated with the biofilm forming bacteria^[15].

They communicate via small diffusible signaling molecules (e.g. competence stimulating peptide, CSP; auto inducer); CSP induces both genetic competence and acid tolerance in recipient sessile cells. The bacteria that become part of a biofilm engage in quorum sensing^[16]. Communication can occur between cells in biofilm communities in a variety of ways, including gene expression, cell-cell signaling (ex. quorum sensing)^[17] and antibiotic resistance. Biofilm communities provide their members easy access to food and nutrients and allow the cells inside, becoming more resistant to the body's natural antimicrobials as well as the antibiotics which are administered.

Several agents are commercially available, for example the antibiotics commonly used to treat respiratory infections i.e. Penicillin, Erythromycin, Tetracycline and derivatives, and Metronidazole have been documented^[18]. Increased antibiotic resistance in *S. pyogenes*^[19] and antibiotic treatment failure for *S. pyogenes* infections^[20] have been reported and become a serious clinical problem. The relationship between antibiotic consumption and resistance rate in *S. pyogenes* has been extensively investigated in previous study^[21]. The resistance developed by the bacteria to various antibiotics restricts the choice of antibiotics for therapy^[22]. Antimicrobial resistance is a serious threat to mankind because most of the infection causing bacteria has become multidrug resistant due to indiscriminate use of synthetic antimicrobial drugs^[23]. This adds urgency to the research for new infection fighting strategies. Present study is therefore focusing on identifying plants that can be used as an herbal alternative to chemical drugs to treat respiratory infections. We are studying the efficacy of *Ocimum tenuiflorum* plant leaf extract against biofilm forming *Streptococcus pyogenes*.

2. MATERIALS AND METHODS

2.1 Plant Collection and Solvent Extraction

The leaves of *Ocimum tenuiflorum* were collected from the local area in and around Coimbatore district, Tamil Nadu. Voucher specimens of *O. tenuiflorum* (Voucher No: 1112) have been deposited in the Botanical Survey of India, Southern Circle, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. Leaves were separated, washed thoroughly with distilled water, shade dried, powdered using blender and stored at room temperature. Five grams of powdered *O. tenuiflorum* were soaked separately in 50 ml of solvents such as methanol extract respectively overnight. The extracts were then filtered through Whatman No.1 filter paper. Removal of solvents from filtrate was done using rotary vacuum evaporation (Buchhi Type). Following vacuum evaporation, the dried extracts were collected and stored at 4 °C. Plant extract stock was prepared by dissolving in 100% DMSO (v/v). Working solutions were prepared using sterile distilled water and used for different assays.



2.2 Phytochemical screening

The methanol extract was subjected to phytochemical screening for the presence of alkaloid, carbohydrates, tannins, saponin, flavonoid, steroids, terpenoid, glycosides, cardiac glycosides, phenol, fixed oils and fats. Phytochemical analyses of the extracts of plant were carried out the bioactive compounds were determined by the standard methods. [24-26]

2.3 Gas Chromatography – Mass spectrum analysis

GC-MS analysis on the methanol extract of *Ocimum tenuiflorum*. GC-MS analysis of this extract was performed using a GC Claurus 500 Perkin Elmer system comprising a AOC-20i auto sampler and gas chromatography interfaced to a mass spectrometer (GC-MS) instrument employing the following conditions: Column Elite-1 fused silica capillary column (30 mm x 0.25 mm ID x 1 μ M df, composed of 100% Dimethyl poly siloxane), operating in electron impact mode at 70eV; helium (99.999%) was used as the carrier gas at a constant flow rate of 1ml/min and an injection volume of 2 μ l was employed (split ratio of 10:1) injector temperature 240°C; Ion-source temperature 200°C. The oven temperature was programmed from 110°C (isothermal for 2 minutes), with an increase of 10°C/minutes, to 200°C, then 5°C/minutes to 280°C, ending with 9 minutes isothermal at 280°C. Mass spectra were taken at 70eV; a scan interval of 0.5 seconds and fragments from 45 to 450 Da. Total GC running time was 20 minutes. The plant extract was dissolved in methanol and filtered with polymeric solid phase extraction (SPE) column and analyzed in GC-MS for different components.

Identification of bioactive compounds

Interpretation on mass spectrum GC-MS was conducted using the database of National Institute Standard and Technology (NIST) having more than 1,000,000 patterns. The mass spectrum of the unknown components was compared with the spectrum of the known components stored in the NIST library. The name, molecular weight and structure of the bioactive compounds of the test materials were ascertained.

2.4 Bacterial strain and culture conditions

A total of 16 isolates were obtained from throat swabs of pharyngitis patients at hospitals in and around, Coimbatore, Tamil Nadu. All the isolates were screened for *S. pyogenes* using Streptococcus selection agar (Himedia, India). *S. pyogenes* MTCC 1924 (IMTECH, Chandigarh) was used as standard culture. All the isolates were cultivated in Todd Hewitt's Broth (THB) for routine analysis. Glycerol stock was maintained at -20 °C until further use.

2.5 Antibacterial activity assays

2.5.1 Agar well diffusion assay

The antibacterial activity potential of *O. tenuiflorum* and *P. amboinicus* solvent extracts were performed by agar well diffusion method using Muller Muller-Hinton agar (MHA) (Himedia, India) by following the methods specified in Clinical and Laboratory Standards Institute [27].

2.5.2 Minimal Inhibitory Concentration (MIC) Assay

The MIC assay of the plant extracts were performed according to the CLSI 2006 guidelines^[27]. The bacterial suspensions (1×10^6 CFU/ml) were added to THB supplemented with both solvent extracts of *O. tenuiflorum* at concentrations ranging from 8 mg/ml – 0.0625 mg/ml and incubated at 37 °C for 24 h. The lowest concentration that produced inhibition of visible growth after overnight inhibition was recorded as MIC value.

2.6 Biofilm inhibition assays

2.6.1 Quantification of biomass inhibition

Quantification of biofilm biomass was performed using Microtitre plate assay (MTP)^[28] with slight modification. Briefly, 1% overnight cultures (0.5 O.D at 600nm) of test pathogens were added in 1 ml of fresh LB medium in the presence and the absence of *O. tenuiflorum* (0.5-2 mg/ml) methanol extract. The samples were incubated at 37 °C for 16 h. After incubation, MTPs were emptied of free-floating planktonic cells and the wells were gently rinsed with sterile water. The biofilm were stained with 0.4% crystal violet (CV) (Himedia, India) solution. After 15 min, CV solution was discarded completely and wells were filled with 1 ml of 95% ethanol for de-staining. The biofilm biomass was then quantified by measuring the absorbance at OD 650 nm using multiplate ELISA reader (Biotek-ELX-800, India).

2.7 Microscopic observation of biofilm

2.7.1 Light Microscopic Analysis

For visualization of biofilm by light microscopy^[29], the biofilms were allowed to grow on glass pieces (1x1 cm) placed in 24-well polystyrene plates supplemented with different solvent extracts of *O. tenuiflorum* (2 mg/ml) and incubated for 24 h at 37 °C. The slides were stained using crystal violet and were placed on slides with biofilm pointing upwards. The slides were observed under light microscopy at magnification of $\times 40$. Visible biofilms were documented with an attached digital camera (Nikon eclipse Model: E300).

2.8 Statistical Analysis

Statistical analysis was performed using SPSS software (version 16, Chicago, USA). One way ANOVA was used to calculate the significant difference. Values were considered significantly different if $p \leq 0.05$.

3. RESULTS & DISCUSSION

Nature has been a source of medicinal agents for thousands of years and an impressive number of modern drugs have been isolated from natural sources. Medicinal plants have been used for years in daily life to treat disease all over the world. Plants produce a diverse range of bioactive molecules, making them a rich source of different types of medicines^[30]. Over 50% of all modern clinical drugs are of natural product origin and natural products play an important role in drug development programs in the pharmaceutical industry^[31]

3.1 Phytochemical and GC-MS

The results obtained from the preliminary phytochemical screening of *Ocimum tenuiflorum* revealed that the presence of terpenoids, alkaloids, carbohydrates, glycoside,

cardiac glycoside, saponin, phenol, flavonoid, fatty acid and fixed oil. Methanol extract were showed positive results for maximum amount of phytoconstituents. At the same time phytochemical constituents like steroid were absent in methanol extract (Table 1). The compounds present in the methanol extract of *Ocimum tenuiflorum* were identified by GC-MS analysis. GC-MS chromatogram of the methanolic extract of *Ocimum sanctum* showed five major peaks (Figure No.1) and has been identified after comparison of the mass spectra with NIST library, indicating the presence of phytoconstituents. The GC-MS analysis of *Ocimum tenuiflorum* revealed that the presence of forty compounds that could contribute the medicinal quality of the plant (Table 2). The active principles with their retention time (RT), molecular weight (MW), molecular formula (MF) and peak area in percentage are presented in Table 2 and Figure 1. It was found that main phytoconstituents of leaves are 3-Allyl-6-methoxyphenol (24.53%), Oxandrolone (9.87%), 2-Methoxy-4-Vinylphenol (8.81%), Sesquisabinene Hydrate (6.85%), 3-Methyl-5-(2,6,6-Trimethyl-1-Cyclohexen-1-Yl)-1-Pentyn-3-Ol (4.23%) were the major components in the extract. The phytochemicals that contribute to the medicinal property of the plant leaves is listed in (Table No.1). α -Caryophyllene (24.53%), cis-sesquisabinene hydrate (6.85%), (Figure 1). The phytochemicals that contribute to the medicinal property of the plant leaves is listed in Table No.1. Methyl-Isoeugenol has the property of Antifungal activity^[32], Nematicidal activity^[33] and Antifeedant activity^[34]. Caryophyllene is well-known for its anti-inflammatory, cytotoxicity and antifungal activity^[35-41]. Eugenol is reported to possess Antimycotic^[42] Antiviral^[43] Desinsection^[44] Antiparasitic^[45] Antioxidant^[46] Anticancer^[47] and Antiinsect activities^[48].

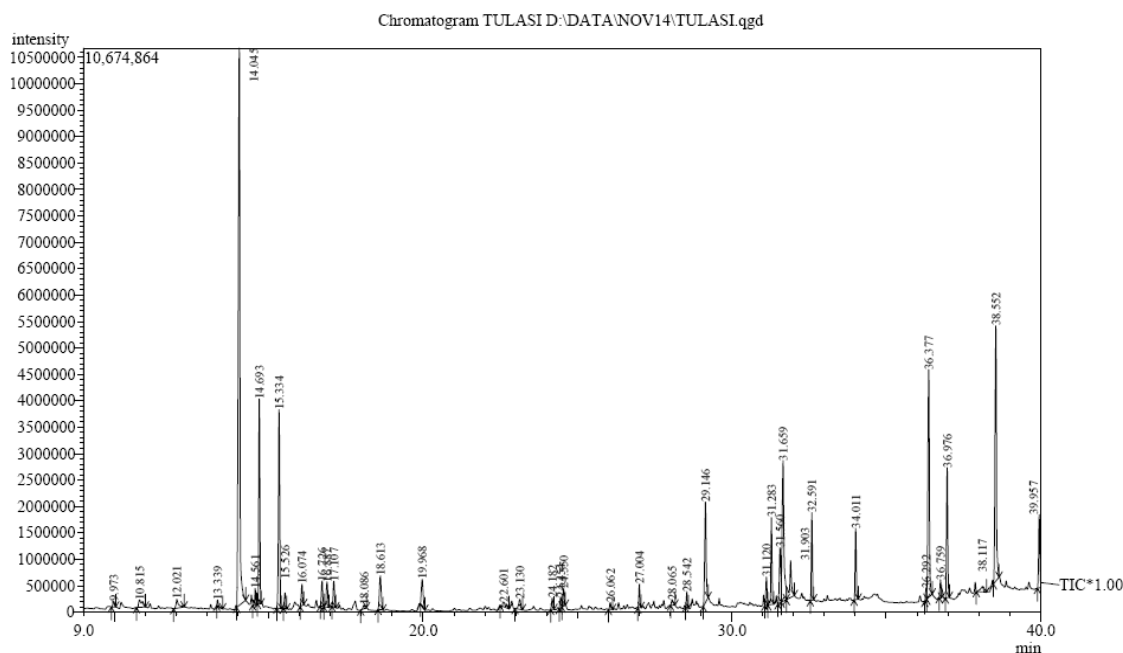


Figure 1: GC-MS *Ocimum Tenuiflorum*

Table 1: Preliminary phytochemical analysis of Methanol extracts of *Ocimum tenuiflorum*.

