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List of Publication AY: 2025-26

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2	Dr. Vandana Agrawal, Dr. Shital Prashad	Sustainable Application of Microalgae for treatment of Textile Industry waste water: Recent progress and challenges	Brazilian Journal of Chemical Engg.	SCI (Q3)
3	Dr. Irfanullah Khan	Sustainable Finance in a New Era: Trends, Themes, Theories, Innovations through bibliometric and narrative insights	sustainable features (Elsevier)	SCI (Q1)
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6	Mr. Ajeet Yadav, Mr. Shalabh Saxena	Domestic Payment Frauds in India (2022–2025): A Quantitative Analysis of Trends, Risk Indicators, and Policy Implications	Nolegein Journal of Supply Chain and Logistics Management	Google Scholar
7	Dr. Anupama Jain	A Thorough Analysis of How Corporate Social Responsibility Affects Consumer Behavior	NOLEGEIN-Journal of Global Marketing	Crossref
8	Dr. Anupama Jain, Ms. Moulima das	Artificial Intelligence and Sustainable Consumer Behavior: Drivers, Mechanisms, and Implications for Green Marketing	INTERNATIONAL JOURNAL OFADVANCED RESEARCH IN COMMERCE,MANAGEMENT & SOCIAL SCIENCE	Crossref
9	Ms. Shefali Madan	Balancing Performance and Privacy in Machine Learning: Issues and Practical Solution	Research & Review: Machine Learning and Cloud Computing (e-ISSN: 2583-4835)	

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10	Ms. Shefali Madan	Comparative Study on Air Pollution Prediction Using Machine Learning Techniques	International Journal of Current Engineering and Technology (IJCET)	
11	Ms. Shefali Madan	Multi-Agent System for Distributed Decision-Making in Autonomous Vehicles	2026 6th International Conference on Intelligent Technologies (CONIT)	Scopus
12	Dr. Stuti Saxena	Hybrid AI Techniques for Enhancing Power System Stability	Hybrid AI Techniques for Enhancing Power System Stability, IEEE conference	Scopus
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14	Dr. B L Yadav	NEP 2020 as a Catalyst for Vikshit Bharat 2047: A Comprehensive Analytical Study	INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH AND ENGINEERING TRENDS	
15	Dr. Rajesh Kumar Singh	Advanced Air Quality Prediction Using Multimodal Data and Dynamic Modelling Techniques	Scientific Reports	SCI (Q1)
16	Dr. Irfanullah Khan	Exploring E-Impulse Buying through Promotional Strategies	Int. J. Media. Mas. Com.	
17	Dr. Irfanullah Khan	Mapping evolving immersive customer experiences (CX) and virtual engagement in the meta verse: insights from bliometrics-topic modelling synthesis	International Journal of Information Technology	Scimago Q1
18	Dr. Irfanullah Khan	Artificial intelligence (AI) and machine learning (ML) in marketing: a 25-year bibliometric-TCCM synthesized mapping of trends, gaps and future research agenda	Quality & Quantity: International Journal of Methodology	Scimago Q1

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19	Dr. Irfanullah Khan	Customer Experience (CX) in Virtual Realms: A Theories-Contexts-Characteristics-Methodologies (TCCM) Guided Bibliometric Study	Journal of Global Marketing	Scimago Q1
20	Sunil Verma	Synthesis and Characterization of Aminophenyl (p-hydroxyphenyl)Tellurium(IV) Dichlorides	Journal of Modern Chemistry & Chemical Technology ISSN: 2229-6999 (Online) ISSN: 2321-5208 (Print) Volume 17, Issue 2, 2026 May–August DOI (Journal): 10.37591/JoMCCT	

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International Journal of Communication Systems

WILEY

RESEARCH ARTICLE

Modeling and Circuit Theory Analysis of Dual-Band Line Fed Microstrip Patch Antenna for the Application of Wireless Communication

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Keywords: dual band | equivalent circuit | FR-4 | line feed | notch

ABSTRACT

An equivalent circuit-based microstrip antenna of dual-band characteristics has been planned by cutting six vertical rectangular notches of different sizes in this article. The bandwidth of the presented antenna is achieved 23.77% (420 MHz) and 5.46% (137 MHz). The antenna is resonating in dual band at 1.903 and 2.489 GHz with return losses of −35.28 and −23.10 dB, respectively. The suggested antenna structure have frequency band between 1.557 and 1.977 GHz in the lower band and 2.441 and 2.578 GHz in the upper band. The gain of the suggested antenna is 3.760 dBi at 1.903 GHz and 3.803 dBi at 2.489 GHz. The efficiency of proposed antenna is 90% and 89% at both resonating frequencies 1.903 and 2.489 GHz, respectively. However, more than 81% antenna efficiency is observed in both operating bands. The suggested microstrip antenna is fabricated on FR-4 substrate of size $39.04 \times 47.64\,mm^2$ ($0.25 \times 0.30\ \lambda_0^2$ at frequency 1.903 GHz) and excited by microstrip line feed of 50 Ω. The presented design of antenna is validated with measurement and equivalent circuit. The lower resonating band 1.557–1.977 GHz is suitable for GPS (1.575 GHz), GSM 2G (1.8 GHz), and PCS (1.90 GHz). However, upper resonating band 2.441–2.578 GHz is suitable for Bluetooth (2.45 GHz), ISM band (2.45 GHz), and 4G (2.5 GHz) applications.

1 | Introduction

The antenna is a key element for wireless communications; it works as a transducer that converts electrical signals to electromagnetic waves at the transmitter end and works in reverse at the receiver end [1]. Although there are many various kinds of antennas used in wireless applications, the microstrip antenna is the most commonly used kind because of its low profile, planar structure, and ease of integration with radio frequency circuits [2, 3]. The need to build an antenna for several wireless applications is high. There is a lot of work that has been done to design such types of antennas, but these antennas have different drawbacks such as large size, complex design, and high cost [4, 5]. The antenna should be simple to design and easy to integrate with RF circuit. Further based on applications, bandwidth, gain, and radiation pattern are desirable [6].

