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Aligning Innovation with Core Competency Development - The Startup Synergy

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Abstract

In an increasingly volatile and competitive global market, startups must rely on more than just disruptive ideas, they require strong, innovation-oriented core competencies to survive, scale, and succeed. This study investigates how innovation-centric capabilities such as technological agility, customer-focused development, adaptive leadership, and organizational learning influence the trajectory of startup success. Drawing on strategic management theory and empirical case examples, the paper explores the mechanisms through which innovation drives competitive advantage in early-stage ventures. Findings reveal that startups that prioritize innovation as a core competency are more likely to achieve product-market fit, attract investment, and adapt effectively to market shifts. Furthermore, the paper outlines the challenges startups face in cultivating such competencies and offers strategic recommendations for embedding innovation into the organizational fabric. By highlighting the central role of innovation in shaping sustainable growth, this research contributes to the broader understanding of entrepreneurial success in dynamic environments.

Keywords: adaptive leadership, embedding innovation, core competencies, sustainable growth, Technological Agility etc

1. Introduction

Startups thrive in volatile, fast-paced environments where uncertainty is the norm and the margin for error is narrow. In such high-risk, high-reward ecosystems, adaptability, speed, and strategic focus often determine survival and growth. Despite facing constraints in capital, infrastructure, and manpower, many startups outperform traditional businesses in their capacity to innovate, experiment, and pivot rapidly.

This paper explores the critical role that innovation-driven core competencies play in shaping the trajectory of startup success—particularly during the formative early and growth phases. In today's hyper-competitive startup landscape, where investor scrutiny is intense and consumer expectations evolve continuously, mere product differentiation is no longer sufficient. To build sustainable and scalable ventures, innovation must be institutionalized, it must become a

foundational aspect of the organization's core capabilities. This research delves into how startups can leverage innovation not just as an outcome, but as a strategic and cultural competency that fuels long-term competitiveness and resilience.

2. Defining Core Competencies and Innovation Orientation

a- Core Competencies:-

Core competencies are the unique capabilities and assets that provide a firm with competitive advantages. For startups, these often include technological know-how, creative problem-solving and agile management structures. Core competencies refer to the harmonized combination of multiple resources and skills that distinguish a firm in the marketplace. When these are innovation-driven, they become the foundation for rapid adaptation, technological edge, and market relevance.

b- Innovation orientation:-

Represents a startups inherent tendency to embrace and cultivate new ideas, emerging technologies, and novel processes. It goes beyond mere strategy; it is deeply embedded in the organizational culture. For startups, this mind-set shapes how decisions are made, how risks are evaluated, and how opportunities are pursued. A strong innovation orientation fosters a proactive, forward-thinking environment where creativity and experimentation are not only encouraged but expected. This cultural disposition becomes a critical driver of agility, competitiveness, and long-term success.

3. Understanding Core Competencies

The idea of core competencies was originally articulated by C.K. Prahalad and Gary Hamel in 1990 as the collective capabilities that give an organization its competitive advantage. In the context of startups, however, these competencies often take a more fluid and adaptive form. Unlike established corporations where competencies are clearly structured and formalized, startups build theirs organically shaped by experimentation, flexibility, and fast decision-making.

Some of the most impactful core strengths found in successful startups includes:

- **Technical flexibility**, such as the ability to quickly develop and iterate new prototypes.
- **User-focused innovation**, where customer feedback is central to product evolution.
- **Streamlined operations**, emphasizing efficiency and agility with limited resources.
- **Collaborative and adaptive teams**, capable of wearing multiple hats and pivoting as needed.

When such attributes are woven into the startups fabric, they create a culture of responsiveness and innovation. These embedded competencies often lead to faster product

cycles, stronger market alignment, and deeper team cohesion, all of which are critical to long-term success in a rapidly changing business environment.

4. The Innovation Imperative

For startups, innovation isn't just a strategic advantage it's a necessity for survival and relevance. Unlike traditional companies that often innovate incrementally, startups are expected to bring fresh ideas and disrupt the status quo from day one. Innovation in this space typically manifests in three key forms:

- **Product Innovation** - The development of new or significantly improved products and features. For example, Duolingo's gamified approach to language learning transformed a conventional domain into an engaging, user-driven experience.
- **Process Innovation** - Enhancing internal workflows, tools, or structures to improve efficiency and productivity. A notable example is the adoption of remote-first operations, which allow startups to scale while minimizing overhead and tapping into a global talent pool.
- **Business Model Innovation** - Rethinking how value is created, delivered, and captured. This includes shifts like transitioning from one-time purchases to recurring revenue through subscription models or introducing premium tiers to boost user acquisition.

When these forms of innovation align with core competencies, the startups not only performs better but also builds resilience.

Case Snapshot: Canva (For clarity)

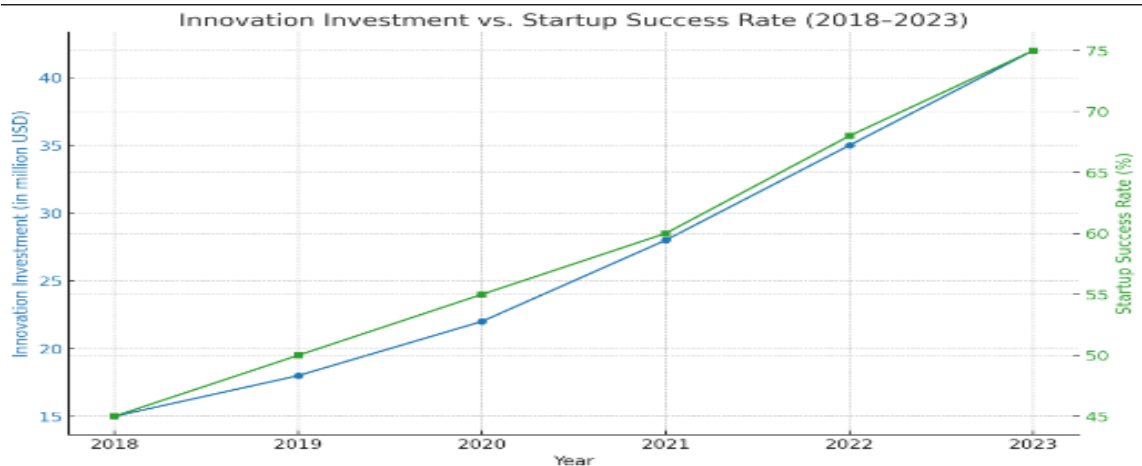
Canva, a Sydney-based startup founded in 2013, revolutionized the graphic design landscape by reimagining how people interact with creative tools. Its innovation lay not in complex functionality, but in simplicity delivering a highly intuitive, drag-and-drop design platform that empowered users with little to no design background.

At the heart of Canva's success was a clearly defined core competency: **making design accessible to everyone**. This vision was tightly integrated with the company's innovation strategy, particularly in user experience (UX) design. By removing technical barriers and offering ready-to-use templates, Canva democratized design for individuals, educators, startups, and large enterprises alike.

This seamless alignment between innovation and core capability allowed Canva to rapidly scale across global markets. By 2023, its valuation had soared beyond \$25 billion, underscoring the power of innovation-driven competencies in creating not just a successful product—but a global design movement.

5. Data Analysis: Innovation v/s Success Rate

Using secondary data, we examine innovation investment vs. startup success rates over 6 years (2018–2023). Here is the visual showing the correlation between innovation investment and startup success rate from 2018 to 2023.



(Source - zerodha.com)

Axis Explanation:-

- **X-Axis (Year):** Spans from 2018 to 2023(05 years).
- **Left Y-Axis (Blue):** Represents Innovation Investment in million USD.
- **Right Y-Axis (Green):** Indicates the Start-up Success Rate (%).