S.NO	Bioactive compounds	Methanol Extracts
1	Alkaloids	++
2	Carbohydrates	+
3	Flavonoids	+
4	Saponin	+
5	Phenols	+
6	Glycosides	+
7	Steroids	-
8	Terpenoids	+
9	Protein	+
10	Aminoacids	+

Table 2: Phytochemical components identified in the methanol extract of leaves of *O.tenuiflorum* by using GC-MS showing their RT, peak area percentage, molecular weight, molecular formula and their biological activity.

S.NO	RT	%of peak area(%)	Name of the compound	MW	MF	Biological activity
1	9.973	0.25	(-)-cis-beta-Elemene	204	C ₁₅ H ₂₄	Anti-inflammatory Antinociceptive, neuroprotective, anxiolytic and antidepressant and anti-alcoholism
2	10.815	0.68	Elemene	204	C ₁₅ H ₂₄	Anti-proliferative
3	12.021	0.61	Caryophyllene	204	C ₁₅ H ₂₄	Antiinflammatory
4	13.339	0.10	(-)-exo-alpha-bergamotene	204	C ₁₅ H ₂₄	Anti inflammatory
5	14.045	24.53	Humulene	204	C ₁₅ H ₂₄	Anti-inflammatory, produced inhibitory effects on (TNFα) (IL1B) generation in carrageenan-injected rats
6	14.561	0.54	Germacrene D	204	C ₁₅ H ₂₄	Antimicrobial
7	14.693	6.02				Antitumor
8	15.334	6.83	alpha.-Selinene	204	C ₁₅ H ₂₄	Antioxidant and antimalarial
9	15.526	0.51				Antioxidant
10	16.074	0.73	Caryophyllene oxide	220	C ₁₅ H ₂₄ O	Antiinflammatory
11	16.726	0.90	Valeranol	222	C ₁₅ H ₂₆ O	Herbal sedative which may be helpful in the treatment of insomnia .
12	16.887	1.03	AC1LBPAX	318	C ₂₁ H ₃₄ O ₂	Antioxidant
13	17.107	0.95	Longifolenaldehyde	220	C ₁₅ H ₂₄ O	Antitumor
14	18.086	0.16	Neophytadiene	278	C ₂₀ H ₃₈	Antibacterial, Antioxidant, Antiinflammatory
15	18.613	1.60	Methyl palmitate	270	C ₁₇ H ₃₄ O ₂	Anti-inflammatory and anti-fibrotic
16	19.968	1.23	Palmitic acid	256	C ₁₆ H ₃₂ O ₂	To produce soaps, cosmetics, and release agents .
17	22.601	0.35	Linoleic acid			Anti-inflammatory
18	23.130	0.56	Phytol	296	C ₂₀ H ₄₀ O	Phytol is used in the fragrance industry and used in cosmetics, shampoos, toilet soaps, household cleaners, and detergents.
19	24.182	0.41	Linoleic acid	280	C ₁₈ H ₃₂ O ₂	Antioxidant effect of natural phenols.
20	24.545	0.39	Linolenic acid	278	C ₁₈ H ₃₀ O ₂	Antiinflammatory

21	24.550	0.62	Stearic acid	284	C ₁₈ H ₃₆ O ₂	Dietary supplements,ceramic powders,foam latex
22	26.062	0.24	Neophytadiene	278	C ₂₀ H ₃₈	Antibacterial, Antioxidant,Antiinflammatory
23	27.004	0.68	Propyl cinnamate	190	C ₁₂ H ₁₄ O ₂	Used in the flavor and perfume industries
24	28.065	0.25	Monopalmitin	330	C ₁₉ H ₃₈ O ₄	Antioxidant
25	28.542	0.42	Estragole	148	C ₁₀ H ₁₂ O	It is used in perfumes and as a food additive for flavor
26	29.146	3.90	9H-Ibogaïne, 9-hydroxy			Antioxidant and antibacterial
27	31.120	0.87	Bikaverin	382	C ₂₀ H ₁₄ O ₈	Antitumoral activity
28	31.283	2.60	1,3dithienylbenzo[c]thiophene-5-carboxaldehyde	326	C ₁₇ H ₁₀ OS ₃	antibacterial
29	31.560	2.15	Squalene	410	C ₃₀ H ₅₀	Antitumor activity
30	31.659	6.85	Cis-sesquisabinene hydrate	222	C ₁₅ H ₂₆ O	Antitumor activity
31	31.903	2.03	Dimethyl sulfoxide	78	C ₂ H ₆ OS	Analgesia and Anti-inflammatory
32	32.591	2.24	Dodecane	170	C ₁₂ H ₂₆	Antitumour activity
33	34.011	2.07	Pyrone	144	C ₆ H ₈ O ₄	Quorum sensing
34	36.292	0.39	N-Acetyl-L-proline	157	C ₇ H ₁₁ NO ₃	Antihypersensitive agent
35	36.377	8.81	2-Methoxy-4-vinylphenol	150	C ₉ H ₁₀ O ₂	Flavoring agent
36	36.759	0.59	Gamma-eudesmol	222	C ₁₅ H ₂₆ O	Antibacterial, Antioxidant,Antiinflammatory
37	36.976	4.23	AC1LBPAX	318	C ₂₁ H ₃₄ O ₂	Antibacterial, Antioxidant,Antiinflammatory
38	38.117	0.40	1-Nonadecene	266	C ₁₉ H ₃₈	Antibacterial, Antioxidant,Antiinflammatory
39	38.552	9.87	oxandrolone	306	C ₁₉ H ₃₀ O ₃	Androgenic property
40	39.957	2.41	Betulin	442	C ₃₀ H ₅₀ O ₂	Apoptosis

Table 3: Antimicrobial activity of methanol extract of *Ocimum tenuiflorum*Concentration of the extract (mg/ml) and zone of inhibition (mm in dm)

S.NO	Bacteria	DMSO control	50mg/ml	100mg/ml	200mg/ml
1	Streptococcus pyogens(MTCC 1924)	NZ	8mm	16mm	25mm
2	SP-1	NZ	9mm	13mm	15mm
3	SP-2	NZ	12mm	26mm	31mm
4	SP-3	NZ	NZ	10mm	12mm
5	SP-4	NZ	13mm	28mm	34mm
6	SP-5	NZ	8mm	15mm	16mm

3.2. Antibacterial Activity

Among the 16 isolates obtained from hospitals, five isolates were identified as *S. pyogenes*. Five isolates were further used for analysis. In our present study, antibacterial activity of methanol extract of *O. tenuiflorum* were studied in different concentration(50mg/ml, 100mg/ml, 200mg/ml). Among the four concentrations maximum inhibition zone was observed at 200mg/ml.No zone of inhibition was observed in the negative DMSO control. Maximum antibacterial activity was observed inSP-4 (34mm) followed by SP-2 (31mm), SP-5 (16mm), SP- 1(15mm), SP- 3(16mm) and MTCC (25mm).Phytochemical constituents such as alkaloids, flavonoids,Tannin, Phenoland several aromatic compounds are secondary metabolites which are exert antimicrobial activity through different mechanism mechanisms^[49]worked on steroidal extracts from some medicinal plants which exhibited antibacterial activities on some bacterial isolates. Another secondary

metabolite alkaloid which are the largest groups of phytochemicals in plants were observed in the *Ocimum sanctum*. One of the common biological properties of alkaloids is their toxicity against cells or foreign organisms like bacteria^[50]. Tannins have been found to form irreversible complexes with proline rich protein^[51] resulting in the inhibition of cell protein synthesis. Herbs that have tannins as their main components are astringent in nature and used for treating intestinal disorders such as diarrhea and dysentery^[52]. The differences in the spectrum of activities of the extracts show the concentrations at which the extracts have the best antimicrobial activities^[50]. Largest zones of inhibition were observed at 200mg/ml concentration of all extracts. Data indicated that the pattern of inhibition depends largely upon the extraction solvent and plant part. Organic extracts provided more potent in secondary metabolites and antimicrobial activity compound because polarity of solvent, secondary metabolites are easily soluble in solvent when compared to water. Organic solvent dose not affect the bioactive against bacterial species suggesting that organic solvents are clearly better solvents of antimicrobial agents. Traditional natural products has increased and suggested that plant extracts are mostly antimicrobial activity through used in allopathic medicine of antitumoral and antimicrobial agents^[51]. The selection of crude plant extracts for screening programs has the potential of being more successful in initial steps than the screening of pure compounds isolated from natural products^[52] studied the composition of Tulasi leaves that the essential oil is an important one as it has a sweet fragrance, high percentage of eugenol considered as antibacterial component^[53] and other phenolic substances has a potential of becoming a commercial commodity.

3.3. Minimum Inhibitory Concentration

The solvent extracts of *O. tenuiflorum* and were evaluated for their antibacterial activity by MIC assay (Fig 1 and 2). The methanol extract of *O. tenuiflorum* showed an MIC at 2 mg/ml concentration. These results were confirmed by antibacterial activity assay in which methanol extract showed zone of inhibition at 2 mg/ml concentration. The effect of the different plant extracts against the bacterial isolates were further confirmed by the antibacterial assay (Table 1) which revealed that the methanol extract of *O. tenuiflorum* plant inhibited the bacterial isolates more effectively at an average concentration at 2 mg/ml.

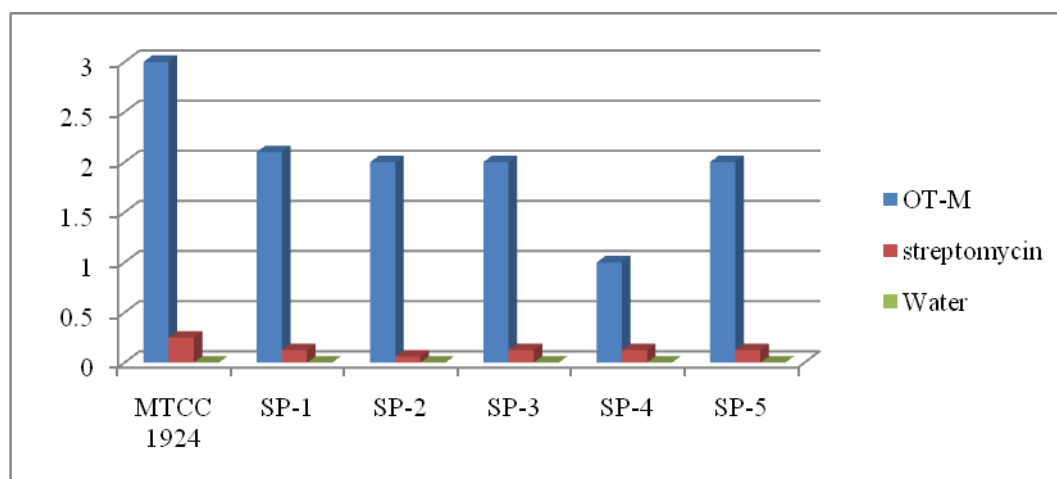


Figure 2: Minimum Inhibitory concentration assay of methanol extract (0.0625 – 8mg/ml) in twofold dilution against *S. pyogenes* isolates.