There are different design techniques utilized to achieve more than one band in the antenna such as split rings [7], cutting slits and slots [8], fractal shapes [9], parasitic ring [10], defected

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REVIEW ARTICLE

Sustainable application of microalgae for treatment of textile industry wastewater: recent progress and challenges

Shamshad Ahmad[1] · Vandana Agrawal[2] · Shital Prasad[2] · Dinesh Kumar Sharma[3] · Bindu Mangla[4]

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Abstract

Textile wastewater is known to possess high color intensity, intricate structures of dyes, salinity, and a high level of chemical oxygen demand. Such wastewater is difficult to treat using conventional biological treatment methods. Dyes are known to persist in water bodies and are recalcitrant in nature, especially azo dyes, which are known to interfere with light penetration in water bodies. Such dyes are a major threat to water resources and human health. In recent times, phycoremediation using microalgae is being considered a promising and economically viable method of treating textile wastewater while producing a valuable resource. In this paper, a structured review of microalgae in textile wastewater treatment is provided. Literature on textile wastewater treatment using microalgae and removal of dyes from textile wastewater using microalgae is reviewed. Scientific literature published in recent times (2000 to 2024) is collected from various scientific databases such as Scopus, Web of Science, and Google Scholar using keywords such as microalgae, textile wastewater treatment, and phycoremediation. This review covers the toxic effects of textile dyes and their environmental impacts, methods of removal of dyes by microalgae (biosorption, bioaccumulation, and biodegradation), and the effectiveness of different species of algae in TWW treatment. Emphasis is placed on the challenges associated with TWW treatment, which are distinct from those of other wastewaters. These challenges include photoinhibition by colored dyes, high salinity levels, variable nutrient composition, and stability of synthetic dyes. Moreover, the use of photobioreactors and open ponds in cultivating algae for TWW treatment is explored, in addition to biomass exploitation for biofuel production. The gaps in TWW treatment using microalgae are also presented, which include pilot-scale studies, effective strains of algae that are resistant to variable TWW composition, and harvesting technologies for scaling up the process.

Keywords Biofuel · Bioremediation · Eutrophication · Microalgae · Textile wastewater

Introduction

With the advancement of science and technology, environmental degradation has become one of the major global challenges. Wastewater released from industrial settlements and the domestic sector is now considered as a primary source of pollution in water bodies. It has been observed that about 52% of global wastewater is treated safely, while 48% of household wastewater is discharged without proper treatment (Sanmuga et al. 2014). Due to inadequate treatment, wastewater has become a primary pollutant in our water bodies. Water quality deteriorates as a result of the massive amounts of wastewater produced by numerous industries worldwide, including the tannery, nuclear, brewery, dyeing, food processing, olive oil milling, iron and steel, and textile industries. Water resources, soil fertility, aquatic life, and ecosystem integrity are all negatively impacted by the release of hazardous effluents from different sectors. One of the major issues facing the textile industry is the presence of color in its effluents. (Routoula et al. 2020). These businesses produce vividly coloured effluents, which harm the environment when they are dumped into receiving waters.

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Sustainable finance in a new era: Trends, themes, theories, and innovations through bibliometric and narrative insights

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Abstract

Amid rising climate disasters, persistent social issues, and governance challenges, sustainable finance and its innovative tools have become increasingly important worldwide. This review offers a comprehensive overview of the evolution and future directions in sustainable finance, examining trends in publication, subject categories, co-authorship networks, keywords, countries, institutions, journal co-citations, and cluster analysis. The study uniquely combined bibliometric analysis, network mapping, LDA topic modeling, and the TCCM framework to provide a systematic analysis of sustainable finance literature. Results emphasize the need for increased global collaboration among researchers. Future research areas include carbon trading, financial inclusion, reporting standards to prevent greenwashing, climate change impacts, mobilizing sustainable finance through green bonds, and exploring technological links between sustainable finance, blockchain, and AI. The study also offers practical implications for stakeholders.

Previous
Next

Keywords

Bibliometric analysis; Climate finance; ESG investing; LDA analysis; Sustainability; TCCM analysis

1. Introduction

The global financial system is undergoing a paradigm shift from a profit-centric, short-term focus to a sustainability-integrated, forward-looking, and risk-impact-return financial system [1]. Recent issues, such as global warming, biodiversity loss, social inequality, and governance failures, have compelled organizations worldwide to reassess their financial decision-making [2,3]. As the world faces unprecedented challenges, the role of finance is being redefined as a key contributor to economic growth and a catalyst for sustainable development. The focus shifts from short-term financial returns to balanced economic, social, and environmental returns. The global sustainable finance market was valued at $5.87 trillion in 2024 and is expected to reach $18.8 trillion by 2029 [4]. It is expected to grow at a Compound Annual Growth Rate (CAGR) of 19.8%.[1] A comprehensive overview of research trends, global policy shifts, key themes in SRI, theories, technological innovations, and a robust framework is needed to advance sustainable finance insights.

Sustainable finance is defined as the process of considering environmental, social, and governance factors when making investment decisions [5,6]. The objective is to invest in long-term sustainable finance projects rather than short-term ones. It enables an economy to divert its resources toward low-carbon initiatives, promoting long-term resilience and a sustainable, inclusive economy [7]. Additionally, the financial system supports the United Nations Sustainable Development Goals (UN-SDGs), aligning financial objectives with broader societal and environmental goals [4,8,9].

The roots of green and sustainable finance can be traced back to the 1970s, when the Industrial Revolution began and the world shifted its attention to environmental concerns like never before [6]. The governments of developed nations, such as the United States, have begun to emphasize climate finance by introducing the United States Superfund Act of 1980, which aims to protect human health and the environment [10]. Initially, the business was compelled to address climate concerns solely due to government regulatory requirements. Gradually, consumers' awareness increased as the role of corporate social responsibility grew, leading investors to invest in products with a social cause and to contribute to a better world. As a result, the corporations realised the potential of the environment-friendly initiatives [11,12]. Various studies have demonstrated that environmentally friendly projects generate higher profits; consequently, an increasing number of organisations, banks, and financial institutions are inclined to finance projects aimed at mitigating environmental concerns [13,14]. The organisations face several challenges in financing such projects due to the high level of uncertainty and low expected profit, which has prompted financial institutions and banks to develop innovative financing methods to overcome this challenge. Green finance, also known as sustainable finance, is a response to this issue and has emerged as an alternative to traditional financing methods to address the pressing problem [[15], [16], [17]].

"Analyzing the Impact of AI-Driven Platforms on Higher Education in India: A Digital Pedagogy Approach"

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ABSTRACT:

India is home to the largest higher education system globally; hence, it is facing various challenges that are affecting its students, such as rural-urban disparities, outdated curricula, faculty deficiencies, as well as inadequate infrastructural facilities that are making its students unemployable. The NEP 2020 is a champion of technology-enabled initiatives such as SWAYAM, DIKSHA, and e-Pathshala to enhance accessibility, equity, and 21st-century skills; however, the adoption of AI is limited in various HEIs. The current research is a narrative thematic review that attempts to synthesize various studies that are related to AI-enabled platforms within HEIs in India. The research aims to fill a gap that is related to various challenges that are affecting HEIs in India, such as gaps related to pedagogical changes, students' outcomes, factors related to the adoption of AI, as well as ethical concerns. The research focuses on various aspects of AI that are related to students' engagement, learning results, feedback-related changes in teaching practices, as well as various factors related to the adoption of AI that are perceived as useful by HEIs. Using Scopus, Web of Science, and Google Scholar databases from 2010 to 2025, it combines research from around the world with research focused on India. The results show that AI enhances personalization, engagement up to 25%, and adaptive feedback. However, if not tailored to Indian context, it may result in bias, over-reliance, and escalation of already existing inequalities. Teaching practices are moving from traditional models to facilitation and AI literacy, conditioned by existing infrastructure and training challenges common in India. The socio-technical approach to understanding AIEd integrates platforms, teaching practices, results, and equity. It suggests that theory-informed models are more important than tool-centric models. The implications of this research recommend that AIEd models consider curricula that are AI-aware, equitable governance structures, and investments in infrastructure for low-resourced HEIs in India. The research recommendations suggest