Trends Observed:-

1. **Consistent Growth in Innovation Investment:**
 - Investment in innovation rose steadily from \$15 million in 2018 to \$42 million in 2023.
 - This reflects a growing emphasis on innovation as a core focus area among startups.
2. **Parallel Increase in Startup Success Rate:**
 - Success rate improved from 45% in 2018 to 75% in 2023.
 - The success rate closely mirrors the trend in innovation investment, suggesting a positive correlation.
3. **Correlation Insight:**
 - As investment in innovation increased year-on-year, so did the success rate of start-ups.

- This parallel trend suggests that startups allocating more resources to innovation (R&D, talent, infrastructure, etc.) tend to perform better and are more likely to succeed.

The chart clearly illustrates a positive correlation between innovation spending and startup success rate. As innovation investment rose from \$15 million in 2018 to \$42 million in 2023, the success rate improved from 45% to 75% respectively.

Key Insight: The graph reinforces the hypothesis that investment in innovation is a significant driver of startup success. Startups that prioritize innovation are more adaptable, capable of differentiating themselves in the market, and ultimately more resilient, leading to higher success rates over time. Investment in innovation consistently results in higher success probabilities, especially for early-stage ventures focused on long-term differentiation.

6. Factor's Influencing Innovation Competency in Startups:-

Several enablers influence whether innovation becomes a core competency:

Enabler	Impact on Startup Innovation
Founder's Vision	Sets the tone for innovation culture
Access to Technology	Facilitates experimentation and rapid development
Team Diversity	Encourages diverse thinking and creative problem-solving
Market Feedback Loops	Enables iterative product development
Investor Support	Provides risk capital for bold innovation

7. Key Challenges in Developing Innovation Competencies for Startups

1. Resource Limitations

- Startups often struggle with financial constraints that limit their ability to innovate.
- They may lack access to experienced talent and essential technological infrastructure.
- These shortages can hinder the execution of high-potential, future-focused ideas.

2. Cautious Mind-set and Risk Avoidance

- Startups, especially in their early stages, prioritize survival over innovation.
- The fear of financial loss or failure discourages bold thinking and experimentation.
- As a result, new ideas are often shelved in favour of safer, more predictable approaches.

3. Balancing Growth and Innovation

- As a company begins to grow, operational demands tend to dominate leadership focus.
- Meeting customer expectations and scaling processes can overshadow innovation efforts.
- Innovation may be viewed as a secondary goal, delaying product or process advancements in the future.

8. Real-World Case Studies: Innovation-Driven Core Competencies in Action

a- Zerodha (India)

Zerodha stands as a prime example of how innovation can redefine an entire industry. By introducing a zero-commission trading model, it disrupted traditional brokerage services in India, where high fees had long been the norm. The company's core competencies lay in its agile fintech development, which allowed for rapid product iterations, and its focus on customer-centric innovation - offering a platform that was both intuitive and transparent. Zerodha also prioritized platform simplicity, enabling even first-time investors to navigate financial markets with ease. This blend of technological innovation and user-friendly design helped it build a loyal user base and become one of India's leading brokerage firms.

b. Notion (USA)

Notion is a standout example of a startup that built its success by turning user needs into its core innovation strategy. The platform integrated customizable workflows, collaborative tools, and an all-in-one workspace experience that resonated with both individual users and teams. What set Notion apart was its commitment to continuous feedback loops-the team actively listened to users, implemented changes rapidly, and refined features to improve usability and flexibility. This approach fostered organic growth, with the product evolving in direct response to real-world usage. Notion's ability to embed user-driven design and iteration into its core competencies turned it from a simple note-taking app into a globally recognized productivity tool.

9. Literature Review:-

- Recent studies have highlighted that leadership plays a pivotal role in embedding innovation as a core competency. According to **Breuer, Sison, and Michaelis (2023)**, founders who actively promote a learning-oriented culture, support open communication, and encourage risk-taking tend to build more innovative and resilient organization culture.
- Building on this, **Clauss, Abebe, and Hock (2022)** noted that innovation is most impactful when it is not an isolated initiative but a shared organizational capability. Their study found that startups that integrated innovation into cross-functional teams- spanning

design, development, marketing, and customer service - saw stronger market traction and faster iteration cycles.

- c. **Gupta and Sharma (2021)**, the integration of technology-enabled tools allowed startups to accelerate feedback loops, personalize customer experiences, and scale operations with agility. These capabilities, once matured, became integral competencies that could not easily be replicated by competitors.
- d. **Blank and Dorf (2020)**, through their lean startup methodology, emphasized the value of validated learning - where customer feedback becomes the compass guiding product evolution. Startups that actively engage users in the innovation process tend to identify market-fit solutions faster and more accurately. This ability to integrate external insights into internal innovation processes becomes core strength, giving the firm a dynamic edge.
- e. **A global report by PwC (2022)** revealed that startups in Southeast Asia and Africa, despite facing resource constraints, demonstrated high levels of frugal innovation-leveraging minimal resources to create high-impact solutions. This ability to innovate under constraint has become regional core strength, showing that innovation-driven competencies are not one-size-fits-all but are shaped by local realities.

In summary, the recent body of literature paints a clear picture: innovation-driven core competencies are among the most critical determinants of startup success. Startups that treat innovation not just as a buzzword but as an embedded, evolving strength are more likely to survive the challenges of early growth and achieve long-term impact in their industries.

10. Conclusion and Future Outlook

In today's fast-moving and highly competitive startups ecosystem, innovation is not merely an advantage. It is a necessity. This study highlights that startups succeed not just by having innovative ideas, but by embedding innovation into their core competencies. These competencies ranging from agile problem-solving and technological adaptability to customer centric thinking and collaborative cultures serve as critical building blocks that shape a startup's long-term success.

Successful startups are those that consistently transform innovative thinking into structured, scalable capabilities. Visionary leadership, empowered teams, responsive feedback systems, and strategic use of technology collectively enable this transformation. More importantly, the ability to evolve these competencies over time without losing agility differentiates resilient startups from those that struggle to grow beyond their early stages.

The findings underscore that innovation must move beyond isolated initiatives and become an integral part of the startup's DNA. When nurtured deliberately, innovation-driven competencies

help startups remain relevant, responsive, and future-ready in an ever-changing landscape. As global markets continue to shift, the startups that prioritize innovation not just as a practice but as core strength will be the ones most likely to endure, scale, and lead in the future.

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Explainable AI (XAI): Advancing Transparency and Trust in Artificial Intelligence Models

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Abstract

Artificial Intelligence (AI) systems have achieved remarkable success across diverse sectors including healthcare, finance, security, and transportation. However, the opacity of complex AI models, particularly deep learning architectures, has raised significant concerns regarding trust, accountability, and ethical use. The demand for interpretability and transparency in AI decision-making has led to the emergence of Explainable Artificial Intelligence (XAI). This paper critically examines the concept of XAI, its importance in ensuring transparency, various techniques used to enhance explainability, and the challenges it faces. Through an extensive review of existing frameworks and case studies, this study highlights the necessity of explainable models in promoting responsible AI adoption and suggests future directions for research in this essential domain.

Keywords: Artificial Intelligence, Explainable AI (XAI), Transparency, Interpretability, Ethical AI, Accountability

1. Introduction

Artificial Intelligence (AI) has revolutionized the way modern societies operate, with machine learning models being embedded in critical decision-making systems. While AI-driven applications offer unprecedented accuracy and efficiency, their decision-making processes often function as 'black boxes,' where even developers are unable to trace or comprehend the rationale behind specific outcomes. This opacity poses serious risks, particularly in high-stakes areas such as healthcare diagnostics, credit scoring, legal sentencing, and autonomous driving.