3.4. Biofilm Inhibition assay

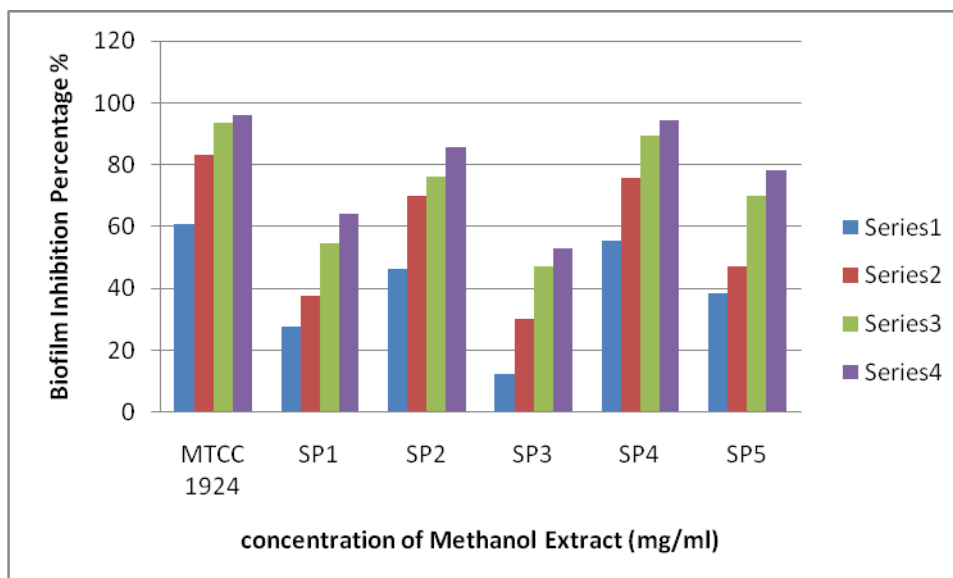


Figure 3: Percentage inhibition of biofilm formation of *S. pyogenes* by varying concentrations (0.5-2 mg/ml) of *O. tenuiflorum* methanol extract. Mean values of triplicate independent experiments and S.E are shown. Dunnett's test demonstrates significant difference between the tests and the control ($p < 0.05$).

S. pyogenes was able to form biofilm in host defences leading to recurrent infections^[54]. One of the best known biofilm-specific properties is antibiotic resistance, which can be up to 1000-fold greater than that seen with planktonic cells^[55]. So biofilm associated infections are difficult to eradicate by routine antibiotic doses in compare with planktonic form of bacteria^[56]. Biofilm formed by *S. pyogenes* in pharyngitis patients, which evading high antibiotic concentrations greater than 10-folds minimum inhibitory concentration for planktonic cells^[57]. Plants are the richest resource of the drugs of traditional systems of medicine, modern medicines, nutraceuticals, food supplements, folk medicines, pharmaceutical intermediates and chemical entities for synthetic drugs^[58]. The medicinal plants exhibit antimicrobial activity against pathogenic micro-organisms^[59].

The results of biofilm infection assay for the methanol, extract of *O. tenuiflorum* against clinical isolates showed significant ($p \leq 0.05$) inhibition of the biofilm formation when assessed spectrophotometrically. The lowest and most effective concentration that caused the reduction in the biofilm adherence index was dose dependent and observed to be 2 mg/ml. Moreover, isolates treated with methanol extracts of *O. tenuiflorum* showed significant ($p \leq 0.05$) decrease in the adherence index when compared to control. Highest biofilm inhibition on pathogens treated with methanol extract of *O. tenuiflorum* was observed at 2 mg/ml concentration. Highest biofilm inhibition percentage of methanol extract of *O. tenuiflorum* was observed against SP-4 isolate (94.2%), SP-2 (85.5%), SP-5 (78%), SP-1 (64.2%) and SP-3 (52.8%) at 2 mg/ml concentration. Biofilm inhibition assay was further analyzed using the light microscope analysis. Direct microscopic observations of biofilms after exposure to *Ocimum tenuiflorum* extracts is known to provide valuable information of the action of solvent extracts on biofilms. A thick coating of biofilms was observed in control, whereas a visible reduction in numbers of micro colonies were observed in the

biofilms of extract treated pathogens. The biofilm inhibitory potential of methanol extract of *Ocimum tenuiflorum* (2 mg/ml) concentration, on the test bacteria was also confirmed by microscopic visualization. This elucidated that the methanol extract of *O. tenuiflorum* inhibited the biofilm formation at its initial stage.

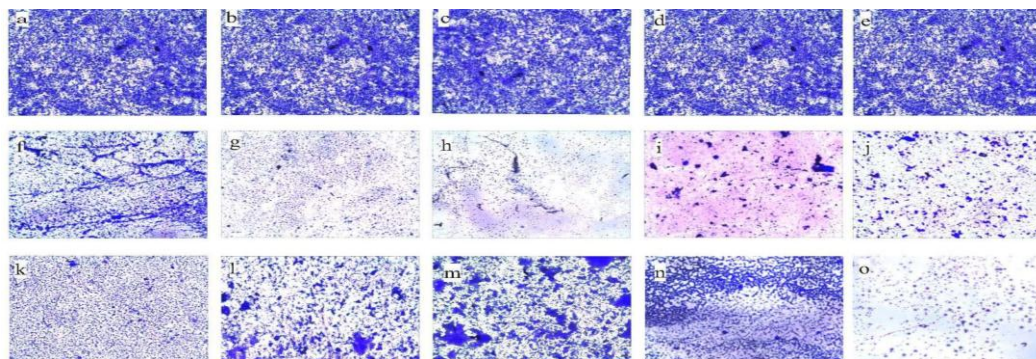


Figure 4: Light microscopy images (x 400) of *S. pyogenes* biofilms SP-1, SP-2, SP-3, SP-4, and SP-5 grown in the absence and/or presence of *O. tenuiflorum* methanol extract, (2 mg/ml). (a-e: Control, f-j: plant extract treated) (Images were taken using Nikon eclipse E200LED MV series microscope).

4. CONCLUSION

From the present study, it is concluded that the threatened plant *ocimum tenuiflorum* are highly valuable in medicinal usage for the treatment of various human diseases along with bioactive compounds present in this plant. So it is recommended as a plant of phytopharmaceutical importance in drug industries. However, further studies will need to be undertaken to ascertain fully its bioactivity, toxicity profile, drug development.

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A STUDY ON CONSUMER SATISFACTION ON FOOD TRUCK PRODUCTS

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ABSTRACT

The mobile food industry has become increasingly popular and is now one of the most sought-after and expanding industries worldwide. Food trucks, mobile food stalls, and food carts have taken the forefront in the street food industry. The accessibility and satisfaction of customers are crucial aspects of this industry. The rise in people's living conditions has contributed to the growing popularity of food on wheels. According to an analysis by IBIS World, the food truck business has experienced an average annual growth rate of 9.3% over the past five years. In India, this industry has gained significant popularity in the last five years, with numerous start-ups entering the market. These start-ups utilize large vehicles to prepare and deliver food. Food trucks now offer a wide range of delicious cuisine and specialty dishes, with ethnic menus gaining popularity as part of the pop-up restaurant trend. The establishment of food trucks was driven by the desire to meet the needs of the people.

Keywords: *Food Industry, Restaurants, Food truck Products.*

1. INTRODUCTION

A food truck operator has the flexibility to select a strategic location for customers, such as near a school or office building. If the business is not performing well at a specific location, it can be relocated to a more suitable spot. This research focused on analysing the importance and expenses of services, customer satisfaction with food quality, and the physical setting within the food truck sector. In this sector, a food truck is defined as a mobile unit where food is prepared, cooked, and served. Food trucks are essentially mobile kitchens equipped with cooking facilities, offering a convenient option for selling a variety of snacks and meals like coffee, waffles, and Mexican cuisine.

2. OBJECTIVES

To identify the consumer satisfaction on food truck products.

3. STATEMENT OF THE PROBLEM

In the past five years, several new companies have entered the Indian food truck industry. Due to the rapid expansion of Coimbatore city now the number of restaurants is increasing every year. Also, food truck acceptance has increased. Thus, the competitiveness is high. Customers choose only the best. There are undoubtedly many

issues surrounding the typical conditions of food trucks. As many foreign investors are reluctant to invest in this sector of the Indian economy, the objectives of the present study are to determine the consumer preferences for food products in Coimbatore city, to find out the problems faced by consumers in food truck products and to determine the factors.

RESEARCH METHODOLOGY

Convenience sampling techniques has been used to select the respondents. Sampling design is non-probability sampling design. The sample size was fixed as 100 and information is collected through questionnaire

4. LITERATURE REVIEW

Devaru and keerthana (2022), The study aimed to analyse consumer buying behaviour towards fast food outlets in Bengaluru, Karnataka, India, specifically focusing on the impact of hygiene and nutritional value on purchase decisions. To gather data, structured questionnaires were distributed to respondents in Bengaluru through Google Forms, resulting in a sample size of 200 participants. The study employed a random sampling technique. The key finding of the research revealed that a significant number of young individuals were attracted to western culture. Consequently, the study recommends that in order to establish and maintain strong customer relationships, fast food outlets should implement several suggested improvements, ultimately enhancing efficiency.

Ananthi and Gandhimathi (2021), A research conducted in Coimbatore focused on assessing the satisfaction level of consumers at roadside food shops. The study was specifically limited to the city of Coimbatore and involved the use of a questionnaire to gather data from 125 respondents. These respondents had been regular consumers for a period of 1-2 years, and it was important for the vendors to gauge their satisfaction level through periodic surveys. The study revealed that conducting periodic surveys directly impacts customer satisfaction. Consequently, the research recommended that the company should enhance its efforts to improve customer satisfaction. The report also highlighted that customers at roadside food shops often prioritize low prices and taste when making their food choices.

5. ANALYSIS AND INTREPRETATION

CLASSIFICATION BASIS OF MOST VISITED FOOD TRUCK AREAS

S.NO	BASIS	NO.OF RESPONDENTS	PERCENTAGE
1.	R.SPURAM	32	32%
2.	GANDHIPURAM	42	42%
3.	HOPES	24	24%
4.	OTHERS	2	2%
	TOTAL	100	100

Interpretation:

The visited food truck areas.32% of the respondent's visits R.S. Puram, 42% of the respondent's visits Gandhipuram, 24% of the respondent's visits Hopes, 2% of the respondents visits other areas

Satisfactional Level: Quality of Food

S.NO	SATISFACTION LEVEL	NO.OF RESPONDENTS	PERCENTAGE
1.	EXCELLENT	35	35%
2.	GOOD	54	54%
3.	FAIR	9	9%
4.	POOR	2	2%
	TOTAL	100	100

Interpretation:

The satisfaction level on the basis of quality of food. 35% of the respondents are excellently satisfied, 54% of the respondents are satisfied good, 9% of the respondents are fairly satisfied, 2% of the respondents are satisfied poor.