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Review NJSCLM

A New Heuristic Method for the Classical Transportation Problem's First Viable Solution

Poonam Rani*

Abstract

The transportation problem is a classic optimization issue in linear programming that focuses on determining the most cost-effective way to allocate resources from multiple supply points to various demand points while meeting specific constraints. Traditionally, methods, like the North-West Corner Rule (NWCR), Least Cost Method (LCM), and Vogel's Approximation Method (VAM), have been employed to generate an initial feasible solution (IFS). However, these approaches often overlook key factors, such as supply–demand dynamics or cost balance, which may result in suboptimal starting solutions and longer optimization time. To address these limitations, this paper introduces a novel heuristic approach known as the Weighted Cost Distribution Method (WCDM). This method enhances the initial solution process by calculating a weighted cost matrix that considers both the unit transportation cost and the relative size of supply and demand. By sorting and allocating based on this weighted measure, WCDM identifies more efficient routes for early allocations. Comparative analysis demonstrates that WCDM frequently yields better or equivalent initial solutions than conventional methods, thereby reducing the number of iterations needed in final optimization procedures like the Modified Distribution (MODI) method or the stepping-stone method. This leads to faster convergence to the optimal solution and improved computational efficiency.

Keywords: Transportation problem, heuristic method, initial feasible solution, cost optimization, linear programming, Weighted Cost Distribution Method

INTRODUCTION

The transportation problem (TP) aims to determine the most cost-effective way to transport goods from several suppliers to several consumers while satisfying supply and demand constraints. Due to its extensive applications in logistics, supply chain management, and operations research, efficient methods to solve TP are of great practical interest.

An essential step in solving TP is finding an initial feasible solution (IFS). While methods, like the North-West Corner Rule (NWCR), Least Cost Method (LCM), and Vogel's Approximation Method (VAM), are commonly used, they often result in non-optimal or suboptimal starting points [1]. This paper proposes a new heuristic called the *Weighted Cost Distribution Method (WCDM)* to produce an IFS that reduces the number of iterations required to reach optimality. An essential step in addressing any TP is the identification of an IFS, which acts as the foundation for subsequent optimization through methods like the Modified Distribution Method (MODI) or the Stepping Stone Method. Approximation Method (VAM) the NWCR, LCM, and VAM, are widely used to obtain an IFS due to their simplicity and ease of implementation. However, these conventional techniques often yield

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Domestic Payment Frauds in India (2022–2025): A Quantitative Analysis of Trends, Risk Indicators, and Policy Implications

Shalabh Saxena

Ajeet Yadav

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ABSTRACT

The rapid rise of digital payment systems in India, especially the Unified Payments Interface (UPI), has changed how financial transactions are made by improving convenience, speed, and access for everyone. However, this increase in digital payments has also led to more cyber-related risks, particularly domestic payment fraud. This research aims to look at the patterns and implications of domestic payment fraud in India from September 2022 to March 2025, using secondary data from the Reserve Bank of India (RBI). The study depends on three main indicators: the total volume and value of digital transactions, how often fraudulent transactions occur (measured as one in every 'X' transactions being fraudulent), and the fraud transaction share (FTS), which is the value of frauds per 10,000 transactions. By using descriptive statistics and trend analysis, this paper investigates whether there is a link between rising digital payment volumes and increasing fraudulent activity. The findings show an interesting pattern. While the volume and value of digital payments have steadily gone up, the occurrence of fraud and the FTS have not increased at the same rate. In fact, they show cyclical variations and sometimes even a downward trend. This indicates that better fraud detection methods, awareness campaigns, and regulatory actions may be

reducing risks even as usage grows. This research provides valuable insights for banks, fintech companies, and regulators to grasp the changing nature of fraud in India's digital landscape. It also offers solid evidence to help build stronger security measures for UPI and other digital platforms. The paper concludes by stressing the need for proactive risk assessment, real-time fraud monitoring systems, and ongoing consumer education to ensure safe digital financial services in India.

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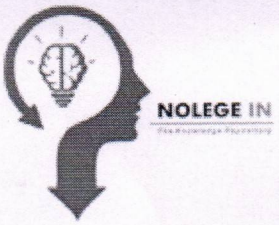
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A Thorough Analysis of How Corporate Social Responsibility Affects Consumer Behavior

Anupama Jain

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Abstract

Corporate Social Responsibility (CSR) has transitioned from being a marginal concern to a core element of business strategy, playing a crucial role in shaping consumer attitudes and behaviors. This review draws from a wide range of scholarly work and empirical evidence to explore the effects of CSR activities on consumer perception, buying behavior, brand commitment, and customer advocacy. Through the inclusion of quantitative findings and illustrative case examples, the study examines the complex interplay between CSR and consumer responses, offering valuable guidance for companies seeking to align their practices with the expectations of ethically aware consumers. This comprehensive review brings together a wide array of scholarly research, theoretical models, and empirical evidence to explore the diverse ways in which Corporate Social Responsibility (CSR) influences consumer behavior. It examines how key CSR components – such as sustainability initiatives, fair labor practices, community involvement, and corporate transparency – shape consumer trust, emotional engagement, and long-term loyalty to brands. The study further integrates statistical data and real-world examples to demonstrate how effective CSR strategies can boost consumer interaction and drive business success. By uncovering the psychological and behavioral drivers behind consumer reactions to CSR, the review offers strategic guidance for marketers, business leaders, and policymakers seeking to embed ethical practices within their organizational framework. The analysis highlights the increasing necessity for companies to align their values with those of socially conscious consumers to gain a competitive edge, build a positive brand image, and support long-term, responsible growth in today's value-driven market landscape

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Artificial Intelligence and Sustainable Consumer Behaviour: Drivers, Mechanisms, and Implications for Green Marketing

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ABSTRACT

The convergence of artificial intelligence (AI) and sustainability has introduced a transformative paradigm in the study of consumer behaviour. It has been observed that AI-driven tools, recommendation systems, predictive analytics, and digital nudges subtly influence environmentally and socially conscious purchasing decisions. This review synthesizes interdisciplinary scholarly evidence to examine how it is done. Drawing on empirical studies, industry data, and illustrative case examples, the paper explores the mechanisms through which AI augments sustainable consumption, identifies barriers to adoption, and provides strategic guidance for businesses and policymakers. The analysis demonstrates that AI, when ethically deployed, can serve as a powerful catalyst for green consumer transitions across sectors ranging from retail and energy to fashion and food systems.