As AI systems increasingly influence human lives, the demand for transparency and accountability has intensified. Explainable AI (XAI) aims to bridge this gap by making AI decisions understandable to humans, ensuring trustworthiness, fairness, and regulatory compliance. The fundamental premise of XAI is to offer insights into how models arrive at conclusions, thereby enabling users to scrutinize and validate outcomes.

This paper explores the significance of transparency in AI models, elaborates on the core principles of XAI, surveys existing techniques for enhancing explainability, and discusses the implications and challenges associated with deploying explainable models in real-world applications.

2. Importance of Transparency in AI

2.1 Trust and Ethical Considerations

The absence of transparency in AI models erodes public trust and raises ethical concerns. If stakeholders cannot comprehend how a decision is made, especially one affecting human rights or social equity, it undermines the legitimacy of AI applications. Transparent models enable users to verify whether decisions are fair, unbiased, and aligned with ethical norms.

2.2 Regulatory Compliance

With the advent of legal frameworks such as the General Data Protection Regulation (GDPR) in Europe, which grants individuals the 'right to explanation,' AI developers are obligated to provide understandable reasons behind automated decisions. This legal impetus has accelerated research and implementation of explainable models to ensure compliance.

2.3 Improved Model Performance

Transparency not only fosters trust but also facilitates model debugging, error analysis, and performance optimization. By understanding a model's internal reasoning, developers can identify potential biases or vulnerabilities and refine algorithms for better outcomes.

3. Explainable AI (XAI): Concept and Principles

Explainable AI (XAI) encompasses a set of processes and methods that enable human users to comprehend and trust the results and outputs created by machine learning algorithms. XAI does not only explain what an AI system did, but also why it did so.

3.1 Interpretability vs. Explainability

Interpretability in AI refers to the degree to which a human can understand the internal mechanics of a model — essentially how the model arrives at a specific decision or prediction. Highly interpretable models, like decision trees or linear regression, allow users to directly trace how input features contribute to the output. The focus here is on making the model's structure and computations transparent and comprehensible to humans without additional tools. Interpretability is crucial in applications where direct, transparent reasoning is essential, such as healthcare diagnoses or financial decisions.

Explainability, on the other hand, is a broader concept that aims to provide understandable reasons for a model's predictions, even if the model itself remains a "black box." Many modern AI systems, particularly deep learning models, are inherently complex and difficult to interpret directly. Explainability methods — such as feature attribution, surrogate models, or counterfactual explanations — offer post hoc insights that help users grasp *why* a model behaved a certain way. While interpretability concerns the model's inherent transparency, explainability focuses on generating human-understandable justifications for its outcomes, ensuring trust and accountability in AI-driven decisions.

Simple models like decision trees and linear regression are inherently interpretable, whereas complex models like deep neural networks require external tools or techniques to generate explanations.

3.2 Core Principles of XAI

Several principles guide the development of explainable AI systems:

- **Transparency:** Clear insight into how and why decisions are made.
- **Justifiability:** Ensuring decisions can be justified ethically and legally.
- **Reliability:** The model should provide consistent and accurate explanations.
- **User-Centricity:** Explanations should be comprehensible to intended stakeholders.

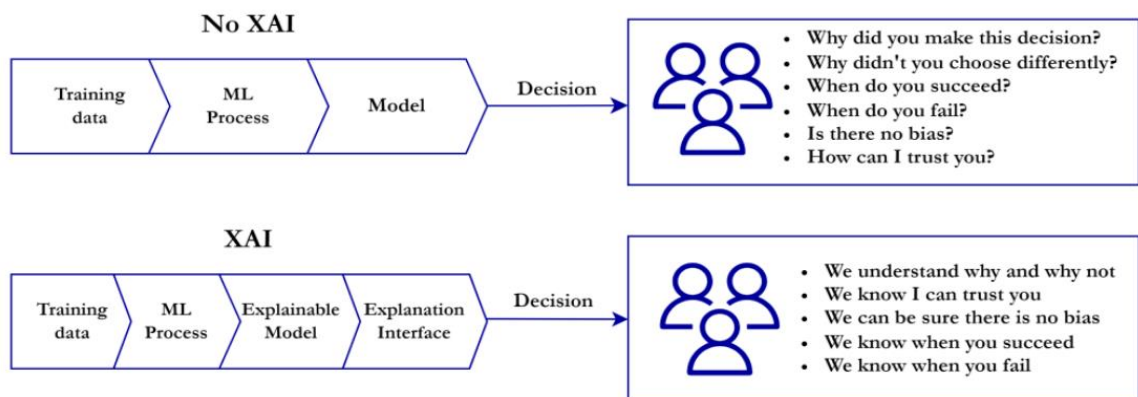


Diagram 1: Representation of No XAI and XAI

4. Techniques for Explainability

Explainability techniques can be broadly classified into model-specific and model-agnostic approaches.

4.1 Model-Specific Techniques

These techniques are tailored for specific types of models:

- **Decision Trees:** Naturally interpretable through node splitting.

- **Linear Models:** Coefficients directly indicate feature impact.
- **Rule-Based Systems:** Provide if-then rules for decision-making.

4.2 Model-Agnostic Techniques

Designed to explain any black-box model, these include:

- **LIME (Local Interpretable Model-Agnostic Explanations):** Generates local surrogate models to approximate predictions.
- **SHAP (SHapley Additive exPlanations):** Based on cooperative game theory, assigns each feature an importance value for a prediction.
- **Partial Dependence Plots (PDP):** Illustrate the relationship between features and predicted outcomes.
- **Counterfactual Explanations:** Show how minimal changes to input can alter the prediction.

5. Challenges in Achieving Explainability

Despite its importance, implementing explainable AI presents several obstacles:

5.1 Trade-off Between Accuracy and Explainability

One of the fundamental challenges in XAI is balancing model performance with interpretability. While complex models like deep neural networks and ensemble methods deliver superior predictive accuracy, they often operate as “black boxes,” making it difficult for users to understand their decision processes. Attempts to simplify these models for transparency, such as using surrogate models or rule-based approximations, can lead to a loss in predictive precision. This trade-off is particularly critical in sectors like healthcare or finance, where both accuracy and interpretability are vital for safe and ethical decision-making.

5.2 Subjectivity in Explanations

Explanations generated by AI systems must cater to the knowledge level, cognitive preferences, and needs of different stakeholders — from technical experts to policymakers and end-users. What is clear and actionable for a data scientist might be overly technical for a clinician or misleading for a layperson. This inherent subjectivity complicates the creation of explanation frameworks that are both universally understandable and contextually meaningful. Addressing this challenge requires customizable explanation interfaces and adaptive systems capable of tailoring explanations based on user profiles and situational contexts.

5.3 Security Risks

In the pursuit of transparency, exposing too much about a model’s inner workings or decision rationale can inadvertently introduce security vulnerabilities. Detailed explanations might reveal sensitive data patterns, proprietary algorithms, or decision rules that adversaries could exploit

through model inversion, data poisoning, or adversarial attacks. Especially in sectors like cybersecurity, finance, or defense, the challenge lies in providing sufficient transparency for trust and accountability while safeguarding sensitive system details and ensuring operational security.

5.4 Lack of Standardized Metrics

Despite significant advancements in XAI, there remains no universally agreed-upon set of benchmarks or metrics to objectively evaluate the quality, usefulness, or completeness of AI-generated explanations. Different methods assess explanation fidelity, relevance, and comprehensibility in diverse ways, making it difficult to compare results across models, domains, or application scenarios. The absence of standardized evaluation protocols hinders both academic progress and practical adoption of explainable systems, emphasizing the need for consensus-driven, domain-sensitive metrics to guide XAI development and validation.