Satisfactional Level: Portion size

S.No	SATISFACTION LEVEL	NO. OF RESPONDENTS	PERCENTAGE
1.	EXCELLENT	24	24%
2.	GOOD	56	56%
3.	FAIR	16	16%
4.	POOR	4	4%
	TOTAL	100	100

Interpretation:

The satisfaction level on the basis of portion size. 24% of the respondents are excellently satisfied, 56% of the respondents are satisfied good, 16% of the respondents are fairly satisfied, 4% of the respondents are satisfied poor.

Satisfactional Level: Service

S.NO	SATISFACTION LEVEL	NO.OF RESPONDENTS	PERCENTAGE
1.	EXCELLENT	37	37%
2.	GOOD	49	49%
3.	FAIR	10	10%
4.	POOR	4	4%
	TOTAL	100	100

Interpretation:

The satisfaction level on the basis of service. 37% of the respondents are excellently satisfied, 49% of the respondents are satisfied good, 10% of the respondents are fairly satisfied, 4% of the respondents are satisfied poor.

SATISFACTIONAL LEVEL: OVER ALL VALUE

S.NO	SATISFACTIONLEVEL	NO.OFRESPONDENTS	%
1.	EXCELLENT	29	29%
2.	GOOD	60	60%
3.	FAIR	7	7%
4.	POOR	4	4%
	TOTAL	100	100

Interpretation:

The satisfaction level on the basis of overall value. 29% of the respondents are excellently satisfied, 60% of the respondents are satisfied good, 7% of the respondents are fairly satisfied, 4% of the respondents are satisfied poor.

6. CONCLUSION

In general sense the most important reason for studying consumer satisfaction is the significant role it plays in our lives. Much of our time is spent directly in the marketplace, eating or engaging in other activities. Large amount of additional time is spent thinking about products and services, talking to friends about them, and seeing or hearing advertisements about them. In addition, the foods people eat and the manner which they visit them significantly influence how they are satisfied with food truck products. These general concerns are more enough to justify our study of consumer satisfaction towards food truck products.

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Factors Impacting Job Satisfaction of Employees in the Fast Food Indus by Ukandu-2014.

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AUTHOR PROFILE

Author – 1



Mrs.P.Indumathy, M.Com, M.Phil., has teaching experience of 10 years, has published 7 articles in international and national journal, Participated and presented in many seminars, conference proceedings and FDP, Question paper setter, 2 Patents published.

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Dr. Priya P. currently serves as the Professor and Head of the Department of Commerce & Commerce PA at Hindusthan College of Arts & Science (Autonomous) in Coimbatore. She commenced her academic career as a Lecturer in the Department of Commerce in 2001. Over her 24 years in the field, she has experienced considerable professional advancement, reflected in the diverse positions she has occupied. Her expertise spans Finance, Marketing, Human Resources, and Information Technology. In addition, she has authored and presented a multitude of papers at both national and international conferences. Dr.

Priya P. has received the Vocational Service Award from the Rotary Club of Coimbatore Downtown. She is actively involved in various academic committees within and beyond the college, including the CDC cell, academic audit, Board of Studies, and examination cell. Moreover, she acts as a research supervisor and has successfully guided two Ph.D. candidates to completion. Dr. Priya P. has also published patents and has been invited to contribute as a Resource Person at both national and international forums.



IMPACT OF ZINCOXIDE NANOPARTICLES IN PHASE CHANGE MATERIAL FOR IMPROVING THE YIELD RATE OF SOLAR STILL

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ABSTRACT

Different nano materials are used in the solar still to enhance thermal conductivity. The larger surface area and higher thermal properties of nanoparticles are very much supported to enhance the yield rate of the solar distillation than the macro particles. The experiments were conducted in the following levels: (1) SSSS with PCM (vanaspati) only (2) SSSS with PCM (wax) and ZnO. Two identical SSSSs were built with 1 m² absorber area and tested under the same climatic conditions of Coimbatore, India during the period of March to April 2023. Here it is proven that Nano PCM has a higher potential than PCM for saline water desalination processes. The Zinc Oxide (ZnO) nanoparticles were found to be attractive for mixing with PCM to increase thermal conductivity. The results show that the induced heat transfer was significantly enhanced with metal oxide particles. The nanoparticles impregnated in phase change material with wick increased the productivity of distillation. This study demonstrates that the ZnO NPCM boosts efficiency due to the NPCM's thermal absorptance.

Key words: *Purification, Nanoparticles, Solar energy, Distillation, Latent heat, Paraffin*

1. INTRODUCTION

Water is a primary source for all living beings on this earth. The purification of water is very crucial for a healthy life and can be achieved through various methods. Here, we have used solar desalination process for purification of water with different phase change materials.

Mohammed, A. H et.al., The phase change materials have a prominent effect on improving the solar desalination output. Although solar stills are in use for decades for the desalination process, the efficiency of producing freshwater using solar stills is less when compared to other commercial techniques [1].

A.F. Mohamed et al., in their study, found that the energy efficiency of the solar still with 1-cm, 1.5-cm and 2-cm fine stone particle size was enhanced by about 65%, 104.4% and 123%, respectively compared to solar still without stones. In addition, the empirical correlations to estimate the Nusselt and Sherwood numbers inside the solar still cavity were obtained. The agreement between these correlations and experimental results was fairly good

[2]. P. Manoj Kumar et al., conducted desalination experiments in hot and humid weather conditions at Coimbatore, India during the month of April 2020 to investigate the performance of a conventional single slope passive solar still (CSS) with paraffin-based phase change material (PCM) and nano silica incorporated PCM (NPCM) in terms of fresh water yield. The results evidenced that the addition of PCM and NPCM improved the fresh water production by 51.22% and 67.07%, respectively [3]. A.S. Abdullah et al., showed that modified solar cell-internal reflector PCM (MSS-IR-PCM) was 115% more productive overall than CSS. As a result, utilizing PCM boosted MSS-IR productivity by roughly 34% when compared to the case without PCM. They also carried out an economic analysis which was also considered. For the CSS and MSS-IR-PCM, the cost of the distilled freshwater was 0.03 and 0.0235 \$/L, respectively [4]. Shahin Shoeibi et al., found that the energy efficiency of the solar desalination using activated carbon as a porous media was enhanced by 94.14%. Moreover, the productivity of the solar still desalination by aluminium fins and black steel wool fiber as a porous material was increased by about 42.3% and 20.9%, respectively [5]. A.S. Abdullah et al., achieved 2400 and 5000 mL/m² freshwater a day, respectively, with conventional and tray solar stills. Moreover, the thermal efficiency of the tray distiller with reflectors, nano-paint coating, and PCM-CuO nanoparticles mixture was 51.5% [6]. A.E. Kabeel et al., compared freshwater production by a tubular solar still (TSS) alone, TSS with paraffin wax as the phase change material (TSS with PCM) and TSS with graphene oxide nanoparticle-infused PCM, respectively. When the NPCM was used as the energy material, the evaporation rate from the absorber improved by 41.3%, whereas, the average evaporative heat transfer coefficient for TSS and TSS loaded with PCM alone improved by 32.76 and 34.32%, respectively. The total cumulative yield produced per m² area from TSS, TSS with PCM, and TSS with NPCM was found to be 2.59, 3.35 and 5.62 kg, respectively [7]. The same authors, in another work, studied the effect of concentration of graphite nano particles used along with the phase change material paraffin on the daily efficiency and achieved 51.41%, 54.94%, 59.2%, 62.38%, and 65.13% for graphite mass concentrations of 0.0%, 5%, 10%, 15%, and 20%, respectively, while for the conventional still it was about 32.257% [8]. Dashtban, M et.al., suggested that, the daily productivity was theoretically found to be 6.7 and 5.1 kg/m² per day, for the still with and without PCM, respectively. In another study, a weir-type cascade solar still was constructed and paraffin wax was used as the PCM. The results showed that the productivity of the still with PCM was theoretically 31% higher than that of one without PCM [9]. Wang, Q et.al., confirmed that phase change materials have excellent heat storage capacity and their phase transition temperature is close to a constant and they have been widely used for solar heat collection, but their thermal conductivity is low. Nanoparticles have unique photo thermal properties. Nano-enhanced phase change materials (NEPCMs) formed by dispersing NPs in PCMs can enhance the photo thermal conversion efficiency, improving the thermal conductivity of PCMs and have better application value [10]. Tripathi, B. M et.al., reported that the thermal Energy Storage (TES) using Phase Change Material (PCM) is the valuable techniques of charging, storing, and discharging thermal energy and improving solar to thermal performance and thermal conductivity of the PCM [11]. Tewari, K et.al., suggested that heat transfer enhancement is important in solar energy productivity, usage of capsule based energy storage material was improved the energy density of PCM when increases the channel to capsule ratio [12]. Zeng, L et.al., viewed that macrocapsules of Carbonate eutectic salt was used as phase change material (PCM) for high temperature thermal storage application, with good heat storage capability and good thermal cycling durability, while using the size of the capsule was 10@1.5@3 showed a high heat

storage capability of 380 J/g in a temperature range of 400–600 °C[13]. Wu, M. et.al., reported that the sodium dodecyl sulfate (SDS) was used to mix carbon black (CB) and lauric acid (LA) in the top layer to improve photo thermal conversion, and expanded graphite (EG) was added in lauric acid in the bottom layer to enhance heat transfer and study reported the ratio of the photo thermal conversion material in the top layer is 100:5:1 (LA: CB: SDS), and the preferred ratio of the bottom layer material is 100:1.4 (LA: EG), while carbon material has produced minimum effect on the latent heat properties of the whole material[14]. Kumar, A et.al., confirmed that the advanced ZnO was used to produce Maximum thermal efficiency and improved yield rate of 51% and 6600 ml/m², the productivity of ASS-ZnO/PCM has increased by about 36% compared with the PCM[15]. Sampathkumar, A et.al., The comparison is made Solar Still with Palm Flower Powder (SSPFP) and Conventional Solar Still (CSS). The fresh water yield for (SSPFP) was 3530 mL/m² in day 1 and 4120 mL/m² in day 2, whereas for (CSS) it was 2600 mL/m² in day 1 and 3100 mL/m² in day 2. The SSPFP enhanced the productivity of freshwater by 35% on day 1 and 33% on day 2 when compared to CSS [16]. Banoqitah, E et.al., reported that there are three different stepped Solar Still(SS), SS with paraffin wax, SS with paraffin wax doped with Ag nanoparticles, and SS without paraffin wax are constructed and experimental results were found that the SS using nanocomposite PCM and PCM without nano additives are remarked by about 75.65% and 114.81% respectively[17]. Thakur, A. K found that the absorber plate of a single basin solar still (SS) is coated by black paint doped with reduced graphene oxide (RGO) nano sheet of 12 wt% RGO doped with black paint-coated absorber improved the water and absorber temperature by 14.7% and 15.7%[18]. Dhasan, K. S confirmed that the experimental results showed that the influence of iron oxide nanoparticle as absorber coating material improved the rate of fresh water generation by 36.08 % than the conventional solar still for different thickness of water as 10, 20 and 30 mm is improved about 6.03, 5.36 and 4.72 kg/m² respectively [19]. Sathyamurthy, R et.al., reported that the Usage of fumed silicon oxide nanoparticle in black paint at a different concentration (10–40%) coated on the absorber plate of stepped solar still showed that the total yield of the solar still is improved by 27.2, 34.2, 18.3, and 18.4% for 10, 20, 30 and 40% respectively while compared to that of ordinary black paint [20].