Keywords: *Artificial Intelligence, Sustainable Consumer Behaviour, Green Marketing, Digital Nudging, Ethical AI.*

Introduction

The twenty-first century has witnessed an unprecedented intersection of two macro-forces reshaping commerce and society: the urgency of environmental sustainability and the proliferation of artificial intelligence. Global consumers are increasingly confronted with the moral calculus of their purchasing choices, while businesses grapple with aligning profitability against ecological stewardship. In this context, AI has emerged not merely as an operational tool but as a behavioural architect capable of shaping, guiding, and reinforcing sustainable consumption at scale.

Consumer behaviour research has long established that awareness alone is insufficient to bridge the "intention-action gap" in sustainable purchasing—people may value sustainability but still choose convenience or price over ecological impact. AI technologies offer a novel mechanism to close this gap by making sustainable choices more visible, easier, and personally relevant. From personalised sustainability scores in retail apps to algorithmic nudges in smart home energy systems, the applications are both vast and rapidly evolving.

This paper provides a comprehensive review of the relationship between AI and sustainable consumer behaviour, examining the theoretical underpinnings, empirical evidence, practical case studies, and ethical considerations that define this emerging field. The discussion is framed within the context of the United Nations Sustainable Development Goals (SDGs), particularly SDG 12 (Responsible Consumption and Production), which calls for systemic shifts in how goods and services are produced and consumed globally.

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Conceptual Framework

- **Defining Sustainable Consumer Behaviour**

Sustainable consumer behaviour refers to purchasing, using, and disposing of products and services in ways that minimise negative environmental impacts, support social equity, and contribute to long-term ecological balance (Peattie, 2010). It encompasses a wide spectrum of actions, including choosing energy-efficient appliances, opting for plant-based diets, reducing single-use plastics, supporting fair-trade brands, and participating in circular economy models such as product sharing, leasing, and recycling.

Academic frameworks including the Theory of Planned Behaviour (Ajzen, 1991), Value-Belief-Norm Theory (Stern, 2000), and the Attitude-Behaviour Gap model have long attempted to explain why consumers sometimes act inconsistently with their stated environmental values. These frameworks underscore the complex interplay of attitudes, social norms, perceived behavioural control, and situational factors that ultimately determine consumption choices.

- **The Role of Artificial Intelligence**

Artificial intelligence, broadly defined, encompasses machine learning (ML), natural language processing (NLP), computer vision, and predictive analytics systems capable of learning from data, identifying patterns, and making decisions with minimal human intervention. In the commercial sphere, AI manifests in recommendation engines, dynamic pricing algorithms, chatbots, sentiment analysis tools, and supply chain optimisation systems.

The intersection of AI and sustainability research draws from behavioural economics, environmental psychology, marketing science, and information systems. AI's capacity to process vast quantities of consumer data and generate personalised, contextually relevant interventions positions it as a potent enabler of sustainable behaviour change—going far beyond traditional top-down environmental campaigns.

Mechanisms through which AI Influences Sustainable Consumption

- **Personalised Sustainability Recommendations**

One of AI's most direct applications in promoting sustainability is through personalised recommendation systems. Unlike generic environmental messaging, AI-driven systems analyse individual purchase histories, preferences, dietary patterns, and location data to generate tailored suggestions for lower-carbon or ethically sourced alternatives. Research by Berger et al. (2022) found that personalised eco-labelling increased the likelihood of sustainable product selection by 34% compared to generic labels.

Retail giants such as Amazon and Alibaba have begun integrating sustainability filters powered by ML models that rank products by carbon footprint, recyclability, and supply chain transparency. When recommendations are framed around both personal benefit (cost savings, health) and collective impact (carbon reduction), adoption rates increase substantially, suggesting that AI personalisation can effectively align individual motivation with broader sustainability goals.

- **AI-driven Nudging and Choice Architecture**

Behavioural nudge theory (Thaler & Sunstein, 2008) suggests that small, well-designed environmental cues can significantly steer decision-making without restricting choice. AI enhances the precision and timing of such nudges by deploying them at critical moments in the consumer journey. Smart energy platforms like Google Nest use ML algorithms to learn household consumption patterns and deliver real-time feedback, automatically adjusting heating and cooling systems to minimise energy waste—resulting in average savings of 10-15% on household energy bills.

Digital nudges can also appear as social proof indicators (e.g., "82% of customers in your area chose the eco packaging option"), gamified sustainability challenges, or real-time carbon footprint trackers embedded in mobile payment apps. These AI-curated interventions exploit well-documented cognitive biases such as loss aversion, social comparison, and present bias to make sustainable defaults more attractive.

Research & Review: Machine Learning and Cloud Computing (e-ISSN: 2583-4835)

Balancing Performance and Privacy in Machine Learning: Issues and Practical Solutions

Ritu Kaushik

Shefali Madan

Keywords: Data privacy, Differential privacy, Federated learning, Model accuracy, Machine learning Privacy-preserving

Abstract

Finding the correct balance between model accuracy and data privacy has emerged as one of the current machine learning's most significant concerns. On the one hand, companies seek extremely precise models that produce solid predictions. On the other hand, they must safeguard the sensitive information needed to train those models, especially as concerns about data misuse and security breaches continue to grow. This balance necessitates a thoughtful combination of technology techniques and acceptable data practices. Differential privacy, federated learning, and secure multiparty computation are examples of privacy-preserving techniques that can minimize raw data exposure while still enabling models to identify significant trends. However, the risk of privacy leakage can be reduced without appreciably impairing performance by using strategies like regularization, adversarial training, and controls that prohibit models from memorizing certain data points. The entire machine-learning pipeline is further protected by robust security measures, such as encryption, access controls, and ongoing monitoring. However, these safeguards might create noise or limit the amount of information available to the model, thereby leading to decreased accuracy if not effectively controlled. As a result, teams must constantly test and change their techniques, considering the trade-offs based on the project's objectives, risk level, and regulatory requirements. Finally, establishing a balance between accuracy and privacy is a continuous process that involves coordination among data scientists, security professionals, and policy experts.

References

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Comparative Study on Air Pollution Prediction Using Machine Learning Techniques

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Abstract: The Air Quality Index (AQI) measures how air pollution affects human health. As pollution levels rise in Indian cities, we need reliable prediction models for better environmental management. This paper analyses different machine learning techniques for predicting AQI. We use Support Vector Regression (SVR), Random Forest Regression (RFR), and CatBoost Regression (CR) on data from New Delhi, Bangalore, Kolkata, and Hyderabad. We evaluate model performance using Root Mean Square Error (RMSE) and accuracy.