6. Applications of Explainable AI

XAI is crucial across various domains:

6.1 Healthcare

In healthcare, explainable AI not only supports clinical decision-making but also plays a crucial role in medical research and patient communication. By revealing which patient attributes or medical indicators influenced a diagnosis or treatment suggestion, clinicians can better validate AI recommendations against clinical guidelines and patient history. This transparency strengthens physician-patient trust and enhances shared decision-making, particularly in sensitive cases involving life-altering treatments or rare diseases.

6.2 Finance

The financial sector increasingly integrates AI in areas like credit risk evaluation, loan approvals, and algorithmic trading. Here, XAI is essential not only for regulatory compliance under frameworks like GDPR or the Fair Credit Reporting Act but also for operational risk management. Explainable models help financial analysts and auditors understand anomalies, such as flagged transactions or investment recommendations, reducing reliance on opaque algorithms and enabling evidence-based financial decisions.

6.3 Autonomous Systems

In the realm of autonomous systems — including self-driving vehicles, drones, and industrial robots — explainability ensures that decision processes are transparent and can be audited after critical events. When accidents or malfunctions occur, explainable AI can reconstruct decision pathways, identifying what environmental factors or sensor inputs led to specific actions. This

capability is vital for safety assurance, legal investigations, and continuous system improvement in complex, real-world scenarios.

6.4 Legal and Judicial Systems

The use of AI in legal contexts, such as predictive policing, bail decisions, or sentencing recommendations, demands high levels of explainability to uphold civil rights and legal integrity. Transparent AI systems can clarify how various factors — like prior records, case details, or demographic data — influence risk assessments or legal outcomes. This openness not only promotes accountability but also mitigates biases, ensuring AI applications in justice remain ethical, lawful, and publicly accepted.

7. Future Directions

As AI continues to permeate high-impact sectors, advancing XAI research is imperative. Future work should focus on:

Developing hybrid models that balance accuracy and explainability:

It involves integrating the strengths of both highly accurate but complex models and simpler, interpretable algorithms. While advanced models like deep neural networks offer superior predictive performance, they often lack transparency. Hybrid approaches aim to retain this accuracy while enhancing interpretability, either by combining interpretable models with complex ones in ensemble systems or by designing inherently explainable architectures with layered reasoning. Techniques such as using attention mechanisms, interpretable surrogate models, or modular AI systems allow certain parts of the decision-making process to remain transparent without significantly compromising performance. This balance is especially important in high-stakes domains like healthcare, finance, and law, where decisions must be both reliable and clearly understandable to human users.

Creating domain-specific explanation interfaces tailored to user expertise:

Designing explanation tools and visualizations that align with the knowledge, expectations, and decision-making needs of different user groups within a particular field. Since the usefulness of an AI explanation depends on the user's ability to interpret and act upon it, these interfaces must be customized. For example, offering statistical confidence intervals and feature importance scores to data scientists, while providing clear, plain-language justifications or risk indicators to clinicians or financial analysts. By tailoring the depth, format, and complexity of explanations to the domain and user role, XAI systems can improve clarity, usability, and trust, ensuring that critical AI-driven decisions are understood and responsibly applied in real-world settings.

Establishing standardized evaluation metrics for explanations:

It is essential for objectively assessing the quality, clarity, and usefulness of AI-generated explanations across different models and applications. Currently, the absence of universally accepted benchmarks makes it difficult to compare the effectiveness of various explanation techniques or determine their suitability for specific domains. Standardized metrics would provide a consistent framework to evaluate aspects like explanation fidelity (how accurately it reflects the model's reasoning), comprehensibility (how easily users can understand it), and actionability (how well it supports decision-making). Developing such metrics is crucial for promoting transparency, ensuring fairness, and guiding the responsible deployment of AI systems in sensitive, high-stakes environments.

Integrating ethical and legal considerations into XAI frameworks:

Ensuring that AI explanations not only clarify how decisions are made but also uphold principles of fairness, accountability, privacy, and human rights. As AI systems increasingly influence critical areas like healthcare, finance, and criminal justice, their decisions must comply with legal regulations such as GDPR, which mandates the right to explanation, and avoid reinforcing societal biases or discrimination. Embedding ethical guidelines and legal standards within XAI frameworks helps guarantee that explanations are transparent, non-discriminatory, and respect user privacy, while also making AI outcomes auditable and legally defensible. This integration is vital for fostering public trust, safeguarding individuals' rights, and ensuring responsible, socially acceptable AI adoption.

8. Conclusion

Explainable AI represents a crucial frontier in modern AI development. As the complexity of AI models escalates, ensuring transparency, fairness, and accountability becomes indispensable. By demystifying the decision-making processes of AI systems, XAI enhances trust, facilitates compliance, and supports ethical AI adoption. Although significant challenges persist, ongoing advancements in explainability techniques promise a future where AI systems are not only powerful but also interpretable, responsible, and human-aligned.

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7. Introduction to Explainable AI (Explainable Artificial Intelligence or XAI) - 10 Senses

Sustainable Finance in India: Trends, Challenges and Corporate Adoption

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Abstract- This research paper examines the evolving landscape of sustainable finance in Indian companies. The practice of considering environmental, social, and governance factors when making financial sector investment decisions is known as "sustainable finance," and it results in greater long-term investments in sustainable economic endeavours. With growing global concern about environmental and social issues, companies in India are increasingly integrating sustainability principles into their financial strategies. For investors looking for assets that support the Sustainable Development Goals (SDGs), India has become a popular destination.

This paper provides a comprehensive analysis of sustainable finance practices in Indian businesses, exploring the drivers, key initiatives, challenges, and potential for creating a more sustainable and socially responsible corporate sector in India. Indian companies involved in the Projects relating to Renewable Energy, Waste Management, Electric Vehicles (EV), Solar Power Plants, Clean Energy, Recycle and Energy conservation could help to achieve India's commitment to Net Zero Emissions by 2070.

RBI has considered Green and Sustainable projects should be put under Priority Sector Lending to support Green economy growth and to meet the Sustainable Development Goals and ESG (Environmental, Social and Corporate Governance) guidelines for fundraising.

Authors explore that Sustainable Finance is much more than numbers and profits, it represents a commitment to a broader impact of investment decisions. It's about supporting economic growth while simultaneously using the power of investment funds to back companies that uphold the highest standards in environmental, social, and governance aspects. It's not simply about where the money goes, but how it's used to foster a better and more sustainable world.

Keywords- Sustainable Finance; Climate Finance; Green Economy; Sustainability; ESG (Environmental, Social and Corporate Governance); Social Responsibility; Sustainable Development Goals (SGS's)

1. INTRODUCTION-

The Indian corporate landscape is undergoing a transformative shift towards sustainability. Indian companies are recognizing the importance of sustainable finance practices to address the prevailing environmental, social and governance challenges while ensuring long-term financial stability. The concept of Sustainable Finance focuses on using finance as a means to achieve the environmental and social goals, so that we can divert the planet and its economy from its current path to a world that is sustainable for all.

The European Commission were the first to define the concept of **SUSTAINABLE FINANCE** as the process of taking environmental, social and governance (ESG) considerations into account when making investment decisions in the financial sector, leading to more long-term investments in sustainable economic activities and projects.