2. PREPARATION OF ZnO

ZnCl₂ (0.4 M) and NaOH (0.8 M) were dissolved in de-ionized (DI) water to obtain various molarities. The NaOH solution was added into ZnCl₂ solution drop by drop under vigorous stirring without any heat treatment until a white suspension was formed. Then, each of the suspension solutions was centrifuged to obtain precipitated form of Zn(OH)₂. Finally, the precipitate of Zn(OH)₂ was calcined at the temperature of 400°C to obtain ZnO nano powder.

3. PREPARATION OF PARAFFIN WAX IMPREGNATED WITH ZnO

Paraffin wax was heated above its melting point and poured into metal tubing before being mixed with the nanoparticles. About 150 mL of wax was needed per pipe. Paraffin wax was mixed with 0.1 % zinc oxide (ZnO) nanoparticles while maintaining a temperature above the mixture's melting point. The mixture of PCM and nanoparticles was stirred using a magnetic stirrer at 350 rpm for 45 minutes at 200°C to prevent the agglomeration of nanoparticles. It is considered that if the sample weight concentration is less than 0.5%, then the thermal conductivity and stability are good. Individually impregnated 0.1% nanofluids were prepared and used to create NPCM in this research. Following this, NPCM was loaded

using a 28-cm long steel pipe and 8 such pipes were used for NPCM loading. The ends of the pipes were properly sealed using appropriate sealing procedure. The loaded pipes were positioned over the absorber of the still with the inner basin, which was then filled with 10 liters of water. The reading was recorded for 24 hours. Readings were obtained by repeating the experimental procedures for several days.

4. CONSTRUCTION OF SOLAR STILL

A single slope solar still was designed and fabricated to compare the effects of ZnO nanoparticle-incorporated paraffin wax (NPCM) and bare vanaspati (PCM) on the efficiency under the given climatic conditions of Coimbatore, Tamil Nadu. The inner system was made of 14 kilo gauge steel sheet of 2-m length and 1-m breadth. The outer system was made of 18 kilo gauge steel sheet with 90 cm length and 50 cm height. The glass and cover of solar still were sealed air tight to avoid loss of heat due to convection and radiation. A black acrylic paint was chosen for the basin material, which was painted on both the inner and outer systems for maximum solar radiation. A thermocoal sheet was used between inner and outer systems for insulation. Five temperature sensors were used in the solar still to measure the temperature of water, room, glass, air and the ambience. Two beakers were used to collect the distilled water. The working of experimental setup was checked by conducting trials. Then the actual experiment was carried out by pouring 9 liters of water into the system. For every half an hour, readings were taken from 9 am to 5 pm. Later, readings were taken from 5 pm to 9 am. Thus, the readings were taken for 24 hours. The same procedure was repeated and the readings were noted. The values were then compared and analyzed.

5. EXPERIMENTAL SETUP

The experiment was conducted on the 4th floor of B block of Hindusthan College of Arts and Science without step basin on 27-03-2023 with 7 L of input water. The observations were recorded from 9 am to 5 pm without thermal energy storage setup. The room, glass, water, air and ambient temperatures were recorded every 30 minutes. The amount of distilled water collected was measured. The experiment was repeated on 07-04-2023 with the same amount of input water (7 L) and readings were noted accordingly. Figure 1 shows the experimental setup.

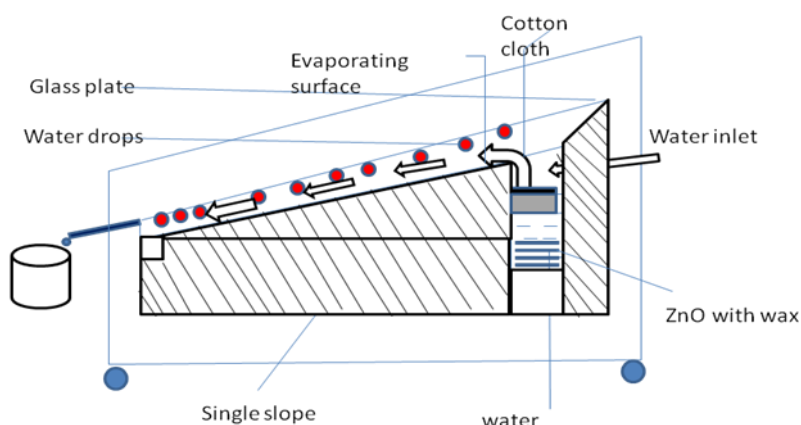


Figure 1: Cross sectional view of Single slope Solar Still

6. RESULTS AND DISCUSSION

(Figures 2 & 3) show the variation of water, air, glass, ambient and absorber temperature with respect to time for vanaspati as PCM and for ZnO nanoparticle integrated paraffin wax as PCM. The readings of the solar radiation, ambient temperature, air temperature and component temperatures of the still were recorded from 9:00 am to 6:00 pm at regular intervals of time. The solar intensity was measured by using a pyranometer. During this study, it was found that the water temperature ranged from 32°C to 59°C. Air temperature range was from 37°C to 58°C.

The glass temperature ranged from 41°C to 69°C. The ambient temperature was in the range 32°C to 40°C. The absorber temperature was in the range 34°C to 58°C. When the solar still was loaded with NPCM, the temperature of water attained a maximum of 59°C at 13:30 pm and minimum of 31°C. The air temperature attained a maximum of 64°C at 13:30 pm and a minimum of 32°C. The temperature of the glass reached a maximum of 64°C at 14:30 pm and a minimum of 31°C at 16:30 pm, respectively. The ambient temperature peaked to 53°C at 13:30 pm and declined to 36°C at 16:30 pm.

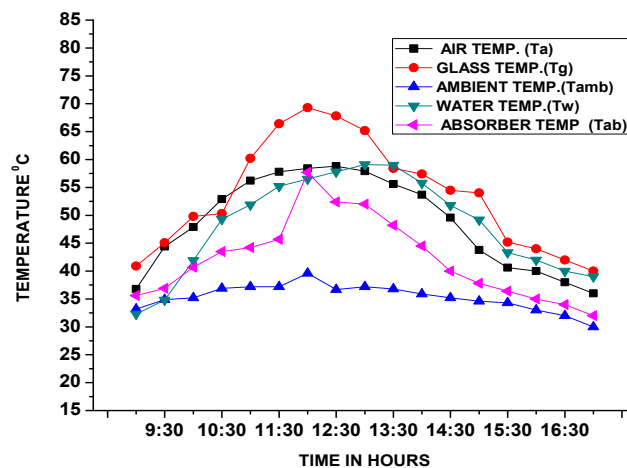


Figure 2: Temperature variation observed in SSSS with vanaspati as PCM

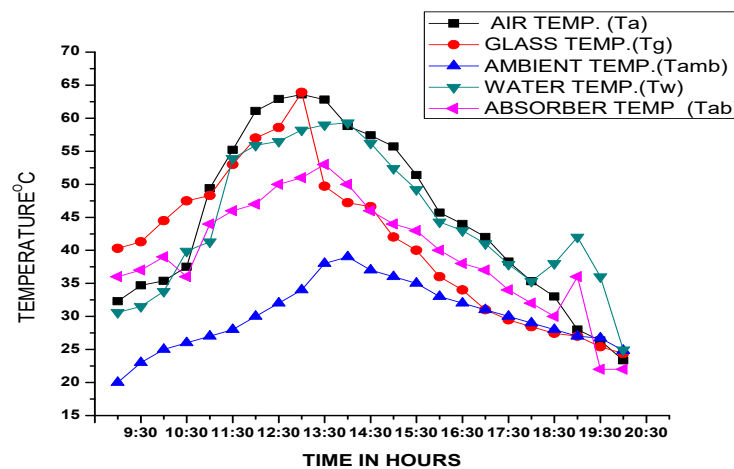


Figure 3: Temperature variation in SSSS with paraffin wax integrated with ZnO

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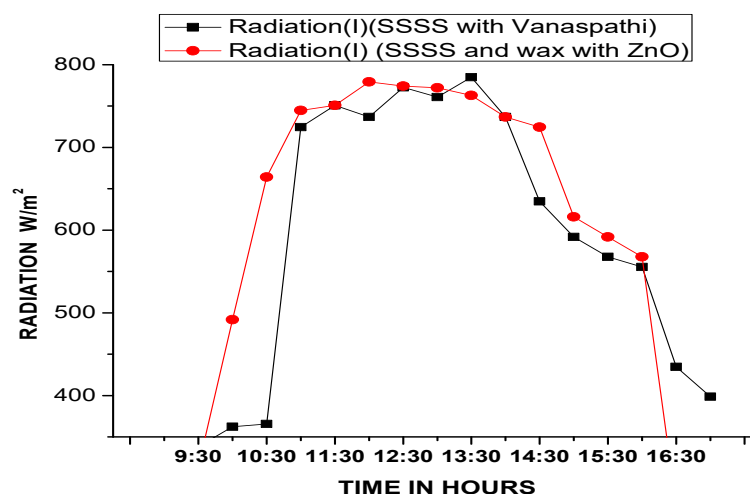


Figure 4: Variation of Solar Radiation during the experiment

The radiation was in the range 229 W/m^2 to 785 W/m^2 and 205 W/m^2 to 779 W/m^2 , respectively; when the experiments were carried out with vanaspathi and nano ZnO-integrated wax. The radiation reached maximum from 12 noon to 2 pm and decreased with time (Figure 4). With vanaspathi as PCM, the maximum output was about 90 mL at 12.30 pm and the minimum was 30 mL at 5 pm, while the PCM integrated with ZnO system yielded the maximum output of 150 mL and minimum of 40 mL (Figure 5). When compared to different water levels, we can conclude that output water increases with decrease in input water, relatively. The average yield rate with vanaspathi and ZnO-incorporated paraffin wax was 50mL and 85ml respectively.

Table 1: Water quality parameters for input, output and standard Water

PARAMETER	TAPWATER	OUTPUTWATER	MINERALWATER
pH	7.19	6.89	7.25
Na(meq/L)	27.03	0.08	0.09
Mg(meq/L)	7.05	0.02	0.19
K(meq/L)	0.37	0.05	0.02
Ca(meq/L)	5.59	-	-
CO ₃ (meq/L)	1.72	0.10	-
HCO ₃ (meq/L)	7.90	0.09	0.42
Cl(meq/L)	25.90	0.01	0.79
SO ₄ (meq/L)	-	-	-
EC (ds/m)	5.45	0.05	0.04
SAR	9.34	-	-
Adjusted SAR	29.68	-	-
RSC	-	0.23	-

Table 2: Concentration of salts/ionic species in input, output and standard water samples

Salt/ion species	Saline water	Output water	Mineral water
Calcium carbonate	1.50	-	-
Calcium bicarbonate	4.07	-	-
Magnesium bicarbonate	2.75	0.24	0.19
Magnesium chloride	5.9	-	-
Sodium bicarbonate	0.12	0.11	0.12
Sodium chloride	20.89	-	-
Residual ions (meq/L)			
Calcium	-	-	-
Magnesium	-	-	-
Sodium	7.06	-	-
Potassium	0.38	-	-
Carbonate	-	-	-
Bicarbonate	-	0.08	0.09
Chloride	-	0.90	0.76
Sulphate	-	-	-

7. CONCLUSION

A single slope solar still was experimentally analyzed using vanaspati as PCM and ZnO nanoparticle integrated paraffin wax as NPCM under the climatic conditions of Coimbatore, India. In the current study, the single slope solar still produces higher output for NPCM. Since the thermal absorptivity value for nanophase change materials is high, melting would occur much more quickly than it would at conventional PCM temperatures. Here, NPCM has boosted the system output. It raises the solar still temperature at off sunshine period and causes release of more energy. The output of solar stills improved by phase change materials enhanced with ZnO nanoparticles was 35% higher than that of solar stills using only PCM (vanaspati).