Experimental results show that RFR performs best in most cities, while CR is most effective in New Delhi. To tackle dataset imbalance, we use the Synthetic Minority Oversampling Technique (SMOTE), which improves prediction accuracy for all models. Additionally, we assess other models, including SARIMA, Support Vector Machine (SVM), and Long Short-Term Memory (LSTM) for Ahmedabad. Among these, SVM with a radial basis function (RBF) kernel shows the best results.

The findings emphasize how combining data balancing methods with machine learning models can improve AQI prediction. This approach can help with pollution control strategies and better decision-making.

Keywords: Air Pollution Prediction, Machine Learning, Deep Learning, NF-VAE, IoT, Time-Series Forecasting, Multivariate Data.

1. Introduction

Air pollution is a major environmental and public health concern across the world, especially in rapidly growing urban areas. Increased industrialisation, urbanisation, and vehicle emissions have led to a significant decline in air quality. Pollutants such as PM2.5, PM10, NO_2, SO_2, CO, and O_3 pose serious health risks, with PM2.5 being particularly harmful due to its ability to penetrate deep into the lungs and bloodstream. Exposure to such pollutants is linked to respiratory diseases, cardiovascular problems, and millions of premature deaths annually [1].

In addition to health impacts, air pollution contributes to environmental issues such as climate change, acid rain, and ecosystem damage. With the development of smart cities, IoT-based sensor networks are widely used to collect real-time air quality data. However, the large and complex nature of this data makes it difficult to analyze using traditional methods, which often fail to capture dynamic and nonlinear patterns [2].

To address this, Machine Learning (ML) and Deep Learning (DL) techniques

are increasingly used for air quality prediction. ML models like Support Vector Machines and Random Forests can identify patterns from historical data, while DL models such as Neural Networks and Recurrent Neural Networks provide better performance for time-series analysis [3]. However, these models often require high computational resources, making real-time implementation challenging.

Optimization techniques such as model pruning and quantization help reduce complexity and enable deployment on resource-limited devices. Additionally, performance evaluation using metrics like MAE and RMSE is essential to identify the most effective models.

Overall, developing efficient and accurate prediction models is crucial for improving air quality management and supporting sustainable urban development [3] [4].

2. Problem Statement

Air pollution has become a significant challenge in modern urban environments, particularly in rapidly developing smart cities where industrialization, vehicular emissions, and population growth continuously degrade air quality. Accurate air quality prediction is essential for enabling timely health advisories, supporting environmental policies, and ensuring public safety. However, predicting air quality remains a complex task due to the dynamic and nonlinear nature of environmental data, which is influenced by multiple factors such as weather conditions, traffic patterns, and geographical variations.

Traditional statistical models have shown limitations in capturing complex patterns and temporal dependencies present in large-scale, real-world datasets. Although Machine Learning (ML) and Deep Learning (DL) techniques have improved prediction accuracy, they often prioritize performance without adequately addressing computational efficiency, scalability, and real-time applicability. This creates a gap between theoretical model performance and practical deployment.

Furthermore, advanced ML/DL models typically require high computational power, memory, and training time, making them unsuitable for deployment on resource-constrained devices such as IoT nodes and embedded systems commonly used in smart city infrastructures. In addition, issues related to data quality, including missing, noisy, or inconsistent data, further reduce the reliability of predictions. External factors such as sudden weather changes and seasonal variations also add to the complexity of accurate forecasting.

Therefore, there is a need to develop an efficient, scalable, and accurate air quality prediction system that not only improves prediction performance but also ensures low computational complexity and real-time applicability. A systematic comparison of various ML and DL models, along with the integration of optimization techniques, is essential to identify suitable approaches for practical deployment in smart city environments.

3. Objectives

The main thing I want to do here is build some machine learning models that can predict air quality pretty well, you know, by trying out different regression methods. It seems like that could be useful for figuring out pollution levels or something.

Multi-Agent Systems for Distributed Decision-Making in Autonomous Vehicles

Publisher: IEEE Cite This PDF

Vinod Joshi ; Rajendra Kachhava ; Neha Paliwal ; Shefali Madan ; Nidhi Singal ; Vishal Sharma All Authors

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V. CHALLENGES AND FUTURE EXPLORATION

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Abstract:
This research paper aims at analyzing the use of Multi-Agent Systems (MAS) in decision-making for self-governed vehicles in a distributed environment and the possibilities of enhancing efficiency and collaboration with reference to centralized systems. Using MAS for autonomous vehicles, traffic situations can be controlled, time can be saved, and accident rates can be minimized, with low communication overhead. This paper also reveals that the MAS algorithms can be very effective in improving the real-time decision making and dealing with the dynamic environments. Nevertheless, the following issues hinder the application of MAS for autonomous vehicles. A challenge that comes with the increase of the number of agents is scalability where there are increased computational and communication costs. Real time decision making is important in order to ensure safety and effective performance, but latency is a problem that can occur. Further, MAS is challenging to design for resilience to environmental variation and to incorporate with the latest technologies such as 5G networks and advanced sensors. As for the future work, it is essential to concentrate on the further advancement of scalable MAS frameworks that would employ distributed and, especially, cloud computing to handle complexity. Real-time processing may be improved by edge computing and to advance the MAS algorithms to make it suitable for various scenarios is also important. Hence, based on the concepts in MAS, there are potential solutions for the application in autonomous vehicle systems but there are some challenges that need to be solved including scalability, real-time performance, robustness, technology issue and ethical concern for it to be effective in its application. As a result, this paper aims at summarising these challenges and discussing possible avenues for future works to contribute to the development of the theory.

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Hybrid AI Techniques for Enhancing Power System Stability

Publisher: IEEE Cite This PDF

Sukhvir Singh Dalal ; Vishal Sharma ; A Bharath ; Stuti Saxena ; Samiksha Sharma ; Vinod Joshi All Authors

4
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Abstract:
This research paper discusses the formulation and implementation of the hybrid AI approaches in improving power system stability, an essential factor in the current electrical energy networks experiencing growing pressures from the incorporation of renewable energy resources and the complexity of modern power system network. By combining the four different approaches of machine learning, deep learning, and the expert system, the proposed hybrid approach would build a strong and intelligent stability control approach to complement the shortcoming of the generally conventional stability control methods. Therefore, stability accuracy, response time, and computational efficiency were better with the visible efficiency of the two proposed hybrid AI models obtained with a rigorous approach to data collection, model building, and testing in like simulated milieu. The effectiveness of integrated system in terms of stabilization was compared with traditional approaches and standalone AI models and proved the superiority of the hybrid system due to its ability to analyze the complex nonlinear dynamics and assure real-time analysis of the stability condition. However, it also outlines some issues among which are scalability, data quality, real-time issue, and the necessary and proper standards of ethics and regulation. These challenges therefore call for more studies which can develop the best models of application of AI especially for large-scale applications as well as the integration of large amount of data into AI systems apart from enhancing the transparency and credibility of the AI systems which are applied in decision-making processes. From the study it can be concluded that there is a great potential of hybrid AI techniques for enhancing the stability of power system and paving way for intelligent and adaptive smart grid for future energy needs.