In Indian context, Sustainable Finance is often referred to as Socially Responsible Finance or Green Finance, is a financial framework that incorporates environmental, social, and governance (ESG) criteria into investment and financial decision-making processes. The primary aim of sustainable finance is to promote responsible and sustainable economic practices while generating long-term financial stability and returns. It is a collection of financial rules, guidelines, conventions, and goods that aim to protect the environment. By funding its agents while upholding a growth purpose, it enables the financial system to establish a connection with the economy and its citizens.

KEY ASPECTS OF SUSTAINABLE FINANCE in Indian context includes-

ENVIRONMENTAL CONSIDERATIONS: Sustainable finance emphasizes environmentally responsible practices. It seeks to invest in projects, companies, and initiatives that promote sustainability, reduce environmental impact, and address issues such as climate change, pollution, and resource conservation. It looks into the way in which a company respects and interacts with its environment. It evaluates areas such as energy consumption, waste management, conservation efforts, treatment of animals, and actions related to deforestation. It's important to actively have a positive impact on the environment rather than only avoiding harm.

SOCIAL IMPACT: Sustainable finance also takes into account social concerns like community development, human rights, and labour standards. By promoting inclusive and equitable growth, it seeks to guarantee that investments benefit society. The social component of sustainable finance looks at a business's connections like- how they interact with their staff, clients, and the local community.

Diversity and inclusion policies, data security, its human rights record, stakeholder involvement, and their wider societal contributions are some of the primary areas of focus.

CORPORATE GOVERNANCE: Strong governance practices within organizations are integral to sustainable finance. This involves transparency, accountability, ethical behaviour and the

promotion of shareholder rights. It focuses on the procedures and frameworks that direct an organization's activities and how it aims to impact and influence decision-makers. It looks at things like executive compensation plans, board of directors diversity and function, shareholder rights, and operational transparency. It also considers the company's position on matters such as political contributions, bribery, and how they pay their business partners.

2. DRIVERS OF SUSTAINABLE FINANCE IN INDIA-

2.1. REGULATORY FRAMEWORK –

(i) The role of SEBI in mandating ESG (Environmental, Social, and Governance) disclosures- SEBI has introduced “Business Responsibility and Sustainability Reporting by listed entities” from FY 2022-23 onwards for the top 1000 listed companies by market capitalization. BRSR stands for Business Responsibility and Sustainability Reporting. Companies use it as a practice to report on their performance and efforts in incorporating sustainable and ethical business practices into their operations. BRSR involves reporting on various aspects such as environmental impact, social responsibility, governance practices, stakeholder engagement, and contribution towards the achievement of sustainable development goals. By providing transparent and comprehensive information, BRSR allows stakeholders, including investors, customers, employees, and communities, to assess a company's commitment to sustainability and make informed decisions.

BRSR is a method that drives an organization's commitment to sustainability and transparently communicates it to interested parties, rather than just presenting the data that has been gathered. The BRSR is an initiative towards ensuring that investors have access to standardized disclosures on ESG parameters. Investors will be able to recognize and evaluate sustainability-related risks and opportunities of businesses and make better investment decisions if they have access to pertinent and comparable information. At the same time, businesses will be able to more effectively showcase their sustainability goals, standing and output, which will lead to the creation of long-term value.

(ii) RBI and NITI Aayog - RBI has made amendments on Priority sector lending and sustainable development in 2012 and 2015 housing, social infrastructure and renewable energy by considering environment risks in assessing agricultural price development.

Project Shoonya, an effort to accelerate the use of electric vehicles (EVs) in the urban delivery sector, was started by NITI Aayog. EVs have the potential to lower CO₂, GHG emissions and the demand for oil.

(iii) Role of NABARD - In order to encourage and illustrate creative adaptation/mitigation strategies and climate-resilient livelihoods, NABARD established a special Climate Change Fund (CCF) to help raising awareness of climate change issues among diverse stakeholders. Sustainable development depends on swift and fair climate action to reduce the effects of climate change and adapt to them.

For people and sectors that are at risk, NABARD's programs in the Agriculture, Natural Resources, and Rural Development (ANR) sector are essential parts of climate action. These include, in addition to its climate change programs, Watershed Development, Tribal Development, Infrastructure Development under RIDF, NIDA, etc.

These projects often involve climate resilience and sustainability component intended at mitigating the effects of climate change and assisting rural communities in adapting to a changing environment.

(iv) Government Missions under National Action Plan on Climate Change (NAPCC) -

The Prime Minister's Council on Climate Change introduced the National Action Plan on Climate Change (NAPCC) in 2008. It seeks to raise awareness of the problem posed by climate change and the actions being taken to combat it among various government agencies, scientists, industry, and community members.

There are 8 national missions forming the core of the NAPCC which represent multi-pronged, long term and integrated strategies for achieving key goals in climate change. These are-

National Solar Mission

National Mission for Enhanced Energy Efficiency

National Mission on Sustainable Habitat

National Water Mission

National Mission for Sustaining the Himalayan Ecosystem

National Mission for A Green India

National Mission for Sustainable Agriculture

National Mission on Strategic Knowledge for Climate Change

2.2. Investor awareness & Stakeholders expectations –

(i) Investors Demand - Investors are increasingly factoring ESG criteria into their decision-making processes. They recognize that strong ESG performance correlates with long-term financial success and risk mitigation. Sustainable investment strategies, such as responsible investing, impact investing and ESG integration, are gaining momentum. Companies that effectively integrate Sustainable Finance can attract and retain investors who prioritize sustainable and ethical investments.

(ii) Long-Term Value Creation - ESG considerations contribute to long-term value creation for businesses. By focusing on sustainable practices, businesses can foster trust, build enduring relationships with stakeholders, and secure their social license to operate. Sustainable Finance integration promotes resilience, helps identify new markets, reduces operational risks, and enhances financial performance over the long run.

(iii) Innovation and Competitive Advantage – Adopting ESG can boost creativity and give you a competitive edge. Businesses that invest in sustainable technologies, develop environmentally friendly products, promote diversity and inclusion, and improve stakeholder engagement are well-positioned to capture new market opportunities. Sustainable Finance considerations can foster creativity, attract top talent, and enhance brand differentiation in a rapidly changing business landscape.

(iv) Stakeholder Expectations - Customers, employees, and other stakeholders are increasingly holding businesses accountable for their social and environmental impacts. Consumers are choosing brands that align with their values, employees are seeking purpose-driven work environments, and communities are demanding responsible corporate behaviour. Businesses that prioritize Sustainable Finance considerations can enhance their reputation, build trust, and foster stronger relationships with stakeholders.

3. SUSTAINABLE FINANCE INITIATIVES BY INDIAN COMPANIES-

Environmental, social, and governance (ESG) initiatives are being adopted by Indian businesses more frequently, demonstrating their dedication to sustainability and ability to adapt to changing stakeholder demands. These diverse programs cover a wide range of topics, demonstrating their commitment to ethical business practices and long-term value generation. Additionally, before investing money, investors evaluate the governance, social, and environmental performance of businesses using ESG standards. To find risks and possibilities that standard financial analysis might miss, it is essential to include ESG considerations in investing decisions. By encouraging sustainable company practices and reducing long-term risks, ESG integration can improve investment outcomes.

To address important sustainability challenges, such as reducing carbon emissions, adopting renewable energy, managing waste, and conserving resources, Indian businesses have been implementing a variety of programs.

One of the top automakers in India, Tata Motors, has advanced the use of renewable energy significantly, at its Pune facility; the company added solar panels, which significantly reduced energy expenses and carbon emissions. To lessen its dependency on traditional energy sources. To acquire a sizable amount of their electricity from renewable sources, companies such as Tata

Power and Tata Motors have signed power purchase agreements with renewable energy producers.