Scope for future work

Future research can be done in incorporating various nanoparticles with PCM beneath the basin to improve the yield rate, thermal properties, heat transfer characteristics and continuous production of fresh water even during the night. The development of software for the purpose of modeling and simulation in solar stills with respect to the various parameters can be undertaken. Glass is used as the cover in most stills, but the maintenance of glass is troublesome. Further research can be done to replace the glass with alternative materials without loss of performance.

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BIMETALLIC COPPER-ZINC NANOPARTICLES USING PUNICA GRANTUM: A BIO-INSPIRED APPROACH TOWARDS TUNABLE ELECTRONIC PROPERTIES AND ENHANCED ANTI-MICROBIAL AND ANTI-OXIDANT ACTIVITY

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ABSTRACT

Combining metallic nanoparticles with natural extracts has gained attention for its potential to enhance antimicrobial properties. This study explores the synergistic effects of copper (Cu) and zinc (Zn) nanoparticles when mixed with *Punica granatum* peel extract (PPE). The synthesis of Cu and Zn nanoparticles was achieved using a green synthesis approach, ensuring environmental sustainability and biocompatibility. The PPE, rich in polyphenolic compounds, was utilized for its inherent antimicrobial activity and potential synergistic effects when combined with metal nanoparticles. The synthesized Cu-Zn with PPE nanoparticles were characterized through various spectral analyses such as Ultraviolet (UV), Fourier Transform-Infrared (FT-IR), X-ray diffraction (XRD), Energy-dispersive X-ray spectroscopy (EDX), Field emission scanning microscopy (FESEM) and Photoluminescence (PL). The results demonstrate a remarkable synergistic effect between Cu and Zn nanoparticles in combination with PPE. The XRD result shows a Hexagonal crystalline structure. In addition to having antibacterial, anticancer, and antifungal properties, the nanoparticles were an efficient electrical component and an excellent conductor.

Keywords: Nanocomposite, *Punica granatum*, Fourier Transform-Infrared (FT-IR), *Punica granatum* peel (PPE).

1. INTRODUCTION

The scientific technology of today is heavily influenced by nanoscience and nanotechnology. They are increasing a particle's efficiency at a smaller size. They range in size from 1 to 100 nanometres and have become a crucial and cutting-edge technology for nanomaterials. Natural synthesis is an effective method of producing nanoparticles. They have a wide range of applications due to their non-toxicity, affordability, and environmental friendliness. Both plant extract and microorganisms, such as bacteria, yeast, and fungi, can be used in the green method. (Because the process is naturally focused and it is orientated naturally.)

Copper nanoparticles (CuNPs) are in high demand for a variety of scientific and industrial applications because of their special physicochemical characteristics. Due to their strong antibacterial features, medical devices and coatings use them to prevent bacterial infections. Further, copper nanoparticles are used to accelerate and improve the selectivity of chemical



reactions. CuNP's size, shape, and surface quality are all determined by their synthesis techniques, which include chemical reduction, electrochemical deposition, and green synthesis with plant extracts. These are the factors that affect the CuNPs' functionality and prospective applications.

Due to their unique physicochemical properties, zinc nanoparticles (ZnNPs) have emerged as a novel formulation in nanotechnology. These nanoparticles can be utilized in diagnosing diseases, eliminating the danger of false-positive results. Owing to their remarkable pharmacological properties among antiviral, antifungal, and antibacterial capabilities, ZnNPs are of great interest for pharmaceutical and medical applications. High surface can improve performance, we can matrix use that ability to target therapeutic to salient and smart drug-delivering devices. Zinc nanoparticles (ZnNPs) are highly reactive and tend to absorb and degrade pollutants. Thus, right now seems like a good time to put their amazing properties to work in environmental remediation, particularly in the realm of water purification. Only then can we take full advantage of their wonderful abilities. Particular investigation on zinc nanoparticles also points to their potential application in biological systems due to their low radiotoxicity and biocompatibility.

Strong antioxidants discovered in pomegranate skins strongly shield against severe heart, and deadly troubles, too. So, pomegranate peels may be used both in poultry feed and in the culinary business. Known for being home to troves of bioactive compounds that transform a lot of what occurs in the body, pomegranate peels could impact heart disease, inflammation, bacteria, healing, and infection by interfering with key processes. They have stabilizing and decreasing properties.

Pomegranate peel extract has shown the potential to synthesize copper and zinc nanoparticles in our present work. The characterization of the Cu-Zn nanoparticles based on pomegranate peels has been carried out using a variety of spectral studies such as Field Emission Scanning Electron Microscope (FESEM), photoluminescence, and, Photoluminescence (PL), X-ray Diffraction (XRD), Fourier Transform-Infrared (FT-IR), Ultraviolet (UV) and Energy Dispersive X-ray Spectroscopy (EDX).

2. MATERIALS AND METHOD

The major materials used can be classified into chemicals required and extract required. The chemicals required are Copper nitrate ($\text{Cu}(\text{NO}_3)_2$) and Zinc nitrate ($\text{Zn}(\text{NO}_3)_2$) while the extract used in the project is pomegranate (*Punica granatum*) peel extract.

3. PREPARATION OF PPE

To prepare the plant extract fresh pomegranate peel (100grams) was used those pomegranates were taken from the nearby tree, to remove the dust particles and unwanted visible particles they were washed with tap water twice and then it was cleaned with the deionized water. The peel was cut down into small pieces so that they could be granulated that peel which was granulated physically with the help of the motor and pestle. The extract is then added to the 50 ml of distilled water and boiled for 30 minutes at 90°C . After that process yellow solution was obtained the solution was filtered with Whatman filter paper to eliminate unwanted particles and procure an exact solution.

4. SYNTHESIS OF CU-ZN NANOCOMPOSITE

To produce Copper and Zinc Nano particle 5 grams of Copper and 5 grams of zinc were diluted in distilled water (60ml) and then boiled at 90°C for 45 minutes. Then pomegranate

peel extract (20ml) was mixed dropwise and then was allowed to stirring process with the magnetic stirrer for 30 minutes at 90°C. There we obtained a color change that confirmed the presence of Copper and Zinc formation with peel extract. The solution mixed with the copper zinc nanoparticle and pomegranate peel extract is allowed to settle down for two hours then the settled particle composites are heated using a magnetic stirrer, Precipitation is kept at a muffle furnace for about 1hr at 440°C. The particles grain. Finally sample is collected in a container they were used to utilize for EDAX, XRD, UV, FE-SEM, PL, FTIR, Antibacterial, Antifungal, Anticancer test.

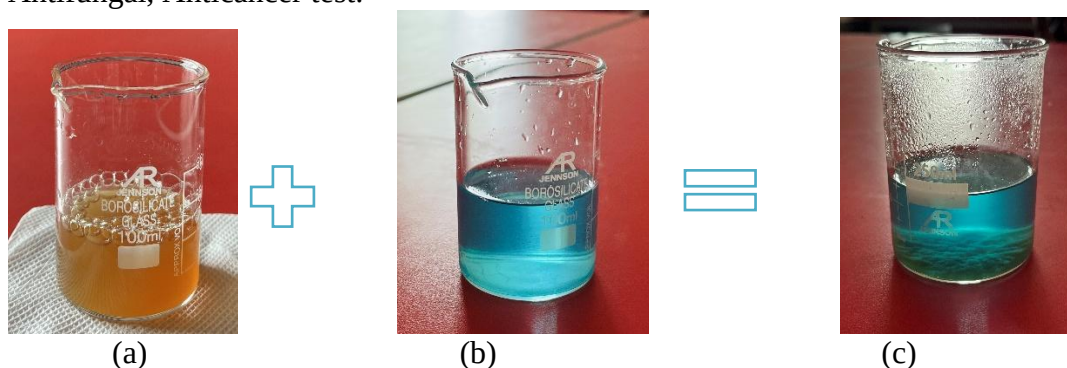


Figure 1: (a) Beaker with pomegranate peel solution (b) Beaker with Cu-Zn solution (c) Beaker with Cu-Zn nanocomposite

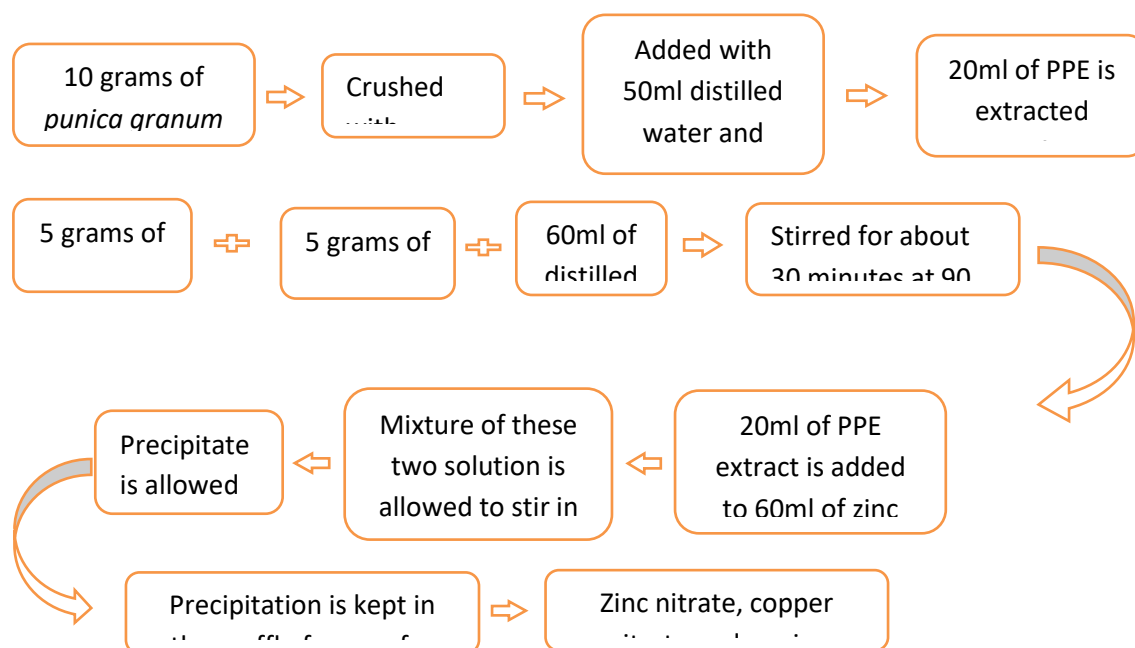


Figure 2: Flow chart of the procedure

5. RESULT AND DISCUSSION

5.1 ENERGY DISPERSIVE X-RAY SPECTROSCOPY (EDX)

An energy-dispersive X-ray study was carried out to look at the elemental composition of the synthesized samples for the conformation of nanocomposite formation. EDAX analysis identified several elements in the synthesized nanopowder, including copper (Cu), zinc (Zn),

and oxygen (O). This suggests that the nanopowder may be a composite material containing these elements. The composition of the percentage of copper and zinc is shown in the figure. The presence of oxygen is much higher than the concentration of copper and zinc in the nanocomposite so it indicates the formation of oxides.