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DATABASE-DRIVEN ENERGY MANAGEMENT IN ELECTRIC VEHICLES

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ABSTRACT— As the years are passing pollution is becoming a major issue for environment and is demanding for environment-friendly products. So electric vehicles (EVs) become more prevalent, effective energy management is crucial to maximize performance and battery life. This research explores a database-driven energy management system (DBEMS) that integrates real-time data from EV components into a structured database, enabling analysis and optimization. Utilizing time-series databases, the proposed system collects data such as battery health, temperature, and energy usage. This paper compares SQL and NoSQL database models for managing EV data and highlights the potential of predictive analytics in energy optimization.

Keywords— Pollution, Electric vehicles, DBMS, SQL NoSQL,

I. Introduction

The increasing global warming has an impending need on us to stop the use of non-renewable resources and reduce carbon emissions. Carbon emissions from vehicles is increasing per year.PM (Particulate matter)are making the air more dangerous.PM 2.5, PM 10 are causing different diseases .The electrical vehicles have been adopted by many countries since it development creating a positive impact on the environment. Efficient energy management is vital to optimize performance and prolong battery life. Computer science, particularly database technologies, plays a pivotal role in storing, processing, and analyzing the massive volume of data generated by EV systems.

II. ROLE OF DATABESES IN EV ENERGY MANAGEMENT

Databases form the backbone of modern energy management systems in electric vehicles by efficiently storing, managing, and processing vast amounts of data generated by vehicles, users, and charging infrastructure. The integration of databases enables the extraction of actionable insights, improving energy efficiency, battery life, and user experience.

a) 2.1 Data Sources

Electric vehicles and their ecosystem generate diverse data types from multiple sources:

- **Battery Management Systems (BMS):** The BMS continuously monitors battery parameters such as voltage, current, temperature, state of charge (SoC), and state of health (SoH). These sensor readings are critical for managing battery usage, preventing overcharge/over-discharge, and predicting battery degradation.

- **Vehicle Telematics:** Telematics systems collect data related to vehicle speed, acceleration, braking, GPS location, and route information. This data helps analyze driving patterns, energy consumption trends, and optimize routes for better energy usage.

- **Charging Stations:** Information about charging station locations, availability, charging speed, and electricity prices are recorded. This enables smart scheduling and cost-efficient charging.

- **User Behavior Data:** User preferences, driving habits, and scheduled trips provide context to tailor energy management strategies. For example, knowing when the user plans to use the vehicle allows pre-conditioning or strategic charging.

- **External Data Sources:** Weather conditions, traffic congestion, and grid energy supply data can influence energy management decisions.

b) 2.2 Database Types and Structures

Handling this heterogeneous and high-volume data demands specialized database systems:

- **Relational Databases (RDBMS):** Used for structured data such as user profiles, charging session logs, and vehicle maintenance records. These databases support SQL querying, ensuring data integrity and relationships.

- **Time-Series Databases:**
  Because sensor data like voltage and temperature are continuously recorded over time, time-series databases (e.g., InfluxDB, TimescaleDB) efficiently store and retrieve this data for trend analysis and anomaly detection.

- **NoSQL Databases:**
  Unstructured or semi-structured data such as GPS logs or telemetry data can be stored in document-based or key-value NoSQL databases like MongoDB or Cassandra, which offer flexibility and scalability.

- **Distributed Databases:**
  To manage data from fleets or multiple geographic regions, distributed databases ensure data availability and fault tolerance.

c) *2.3 Database Functions in Energy Management*

- **Data Collection and Storage:**
  Databases collect and archive real-time data from EV components and infrastructure, forming the historical dataset required for analysis.

- **Data Processing and Analytics:**
  Querying capabilities allow real-time and batch processing to identify patterns, such as peak energy usage times, charging habits, and battery health trends.

- **Decision Support:**
  Based on processed data, the system recommends optimal charging schedules, routes, and maintenance, thus optimizing energy consumption.

- **Predictive Modeling:**
  Historical data stored in databases feeds machine learning models that predict battery degradation, energy demand, and charging needs.

- **Integration with Other Systems:**
  Databases enable interoperability between the EV, charging stations, power grids, and cloud services, facilitating energy trading, grid balancing, and user notifications.

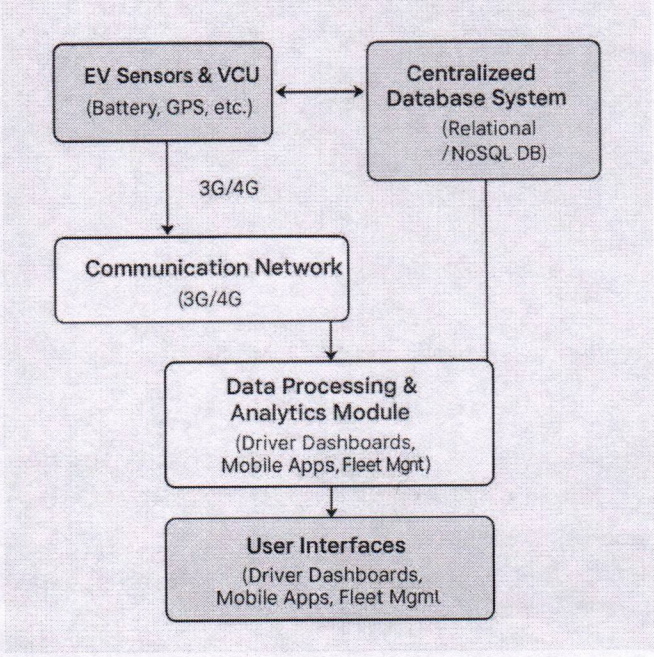
d) *2.4 Importance of Data Quality and Security*

Accurate, consistent, and secure data is paramount. Faulty data can lead to poor energy management decisions, while insecure data poses privacy risks. Databases must implement:

- Validation and error-checking mechanisms.
- Encryption and access controls.
- Compliance with data privacy regulations.

III. ARCHITECTUTRE OF A DATABASE-DRIVEN EV ENERGY MANAGEMENT SYSTEM

The architecture of a database-driven EV energy management system integrates hardware components, data acquisition layers, a centralized database, processing modules, and user interfaces to optimize energy consumption and battery performance in electric vehicles. The system aims to collect, store, analyze, and utilize various data streams to manage energy efficiently.



IV Key Functionaties

Feature	*Description*
Energy Optimization	Adjust motor output and HVAC usage dynamically based on driving habits and conditions.
Route Optimization	Choose energy-efficient routes based on historical and live traffic data.
Charging Management	Recommend best charging points and times based on user patterns and grid load.
Battery Health Monitoring	Use historical battery data to forecast degradation and advise on optimal usage.
Driver Behavior Analysis	Suggest driving habits to conserve energy (e.g., acceleration patterns).