Some examples to show Sustainable Finance Initiatives by Indian Companies -

COMPANY NAME	SUSTAINABLE FINANCE INITIATIVES UNDERTAKEN
TATA Sons Pvt. Ltd.	Tata Sons has a long history of sustainability initiatives, dating back to the early days of the company. In recent years, Tata Sons has stepped up its sustainability efforts, committing to a number of ambitious goals. It focuses on planet resilience; the group aspires to be net zero by 2045 and aims of securing the future by innovating today. By concentrating on three interrelated pillars—promoting the decarbonisation of our companies and value chain, implementing a systemic, circular economy approach to cut waste and resource consumption, and protecting and restoring the environment—it pledges to integrate sustainability into business strategy. Tata Sons is also committed to reducing its water consumption and waste generation. The company has set a goal of reducing its water consumption by 20% by 2025 and its waste generation by 30% by 2030. Additionally, it strives to support sustainable development in the localities in which it conducts business. The company has a number of initiatives in place to support education, healthcare, and economic development in these communities. Tata Steel have adopted water-efficient technologies and practices, it includes rainwater harvesting and recycling water within its operations. Here are some of the sustainability initiatives of Tata Sons: • Net-zero emissions by 2045 • Reducing water consumption by 20% by 2025 • Reducing waste generation by 30% by 2030 • Supporting education, healthcare, and economic development in these communities
ITC Ltd.	ITC has been at the forefront of sustainability initiatives in India. The company's sustainability initiatives are designed to reduce its environmental impact, improve the lives of its employees and communities, and create a more sustainable future. The company has implemented a number of programs to reduce its environmental impact, including:

	• Investing in renewable energy: ITC has installed solar panels on its manufacturing facilities, which has helped to reduce its reliance on fossil fuels. • Reducing water consumption: ITC has implemented a number of water conservation measures, such as rainwater harvesting and recycling. • Reducing waste generation: ITC has implemented a number of waste management measures, such as composting and recycling. • Promoting sustainable practices among its employees: ITC has launched a number of initiatives to promote sustainable practices among its employees, such as providing incentives for using public transportation and encouraging carpooling. ITC's sustainability initiatives have been recognized by a number of organizations, including the United Nations Global Compact and the Carbon Disclosure Project. The company has also been named one of the "World's Most Ethical Companies" by Ethisphere Institute for six consecutive years. ITC Hotels are known as the 'pioneer' of "Responsible Luxury" which means that it provides all luxuries with world class green practices. This initiative of ITC ensures the best of luxury facilities in the greenest possible manner. This unique initiative has made ITC hotels the "greenest luxury hotel chains" in the world.
RELIANCE INDUSTRIES Ltd.	RIL has developed a set of policies that reflect its dedication to fostering an environment of honesty, openness, transparency, and compliance. The organisation's focus on sustainability is driven by the Board at the highest level. The Company holds itself and its value chain partners to the highest standards of social and environmental performance. RIL's sustainability initiatives include: • Reducing greenhouse gas emissions: RIL has set a goal of reducing its greenhouse gas emissions intensity by 30% by 2030. The company has already achieved a 20% reduction in greenhouse gas emissions intensity since 2010. • Investing in renewable energy: RIL has invested in renewable energy projects, including solar and wind power. The company has a goal of generating 100 gigawatts of renewable energy by 2030.

	• Promoting energy efficiency: RIL has implemented energy efficiency measures across its operations, including improving the efficiency of its refineries and petrochemical plants. The company has saved over 100 million barrels of oil equivalent in energy consumption since 2010. • Reducing water consumption: RIL has implemented water conservation measures across its operations, including recycling and reusing water. The company has reduced its water consumption by 25% since 2010. • Promoting sustainable agriculture: RIL has partnered with farmers to promote sustainable agriculture practices, including using less water and pesticides. The company has helped farmers save over 1 billion gallons of water and reduce pesticide use by 20% since 2010. • Investing in education and healthcare: RIL has invested in education and healthcare initiatives in rural areas. The company has built schools and hospitals, and provided scholarships to students. • Promoting gender equality: RIL has implemented programs to promote gender equality in the workplace. The company has increased the number of women in senior management positions by 20% since 2010. • RIL in partnership with Gujarat Engineering Research Institute (GERI) and R & B Department constructed a 900-meter road stretch using 5% plastic waste.
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4. CHALLENGES AND BARRIERS-

4.1. The challenge of obtaining reliable ESG data in India -

Lack of consensus over ESG data and its accessibility is the primary issue faced by the Indian companies. There is no single framework or standard for ESG information, in contrast to traditional financial reporting. This makes it challenging to analyze and compare data across businesses and feeds market scepticism about the efficacy of ESG indicators.

The main factors which create a challenge in obtaining reliable ESG data in India are-

- The lack of a comprehensive ESG reporting framework in India.
- The lack of standardization of ESG data.

- The lack of transparency from companies on ESG issues.
- The lack of tools and knowledge to gather and evaluate ESG data.

These challenges make it difficult for investors, companies, and other stakeholders to assess the ESG performance of companies in India. As a result, there is a need for greater investment in ESG data collection and analysis in India. This will help to improve the quality and availability of ESG data, which will in turn help to promote sustainable development in India. Furthermore, the International Sustainability Standards Board (ISSB) is creating a "comprehensive global baseline" in order to address this issue.

4.2. Regulation Inconsistencies -

ESG reporting is the process of disclosing information about an organization's environmental, social, and governance performance. With SEBI mandating reporting on ESG parameters for the Top 1000 listed companies in India, there is a drastic shift from how companies approached environmental issues earlier.

India is among the few countries in the world to have a specialised court/tribunal to adjudicate environmental matters. To provide clarity for investors and sectors, our laws must undoubtedly be updated on a regular basis and occasionally even consolidated; nevertheless, this should not come at the expense of making the laws less effective. Strong environmental regulations are more important in fostering sustainable growth, but it's also important to make sure that businesses that are ethical, responsible, and environmentally concerned don't face undue obstacles in obtaining the necessary permissions, clearances, and compliances.

4.3. Lack Of Awareness and Education -

There is a greater need for awareness and education regarding sustainable finance in India. ESG parameters have become popular with businesses across the globe with their increasing recognition of the need for imbibing sustainability concerns in their core operational strategy. But lack of awareness about Sustainable finance and ESG literacy in the corporate sector could act as a big hindrance for sustainable development of India. Indian companies should change their perception of 'Profit' with the notion of "Sustainable Business", and should focus on the following, that-

- a) The natural resource base, which is vulnerable to depletion and degradation as a result of short-term rent-seeking behaviours;
- b) Future human capital must be invested in order to create more sustainable value-chains; and
- c) Businesses that invest in the four forces of capital—human, social, physical, and natural capital—will be more competitive in the medium and long term, with the results reflected in their long-term bottom lines.

5. FUTURE PROSPECTS AND POTENTIAL FOR CREATING A MORE SUSTAINABLE & SOCIALLY RESPONSIBLE CORPORATE SECTOR IN INDIA-

Sustainable Finance has provided an integration of Environmental, Social, and Governance (ESG) factors into financial decision-making and have given rise to innovative financial instruments and practices.

Sustainable finance in India aims to align financial activities of Indian Companies with United Nations Sustainable Development Goals, environmental protection, social progress, and good governance.

Following key trends are expected to shape the future of Sustainable Finance in India -

5.1. GREEN BONDS – These are debt instruments specifically designed to fund environmentally friendly projects, such as renewable energy, energy efficiency, and clean technology. The market for green bonds is growing rapidly, and India is one of the leading issuers of green bonds. The green bond market is growing rapidly in India, with a number of large companies and financial institutions issuing green bonds. By providing dedicated funding for ESG-focused projects, green bonds contribute to sustainable development while offering investment opportunities aligned with investors' ESG preferences. The government is also supporting the growth of the green bond market by providing tax breaks and other incentives.