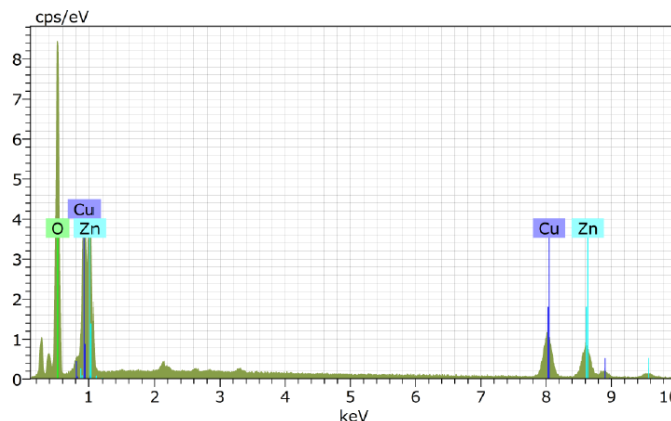


Figure 3: Energy dispersive X-ray analysis of Cu-Zn nanocomposite with PPE

5.2 X-RAY DIFFRACTION ANALYSIS

X-ray properties such as phase composition, crystal structure, and orientation of powder, solid, and liquid samples. Diffraction analysis is used to analyze physical The XRD patterns of synthesized PPE-mediated Cu-Zn nanocomposite are shown in the figure (4).

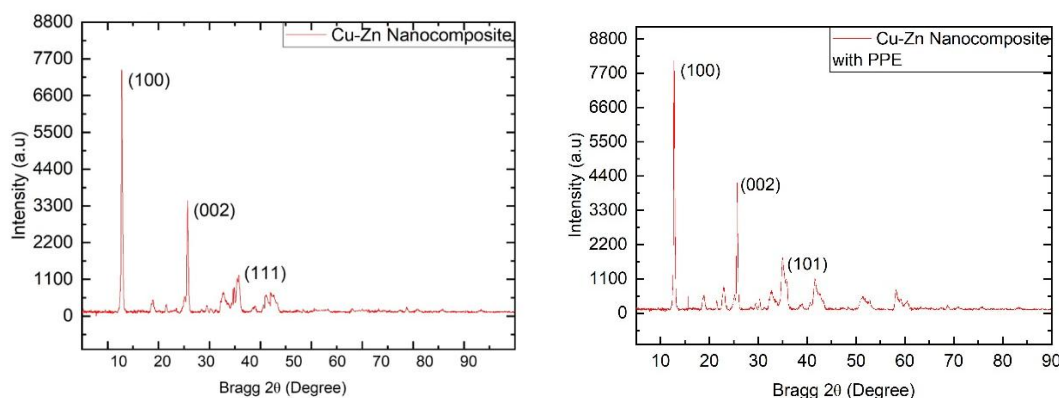


Figure 4: X-ray diffraction of Cu-Zn nanocomposite with and without PPE

The average grain size of all the prepared nanocomposite samples is determined by using the Debye-Scherrer formula:

$$D = k\lambda / (\beta \cos \theta) \quad (1)$$

Consequently the average size is 34.36 nm for nanocomposite with PPE while the average grain size of nanocomposite without PPE extract is found out to be in a range between 36.77-55.45.

5.3 FIELD EMISSION SCANNING ELECTRON MICROSCOPE ANALYSIS (FESEM)

The structural and morphological properties of the nanocomposite are analyzed using FESEM. The size of the particles synthesized is within the nanometer range and they have agglomerated structure. FESEM provides high-resolution images of the surface morphology of a wide range of materials at magnifications ranging from tens to hundreds of thousands of

times. This allows for a detailed examination of surface features such as roughness, texture, and topography

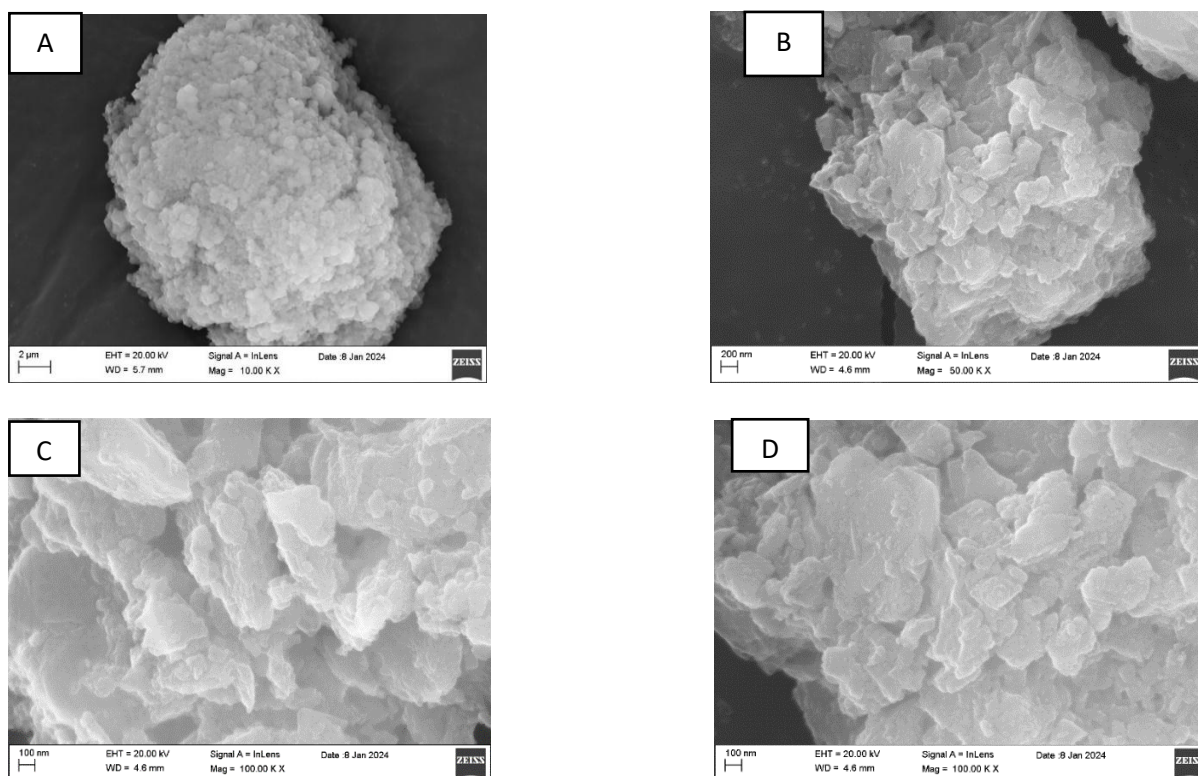


Figure 5: (A) FESEM image of Cu-Zn nanocomposite taken at 2 μ m, (B) FESEM image image of Cu-Zn nanocomposite taken at 200 nm, (C) FESEM image image of Cu-Zn nanocomposite taken at 100 nm, (D) FESEM image image of Cu-Zn nanocomposite taken at 100 nm

5.4 FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

Based on the FTIR spectra the eco-friendly green synthesis of copper and zinc nanocomposite mediated by pomegranate peel extract is revealed. The stretching vibration band of O-H of the alcohol group, as well as the presence of thiocyanate (S-C $\equiv$ N) and allene group (C $\equiv$ C $\equiv$ C), are shown by the absorption peaks 3372.04 cm⁻¹, 2161.78 cm⁻¹, and 1976.36 cm⁻¹. Similarly, the stretching vibration band of the C=N oxime group, carboxylic acid group (O-H), and alcohol group (O-H) are shown by the absorption peaks 1640.02 cm⁻¹, 1417.23 cm⁻¹ and 1359.74 cm⁻¹. The presence of aromatic ester groups (C-O) and amine (C-N) groups are indicated by the peaks 1289.30 cm⁻¹ and 1036.33 cm⁻¹. The peaks at 1976.36 cm⁻¹ and 1417.23 cm⁻¹ were assigned to the C $\equiv$ C $\equiv$ C Stretching band of allenes and carboxylic acid are medium, suggesting their contribution to their stability.

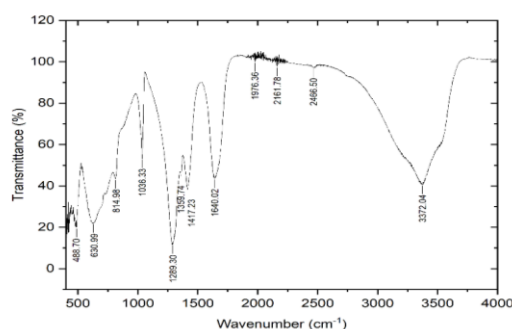


Figure 6: FTIR pattern of synthesized PPE with Cu-Zn nanocomposite

5.6 ULTRAVIOLET VISIBLE SPECTROMETER

The UV absorption of Cu-Zn nanocomposite is shown in the figure (7) at wavelength range from 300-750 nm. By observing how the radiation is absorbed, it's possible to detect the presence of nanoparticles based on their unique light-matter interaction. The absorbance value is exclusively dependent on various factors like the size of nanoparticles and deformities or defects in the grain structure. The UV-Vis spectrum of CU-Zn NPs shows the maximum absorption peak at 450 nm due to exciton recombination at room temperature.

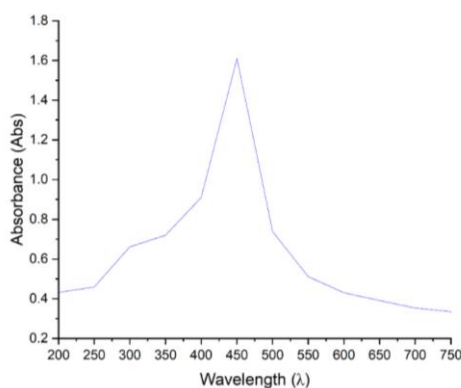


Figure 7: UV spectroscopy graph of the sample

The band gap was calculated using the tauc equation. The bandgap energy calculated from the Tauc's plotting for the directly allowed transition, described by the equation was found to be 2.4 eV respectively for Cu-Zn nanocomposite.

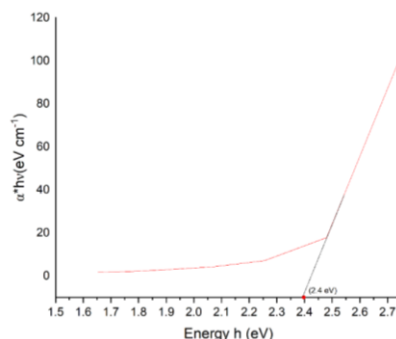


Figure 8: Tauc's plot of the UV spectrum

5.7 PHOTOLUMINESCENCE

For crystalline quality and to study the effects of Cu-doping on ZnO optical properties, the photoluminescence (PL) technique was used. The material first absorbs light energy, typically in the form of ultraviolet or visible light. This absorbed energy excites the electrons in the material, pushing them to a higher energy level. When the excited electrons return to their ground state, they release energy in the form of light. This emitted light is what we observe as photoluminescence. The peak was obtained at 570 nm.

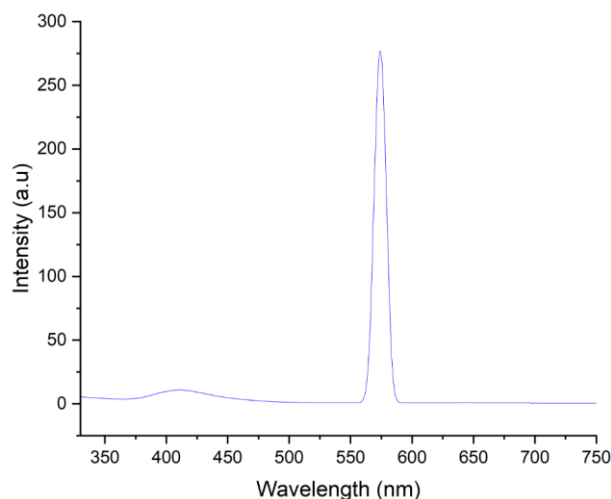


Figure 9: Graph showing photoluminescence

5.8 ANTI-BACTERIAL

The antibacterial activity against *Escherichia coli* (E.Coli) and *Staphylococcus aureus* (S.Aureus) has been analyzed. All media cultures, pipette tips water, and glassware used for the microbiology testing were sterilized using by autoclave. *Escherichia coli* (E.coli) is a gram-negative bacteria and *Staphylococcus aureus* (s.aureus) a gram-positive bacteria were used for the studies. Aqueous solution suspension of nanocomposite ranging from 50 µg/ml, 100 µg/ml, 250 µg/ml, and 500 µg/ml was used on the bacteria. Figure (10) shows nanocomposites varying activity on *Escherichia coli* (E.coli) which is a gram-negative bacteria. The activity depended on the concentration of the nanocomposite. The nanocomposite concentration at 100 ml and 50 ml shows the least activity, while the concentration at 250 ml and 500 ml has significant antibacterial activity.