V. Example Workflow

1. Vehicle starts → Sensors collect data → Data is logged into the database.
2. Database triggers analytics → Detects high consumption pattern.

INTERNATIONAL JOURNAL OF ADVANCE SCIENTIFIC RESEARCH AND ENGINEERING TRENDS

NEP 2020 as a Catalyst for Viksit Bharat 2047: A Comprehensive Analytical Study

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Abstract: The National Education Policy 2020 (NEP 2020) represents one of India's most ambitious educational reforms since independence, aligning directly with the national vision of Viksit Bharat 2047—a developed, equitable, and knowledge-driven India. This research paper synthesizes insights from major scholarly works published between 2020 and 2025 to critically examine how NEP 2020 contributes to India's developmental aspirations. Using a qualitative meta-analysis of existing literature, the study explores NEP 2020's focus on foundational learning, equity, teacher education, skill development, and multidisciplinary curriculum reforms. It also highlights the policy's potential to transform human capital, bridge socio-economic disparities, and reshape India's workforce for the 21st century. The paper identifies key implementation challenges, including resource gaps, teacher shortages, digital divides, and administrative constraints, and proposes policy recommendations for realizing NEP 2020's full potential. The study concludes that achieving Viksit Bharat by 2047 is feasible only through consistent, well-funded, and inclusive implementation of NEP 2020 across national and state levels.

Keywords:*NEP 2020, Viksit Bharat 2047, education reform, skill development, equity in education, vocational education, teacher education, multidisciplinary learning, India's development.*

I.INTRODUCTION:

India's aspiration to become a *Viksit Bharat* (Developed India) by 2047 requires a transformative education system capable of producing skilled, innovative, ethical, and globally competitive citizens. The National Education Policy 2020 is positioned as a foundational instrument for this transformation. It aims to overhaul India's education ecosystem by emphasizing holistic, multidisciplinary learning; foundational literacy and numeracy (FLN); vocational education; mother-tongue-based instruction; technology integration; and teacher capacity building.

However, the extent to which NEP 2020 can drive the national development agenda depends on how effectively it bridges socioeconomic inequities, strengthens human capital, and aligns education outcomes with industry needs. This paper analyzes NEP 2020 through the lens of India's long-term developmental goals, synthesizing current research to identify strengths, gaps, and future pathways.

II. LITERATURE REVIEW

A wide range of studies (Kaur & Khan, 2025; Verma, 2024; Anand & Anand, 2025; Baidya & Baidya, 2025; Christopher & Brintha, 2024) examine NEP 2020's role in national development. The key themes emerging from existing literature include:

2.1 Holistic and Multidisciplinary Education

Research shows NEP 2020's emphasis on flexibility, choice-based learning, and multidisciplinary institutions aligns with global models of higher education, improving creativity and innovation.

2.2 Equity and Inclusive Education

Many studies highlight NEP 2020's focus on reducing gender, socio-economic, and regional disparities—critical for building an inclusive developed nation.

2.3 Skill Development and Employability

Vocational training (from Grade 6 onwards), internships, and multidisciplinary curricula are viewed as crucial components for shaping India's future workforce and contributing to Atmanirbhar Bharat.

2.4 Teacher Education and Professional Development

Scholars stress that teacher quality is the backbone of the policy's success. NEP 2020's proposal for a 4-year integrated B.Ed. program is widely considered transformative.

2.5 Implementation Barriers

Studies emphasize challenges including funding inadequacies, infrastructural deficits, digital divides, and states' readiness.

III. METHODOLOGY

This research adopts a qualitative meta-analytical approach, synthesizing insights from existing peer-reviewed journals, policy analyses, and theoretical papers published between 2020 &2025.

The methodology includes:

- Review of 12 research papers related to NEP 2020 and Viksit Bharat.
- Thematic coding to identify major areas of convergence and divergence.
- Policy gap analysis comparing NEP objectives with India's developmental targets.

scientific reports

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Advanced air quality prediction using multimodal data and dynamic modeling techniques

Umesh Kumar Lilhore, Sarita Simaiya, Rajesh Kumar Singh, Abdullah M. Baqasah, Roobaea Alroobaea, Majed Alsafyani, Afnan Alhazmi & M. D. Monish Khan

Scientific Reports **15**, Article number: 27867 (2025)

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Abstract

Accurate air quality forecasting is critical for human health and sustainable atmospheric management. To address this challenge, we propose a novel hybrid deep learning model that combines cutting-edge techniques, including CNNs, BiLSTM, attention mechanisms, GNNs, and Neural ODEs, to enhance prediction accuracy. Our model uses the Air Quality Open Dataset (AQD), combining data from ground sensors, meteorological sources, and satellite imagery to create a diverse dataset. CNNs extract spatial pollutant patterns from satellite images, whereas BiLSTM networks simulate temporal dynamics in pollutant and weather data. The attention mechanism directs the model's focus to the most informative features, improving predictive accuracy. GNNs encode spatial correlations between sensor locations, improving estimates of pollutants like PM2.5, PM10, CO, and ozone. Neural-ODEs capture the continuous temporal evolution of air quality, offering a more realistic representation of pollutant changes compared to discrete-time approaches. Importantly, we use adaptive pooling, a dynamic operation that optimizes spatial feature reduction while preserving critical information, which sets it apart from traditional fixed pooling layers. This adaptive pooling mechanism reduces computational complexity and

Exploring E-Impulse Buying through Promotional Strategies

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Abstract: E-Impulse buying i.e. a sudden urge to buy online product without any prior planning is showing an imperative facet to understand the online shopping behavior. This paper examines the role of promotional activities used by online retailers in urging e-impulse buying. CIT in the form of mailed

questionnaire is used to collect the data at university level and then statement analysis has been done to get the idea about categories of promotional strategies influencing e-impulse buying further influence online shoppers' experiences and their repurchase decisions. The study suggests a significant role of promotional activities in e-impulse buying. Categories for the identified promotional activities are also suggested along with the gender analysis of the responses of online shoppers. This study also indicates that male respondents show more positive responses for the e-impulse buying and repurchase decisions in comparison to the female respondents. The paper identifies interesting role of promotional activities used by online retailers in e-impulse buying and also conclude the gender wise analysis of their buying experiences and re-purchase decisions. Contributions of this study in examining the role of promotional activities used by online retailers in E-Impulse Buying. These papers proposes a gender wise analysis of online shoppers' responses in terms of their experiences and re-purchase decisions in the context of e-impulse buying and also indicates categories of promotional activities that urge to e-impulse buying.