5.2. SOCIAL IMPACT BONDS - Social impact bonds, also known as pay-for-success bonds, are financial instruments designed to address social issues while generating financial returns. In a social impact bond arrangement, private investors provide upfront capital for social programs, such as education, healthcare, or employment initiatives. The investors receive a return on their investment based on the program's successful outcomes, which are typically measured against predefined social impact metrics. Social impact bonds promote collaboration between public, private, and non-profit sectors to address societal challenges effectively.

5.3. CARBON TAXES - Carbon taxes are a form of carbon pricing where a direct tax is imposed on the carbon content of fossil fuels or the emissions of greenhouse gases. The tax is typically levied at a fixed rate per ton of carbon dioxide or its equivalent. The aim is to make carbon-intensive activities more expensive, providing an economic disincentive for high-emitting behaviours. The tax can be applied at various stages of the supply chain, such as extraction, production, or consumption of fossil fuels. Companies that emit carbon dioxide or other greenhouse gases are liable to pay the tax based on their emissions. Carbon taxes provide a clear and predictable cost signal for carbon emissions, encouraging businesses to reduce their carbon footprint and transition to cleaner energy sources.

5.4. SUSTAINABILITY REPORTING - Companies and financial institutions disclose their ESG performance through sustainability reports, providing transparency to stakeholders. Sustainability Reporting refers to a tripartite reporting framework that highlights the economic, environmental and social performance of an organization in addition to its financial performance. It has become an important element of corporate governance in dealing with organizational issues, such as income disparity, labour conditions, and ecological vitality in top-level decision making besides globalization issues. Used by nearly 800 companies across 53 countries, the GRI or G3 (as popularly known) manifests a standard set of reporting guidelines on economic, environmental and social performances of an organization. The guidelines further assist an investor by providing a road map of the key risk-prone and risk-averse companies, with consistent and timely release of comparable information on a regular basis.

6. CONCLUSION-

Sustainable finance practices in Indian companies are on an upward trajectory, driven by regulatory support, investor demands, and corporate commitment. While challenges remain, including data quality and short-term profit pressures, the potential for sustainable finance to drive positive environmental and social change in India is significant. As Indian companies continue to adopt and integrate sustainable finance principles, they can contribute to a more responsible, equitable, and sustainable future, both nationally and globally.

Sustainable finance has gained significant attention in recent years, as concerns about climate change, social inequality, and corporate responsibility have grown. Regulatory bodies in various countries have developed guidelines and standards to encourage sustainable finance practices, and investors are increasingly factoring ESG criteria into their investment strategies. The goal is to drive a transition to a more sustainable and equitable global economy. Sustainable finance represents a paradigm shift in the financial industry, where profit generation is no longer at odds with environmental and social responsibility. It has the potential to drive global efforts to combat climate change, reduce inequality, and promote responsible economic practices. However, significant challenges must be overcome, including data quality, regulatory inconsistencies, and the need for widespread education. With the right strategies and a commitment to the principles of sustainable finance, Indian companies can transition to a greener and more inclusive economy, ensuring a more Sustainable India for generations to come.

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A Study on Challenges in Human Resource Management

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Abstract

Human Resource Management (HRM) refers to the structured systems organizations establish to oversee their personnel. Core duties of HR managers encompass *talent acquisition, compensation and benefits administration, and job design and structuring*. As Edward L. Gubman notes in the *Journal of Business Strategy*, the fundamental HR mission remains constant: “acquire, develop, and retain talent; align the workforce with the business; and contribute meaningfully to the organization.” These enduring priorities become especially acute in small businesses, which often lack a dedicated HR department and rely on a lone HR specialist or even the CEO to handle these functions. As such, small business leaders must anticipate HR challenges early, so they are equipped to tackle issues effectively as their organization scales. This study investigates HRM challenges, proposes strategies to address them, and highlights emerging trends in the field.

Keywords: Human Resource Management, Challenges, Employees, Business.

Introduction

As advances in communication, cutting-edge technologies, and the removal of economic and social barriers continue apace, the world is evolving into a truly interconnected, borderless ecosystem. Globalization is reshaping economies and redefining how companies operate. In this context, the role of the HR manager has become increasingly strategic: they must now foster inclusive environments where employees of diverse backgrounds, cultures, and nationalities can collaborate seamlessly and thrive.

This shift means HR is undergoing a profound transformation. Routine administrative tasks like payroll or leave processing are increasingly becoming automated or outsourced. According to a recent report, HR professionals are now expected to demonstrate expertise in areas such as data analytics,

digital tools, and strategic workforce planning. As these shifting expectations unfold, HR practitioners are being called upon to evolve into strategic business partners, equipped with business acumen and able to take on unfamiliar—but critical—roles. They must now lead organizational development, manage cultural integration, and advance business goals through talent strategy.

Objectives

1. To study the challenges in HRM.
2. To provide suggestions to overcome challenges.
3. To highlight the future challenges in HRM.

Research Methodology

For this study secondary data has been used. The data has been collected through internet, websites etc.

Findings

Emerging HR Challenges

1. Globalization in HRM

In today's globalized business landscape, organizations no longer rely solely on local talent. Instead, HR leaders tap into worldwide talent pools, enabling them to recruit from anywhere—even across borders. While this expands opportunities to bring in diverse expertise, it also demands strategic HR planning to navigate time zones, legal frameworks, and cultural expectations effectively.

2. Managing a Multicultural Workforce

The modern workforce reflects global demographic diversity, including differences in nationality, age, gender, race, education, religion, family status, and professional background. Cultural variety enriches team creativity and problem-solving, but it also introduces challenges such as miscommunication, bias, and conflict. HR must foster an inclusive environment to harness these benefits while minimizing friction.

3. Employee Selection

Especially in smaller businesses, hiring can be heavily influenced by external and internal pressures—referrals, political ties, personal bias, or even unethical behaviors like bribery. Meanwhile, internal factors like recruitment costs, job analysis, and limited HR planning further complicate selecting

qualified candidates. HR must navigate these dynamics while upholding transparent and merit-based processes.

4. Compliance with Laws and Regulations

Employment laws—covering wages, discrimination, and workplace safety, benefits, and data protection—are constantly evolving across federal, state, and local levels. For small and medium-sized enterprises, tracking these changes and ensuring ongoing compliance is complex and resource-intensive. Failing to comply can result in legal actions, financial penalties, and reputational damage.

5. Training and development

“Training is expensive. Without training, it is more expensive.” – Nehru

Training begins with an honest assessment of one’s current level of skill and knowledge, and charts a path toward future growth and competence. Through training, individuals gain exposure to updated information, refined methodologies, and an opportunity to reinforce previously acquired skills. This continual learning process not only elevates performance but also strengthens confidence and adaptability. Well-trained employees consume fewer resources—such as time, material, and supervision—while achieving higher efficiency. Additionally, training enhances morale and loyalty, reducing turnover and associated costs. Conversely, neglecting training can lead to inefficiencies, increased errors, lower motivation, and higher attrition—ultimately incurring greater costs than the investment in training itself

6. Balance with work life

Balancing work and life assumes relevance when both husband and wife are employed. In India, working women now account for 15% of the total urban female population of 150 million. Any organization that strives to be reckoned as ‘a great place to work’ needs to pay special attention to minimize and facilitate resolution work life conflict of their employees. The challenge however is in knowing and doing things that facilitate and support work life balance without intruding into the personal lives of employees. The HR department of such organization is often stretched for creative solutions that are practical to implement, yet are effective in impact.