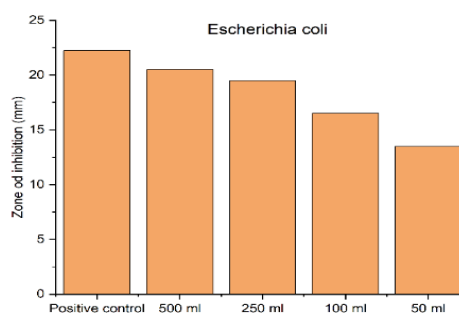


Figure 10: Effect of sample PG against E.coli

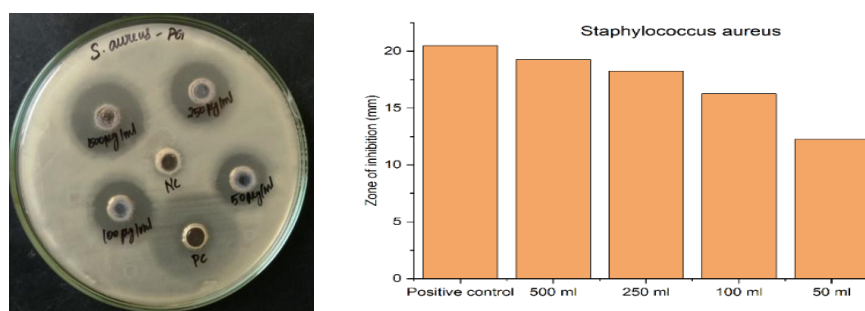


Figure 11: Effect of sample PG against *Staphylococcus aureus*

Nanocomposite however showed higher activity on *Staphylococcus aureus* (S.Aureus). Nanocomposite concentration from 250 ml to 500 ml showed activity as shown in Figure (11), the concentration at 100 ml and 50 ml is significantly lower compared to the higher concentration.

5.9 ANTI-OXIDANT ACTIVITY

Antioxidant properties describe a substance's capacity to neutralize or prevent the oxidation of other molecules. These properties are crucial for safeguarding cells and tissues from damage inflicted by harmful free radicals.

To measure antioxidant capacity, different assays or techniques are used, including:

5.9.1 SUPEROXIDE RADICAL SCAVENGING ACTIVITY

Dismissing superoxide radicals in which superoxide anion is able to take away them by means of reducing yellow dye (NBT²⁺) and generating blue formazan. Superoxide radical scavenging activity of Cu-Zn-PPE NC was at maximum when it was 100 µg/mL as it was at 61.23%. Rutin, on the other hand, had a scavenging activity of 55.87%. The O₂-anion can adversely affect cell components over long periods of time. There is a decrease in absorbance in the reaction mixture containing antioxidants indicating an involvement of superoxide anion in this process. Antioxidants can effectively inhibit formation of blue nitroblue tetrazolium (NBT) precipitate significantly. Hence, there are numerous research works showing that flavonoids function extensively as effective antioxidants through eliminating superoxide anions. Thus, while this might be true, depending on concentration type will determine whether Cu-Zn-PPE NC will eliminate superoxide radicals more efficiently than any other.

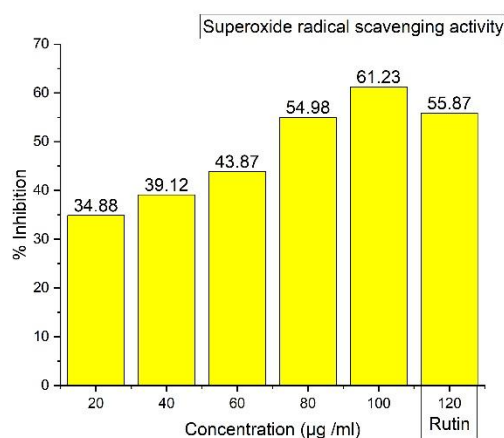


Figure 12: Graph showing the superoxide radical scavenging activity

5.9.2 FRAP RADICAL SCAVENGING ACTIVITY

The nanocomposites derived from *A. sativum* are employed in the ferric (Fe^{3+}) reducing power test which changes Fe^{3+} to Fe^{2+} . A ferro-ferric substance is obtained in line with the earlier described procedure. The color of the Cu-Zn-PPE NC depends on how much antioxidants of different types are present in it and can vary between yellow, blue and green shades. This color change serves as an indicator for Cu-Zn-PPE NC's capability to clean up impurities. A molecule's ability for reduction transformations could serve as a reliable predictor of antioxidant effectiveness. At a 100 $\mu\text{g/mL}$ concentration, the fastest drop in Fe^{3+} observed is 62.12%. It is also important to mention that at the same concentration normal trolox showed drop by 36.54% (figure 13).

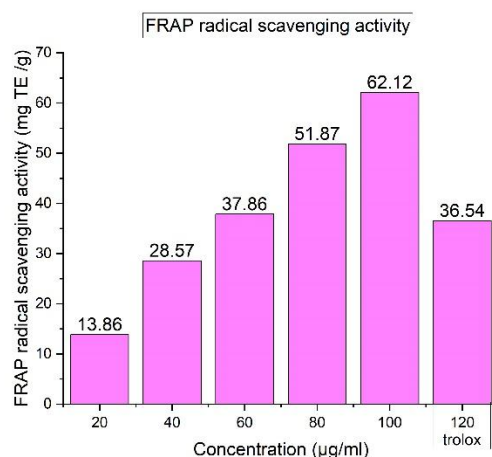


Figure 13: Graph showing the FRAP radical scavenging activity

5.9.3 ABTS RADICAL SCAVENGING ACTIVITY

ABTS radical cation generation in the process of oxidizing ABTS using potassium persulfate was shown by Re et al. [12]. Also, according to Shen et al.'s study [13], the radical cation was reduced by antioxidants donating hydrogen. Noticing that during the chemical reaction the blue ABTS radical cation lost its color gradually where Ilyasov et al. [14]. Also significantly increased ($p < 0.05$) with an increase in the extracts concentrations on ABTS radicals were Cu-Zn-PPE NC whose scavenging power Figure indicates higher than other metallic concentrations (Bar chart). Chloride salts of copper, zinc and PPE are able to inhibit antioxidant enzymes thus counteracting these radical compounds Trolox however can inhibit only 38.24% while scatterings effectiveness for reducing agents range from 33.22% to 70.18%.

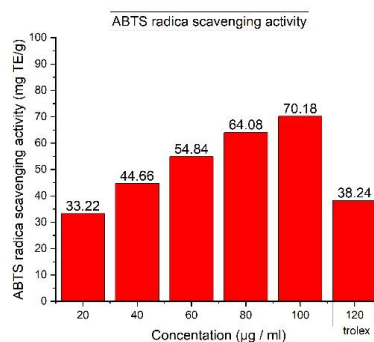


Figure 14: Graph showing the ABTS radical scavenging activity

5.9.4 DPPH RADICAL SCAVENGING ACTIVITY

Most times DPPH radical quenching assays are used to assess total antioxidant capacity. Qian et al. [11] have indicated that a certain antioxidant compound efficiently scavenges DPPH radicals leading to potential inhibition of one of the various ways lipid peroxidation generates oxidative stress. In our experiment, we checked for the radical scavenging abilities at different concentrations of Cu-Zn-PPE NCs. Scavenging tests with Cu-Zn-PPE NCs showed this effective materials properties, resulting in a significant decrease ($p < 0.05$) in DPPH levels (Fig.). The study used Rutin as the standard, which had inhibition percentages of 44.25%, 58.28%, 65.17%, 76.38% and 90.96%.

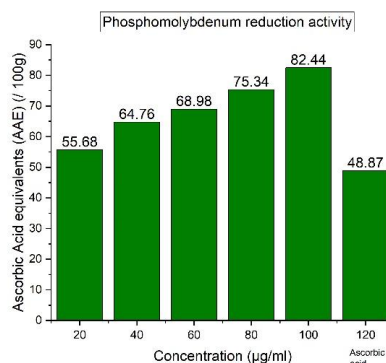


Figure 15: Graph showing the DPPH radical scavenging activity

5.10 ANTIFUNGAL ACTIVITY

The antifungal activity of the synthesized nanocomposite was assessed against *Fusarium oxysporum* and *Phanerochaete chrysosporium* by measuring the mycelial growth. Antifungal potential was observed more in *Fusarium oxysporum* than in *Phanerochaete chrysosporium*. Thus Cu-Zn nanocomposite exhibits very effective broad-spectrum antifungal activities.

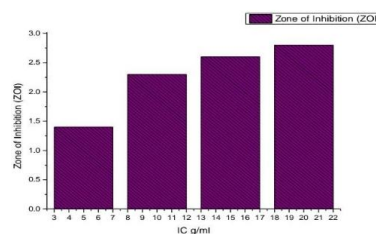


Figure 16: Effect of sample against *Fusarium oxysporum*

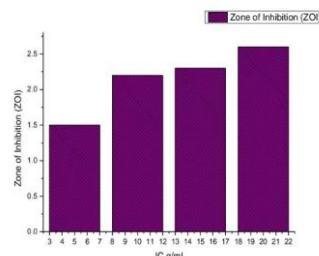


Figure 17: Effect of sample against *Phanerochaete chrysosporium*



6. CONCLUSION

The synthesis of copper, zinc and PPE extract Nanocomposites in the current experiment was quickly produced at low cost and with no environmental impact. The prepared samples were used for various characterization studies such as (EDAX, XRD, FESEM, FT-IR, UV, PL, Antibacterial, Antifungal, and Anticancer). The EDAX analysis specifies the presence of copper and zinc which indicates the formation of the nanocomposite. The XRD studies confirm the hexagonal crystal structure from the copper, zinc, and PPE extract nanocomposite. The particle size was calculated using a diffraction angle is about **34.36 nm**. FESEM analysis confirmed that the synthesized nanocomposites have an Agglomeration shape. The UV analysis gives the absorption peak of the synthesized copper, zinc, and PPE extract nanocomposite band gap energy was calculated (2.4 eV) from the resultant band gap, it is confirmed that our sample is a good conductor. The separation of photogenerated charge carriers is studied Using Photoluminescence (PL). The Green synthesized nanocomposites showed antibacterial activity against *Escherichia coli* (E.coli) and *Staphylococcus aureus* (S.Aureus). Among those two higher activity is observed on *Staphylococcus aureus* (S.Aureus). The green synthesized nanocomposites in the current study exposed the antifungal activity against *Fusarium oxysporum* and *Phanerochaete chrysosporium*. It provides the zone of inhibition is greater for *Fusarium oxysporum*. These findings indicate that this sample could be a promising source of natural antioxidants.

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Volume: 1
Issue: 1
September 2024

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PER ISSUE: RS.500/-
ANNUAL : RS.2000/-

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