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ORIGINAL RESEARCH

Mapping evolving immersive customer experiences (CX) and virtual engagement in the metaverse: insights from bibliometrics-topic modelling synthesis

Abu Bashar[1] · Brighton Nyagadza[2,3] · Irfanullah Khan[4] · Tamer Alkadash[1]

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Abstract
This study maps the research landscape of immersive customer experience (CX) in the metaverse by synthesizing bibliometric analysis and topic modelling. Using 1,460 Scopus indexed journal articles (2000–2025), we examined publication trends, prolific authors, journals, and country contributions, and applied Latent Dirichlet Allocation (LDA) topic modelling, uncover thematic structures. Findings show 22.78% in publications, with increasing global contributions from countries like India, Malaysia, and South Korea. Seven core themes emerged: CX enhancement, brand engagement and virtual services, marketing research trends in CX, digital marketing and NFT adoption, AI-driven engagement, immersive business value creation, and consumer behaviour in virtual retail. While the field is developing, metaverse-specific CX models and measurement tools remain underdeveloped. The study advances theory by CX frameworks to immersive, co-created, and avatar-mediated experiences, and offer practical guidance for firms to adopt customer-centric strategies that leverage AI, gamification, and virtual branding. To our knowledge, this is the first work to combine bibliometric and topic modelling to chart CX research in the metaverse, highlighting current research frontiers and future research agenda.

Keywords Customer experience (CX) · Immersive experiences · Bibliometrics · Topic modelling · Metaverse · Dual analysis · Latent Dirichlet Allocation (LDA)

JEL Classification M31; L36; D83

1 Introduction

In the domain of computer science and digital technology, the metaverse can be viewed as an immersive, persistent, 3D environment enabled by virtual reality (VR) or augmented reality (AR), artificial intelligence (AI), blockchain and high-speed connectivity [1]. The focus here is infrastructure, digital twins, avatars, interoperability and immersive interfaces [2]. However, in the field of business and management, it is seen as the novel market space and value creation arena where firms can monetize and create a competitive advantage through digital assets (e.g.- non-fungible tokens (NFTs), cryptos etc.), virtual economies, platform economies and business models [3]. In consumer research and marketing studies, metaverse is a new channel for experience delivery and customer engagement [4], with a focus on brand interactions, gamification, customer journey, co-creation [5] and virtual consumption [6]. The

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ORIGINAL RESEARCH

Mapping evolving immersive customer experiences (CX) and virtual engagement in the metaverse: insights from bibliometrics-topic modelling synthesis

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Abstract
This study maps the research landscape of immersive customer experience (CX) in the metaverse by synthesizing bibliometric analysis and topic modelling. Using 1,460 Scopus indexed journal articles (2000–2025), we examined publication trends, prolific authors, journals, and country contributions, and applied Latent Dirichlet Allocation (LDA) topic modelling, uncover thematic structures. Findings show 22.78% in publications, with increasing global contributions from countries like India, Malaysia, and South Korea. Seven core themes emerged: CX enhancement, brand engagement and virtual services, marketing research trends in CX, digital marketing and NFT adoption, AI-driven engagement, immersive business value creation, and consumer behaviour in virtual retail. While the field is developing, metaverse-specific CX models and measurement tools remain underdeveloped. The study advances theory by CX frameworks to immersive, co-created, and avatar-mediated experiences, and offer practical guidance for firms to adopt customer-centric strategies that leverage AI, gamification, and virtual branding. To our knowledge, this is the first work to combine bibliometric and topic modelling to chart CX research in the metaverse, highlighting current research frontiers and future research agenda.

Keywords Customer experience (CX) · Immersive experiences · Bibliometrics · Topic modelling · Metaverse · Dual analysis · Latent Dirichlet Allocation (LDA)

JEL Classification M31; L36; D83

1 Introduction

In the domain of computer science and digital technology, the metaverse can be viewed as an immersive, persistent, 3D environment enabled by virtual reality (VR) or augmented reality (AR), artificial intelligence (AI), blockchain and high-speed connectivity [1]. The focus here is infrastructure, digital twins, avatars, interoperability and immersive interfaces [2]. However, in the field of business and management, it is seen as the novel market space and value creation arena where firms can monetize and create a competitive advantage through digital assets (e.g.- non-fungible tokens (NFTs), cryptos etc.), virtual economies, platform economies and business models [3]. In consumer research and marketing studies, metaverse is a new channel for experience delivery and customer engagement [4], with a focus on brand interactions, gamification, customer journey, co-creation [5] and virtual consumption [6]. The

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Artificial intelligence (AI) and machine learning (ML) in marketing: a 25-year bibliometric-TCCM synthesized mapping of trends, gaps and future research agenda

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Abstract

The major aim of the study is to review existing literature, conceptualize and map various future research avenues in line with integrating Artificial Intelligence (AI), Machine Learning (ML) and marketing applications. It employs bibliometric analysis, network analysis and theories, contexts, characteristics, and methodologies (TCCM) framework. Similar techniques were applied in social research studies to study and comprehensively report the existing research structure, gaps and probable studies to bridge them up. The sample data in this analysis collected from 2001 to 2025 and consists of 439 publications selected as per the criteria and used for further analysis, demonstrates the recency of research in AI, and ML in marketing applications. The results show an exponential growth in this domain and collaboration among authors throughout the world. It offers important social, practical and theoretical contributions to the evolving literature on AI, and ML in marketing applications. Originally, the study unpacked innovative development of new frameworks, impact assessment, emerging trends, identification of challenges and opportunities, cross disciplinary insights with significant advancement of effective professional practice and impactful theory development in line with AI, and ML in marketing applications.

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Customer Experience (CX) in Virtual Realms: A Theories-Contexts-Characteristics-Methodologies (TCCM) Guided Bibliometric Study

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ABSTRACT

The study systematically reviews existing literature on customer experience (CX) in virtual realms, with a view to conceptualizing the field and identifying future research avenues. It integrates bibliometric analysis, network analyses with a theories-context s-characteristics-methodologies (TCCM) framework to comprehensively examine the research landscape. Drawing on data from 1460 articles published in 509 journals between 2000 and 2025, the study highlights growing scholarly interest in CX with immersive environments, such as the metaverse. The results show exponential growth in this domain and in widespread international collaboration. Key contributions from this scholarship relate to, amongst other issues, emerging trends, development new frameworks, identification of challenges and opportunities, cross disciplinary insights significantly advancing effective professional practice and impactful theory development on customer experience in virtual realms. Unlike conventional bibliometric studies, this research stands out for its theoretical and methodological rigor, its focus on emerging virtual realms, and emphasis on strategic gaps and research agenda.

KEYWORDS

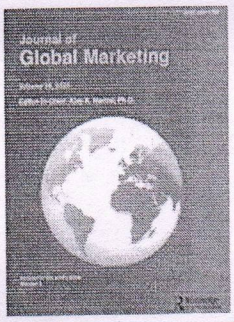
Customer experience (CX); virtual reality (VR); bibliometric study; preferred reporting items for systematic reviews and meta-analyses (PRISMA); theories-contexts-characteristics-methodologies (TCCM)

JEL CLASSIFICATION CODES

M31; L36; D83

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