7. Retaining Employee

- Globalization has given freedom to working professionals to work anywhere in the world
- Now that they have endless lucrative opportunities to work, hiring and retaining the best industry talents is no joke
- Providing excellent work environment and offering more remuneration and perks than your competitors can retain and motivate them.

How to overcome the HR challenges...?

Key Strategies to Address HR Challenges

1. Strategic Workforce & Recruitment Planning

Effective HR begins with a clear and proactive HR strategy. This involves forecasting vacancies, defining job roles and qualifications, and selecting recruitment channels. HR managers should anticipate key milestones and potential obstacles in hiring to ensure a smooth selection process aligned with business goals.

2. Cross-Functional Coordination

HR must foster strong collaboration across departments. Encouraging shared accountability and clear communication enhances teamwork—especially in diverse settings—and ensures HR initiatives are well supported throughout the organization .

3. Empathy-Driven Leadership

Human-centered leadership is essential. HR professionals should cultivate empathy—understanding individual needs and personal situations—to build trust and engagement. This creates a supportive environment that boosts morale and productivity .

4. Deep Understanding of Labor Dynamics

HR leaders must stay informed about labor trends—wage standards, work hour norms, regulatory updates, and workforce demographics. This requires ongoing research, sector awareness, and direct experience. Such insight helps HR to plan accurately and maintain legal compliance .

Following are the some of the challenges being faced by HR Manager which is identified

1. Recruitment and selection

2. Career development and growth
3. Promoting organization culture and heterogeneous workforce
4. Conflict management and resolution
5. Business ethics and values
6. Managing Multi-Generational Workforce
7. Strategies for motivation and retention
8. Flexible work hours
9. Striking work life balance
10. Managing 5 R's

Conclusion

As globalization continues to merge borders economically and culturally, HRM must evolve to navigate an increasingly diverse and dynamic environment. Today's HR managers need more than traditional administrative skills—they must cultivate strategic expertise, cultural competency, and innovation to stay competitive on a global scale.

Technology plays a pivotal role in this transformation. Modern HR functions leverage digital tools—from HR information systems (HRIS) to AI-driven analytics—to streamline core processes and enhance strategic decision-making. Additionally, remote work and virtual collaboration models have become integral, requiring HR to ensure flexibility, well-being, and inclusion across distributed teams.

Looking ahead, HR leaders must continue adapting to rapid technological advances, shifting employee competencies—especially among younger generations—and evolving legal frameworks around employment benefits. Heightened competition means attracting, developing, and retaining top talent demands a proactive, strategic approach tied to innovation and cultural agility.

In essence, HR must transcend its traditional role. It should drive organizational resilience by building agile, digitally enabled workplace cultures that prioritize employee development and fairness in a global, ever-shifting business landscape.

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Digital Poisoning in Artificial Intelligent and Machine Learning Models: Threats, Techniques and Security

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Abstract:

Artificial Intelligence (AI) systems have become integral to decision making, deployed in a several areas including education, healthcare, banking, finance, robotics, transportation, defense system, e-commerce and social networks, security and autonomous systems etc. AI system relies heavily on datasets to train its models. An increased amount of data enhances its capacity to learn and generate precise predictions. However, the other side of AI is use original data where data that can be manipulated or poisoned in digital world, know the digital poison. A new version of threat is emerging and that threat is digital poisoning. Digital Poisoning is issue or challenging and time consuming to spot and when it is discovered with the damage is already included. Unlike traditional attacks that exploit data errors, this emerging threat targets the AI's training data within its algorithm. Data or digital data is now being weapon zed. Though it demands little effort, it has the potential to inflict significant harm. It only requires 2-3% of data to be poisoned to severely diminish an AI system to generate accurate or exact predictions. However, as their influence grows, so does the attack surface through digital poisoning terms? Digital poisoning is a form of adversarial attack, involves injecting malicious or misleading data into the training or inference pipeline of machine learning models, reducing their accuracy, reliability and trustworthiness. This paper explores the techniques, security, impacts and countermeasures related to digital poisoning in AI systems. By analyzing recent case studies and presenting emerging security strategies, we highlight the urgent need for robust AI security mechanisms to mitigate this growing threat. According to Grand View Research Institute analyze that the global AI market was worth 98.5 billion in 2023 and that it will rise at a compound annual growth rate (CAGR) of 42.1% from 2024 to 2030.

Keywords: - Artificial Intelligence, Security, Machine Learning, Digital Poisson, Data Poisson, Tay Chatbot, Trojan, Attacker, Adversarial Training, Threats, Federated Learning.

1. Introduction: - Artificial Intelligence (AI) has revolutionized data-driven automation by enabling systems to learn from massive datasets and make predictions or decisions with minimal

human intervention. From personalized recommendations to self-driving vehicles, AI's capabilities are expanding rapidly. However, this reliance on data and algorithms makes AI inherently vulnerable to intentional manipulation. One such threat is digital poisoning, wherein attackers compromise the integrity of AI systems by inserting corrupted, misleading, or adversarial data into training sets or live input streams.

Digital poisoning is not merely a technical inconvenience — it has serious implications for safety, fairness, and trust. Poisoned models may misclassify objects, generate harmful content, or exhibit biased behavior, often without immediate detection. For instance, manipulated training data in medical imaging models could result in incorrect diagnoses, while poisoned autonomous systems could misinterpret road signs, leading to life-threatening outcomes. The purpose of this research is to provide a comprehensive study on digital poisoning, including:

- Key techniques and classifications of poisoning attacks
- Real-world examples and case analysis
- Significant influence of AI systems based on user feedback.
- Security mechanisms and future research directions

There are different methods through which data poisoning can occur. Example- an attacker might alter a limited portion of the training dataset or insert a large volume of false data.

Regardless of the approach, the aim is to cause the AI model to produce inaccurate predictions or behave in undesirable ways.

As AI systems become more pervasive, securing their learning pipelines against digital poisoning is not optional- it is essential manner. Big Data is the driving force for the new trends of Artificial Intelligence (AI) system in recent years. As reported by Statista, approximately 64.2 zettabytes of data were created, collected, and stored in 2020, and this figure is projected to exceed 180 zettabytes by 2025.

AI is being including to a wide range of useful applications such as voice recognition, spam filters, autonomous cars, digital support and malware detection, (Brundage et al., 2018). AI algorithms adopted large set of data to train, the more high quality dataset the higher system performance and more accurate predictions (Comiter, 2019). However, the methods used in AI have created a new threat called an “Artificial Intelligence Threats (AIT)”. These attacks can arrive in several forms that different weakness in the underlying algorithms called Data or digital Poisoning. Digital poisoning threats add or manipulate data to cause misclassification or create backdoors. AI train from data and when the data is poisoned, it can affect the AI system’s learning process, and finally, making it unreliable and allowing the attacker to control its behavior."

Artificial Intelligence is being integrated into cyber security applications to detect malware, spam, and network intrusions. This integration makes the systems vulnerable to digital poisoning. A hacker can exploit the system's weaknesses by injecting poisoned data to degrade the performance of particular system or channel.

Artificial Intelligence (AI) and its major subfields—Machine Learning, Neural Networks, and Deep Learning—use algorithms to process large amounts of data and find patterns, enabling the AI software to learn. You can take an example for AI generative system e.g. An AI algorithm for an autonomous vehicle or self driving car is assigned the task of learning to identify a stop signal. It is given thousands of datasets containing examples of stop signs. From these examples, it recognizes patterns of color and shape of the stop sign. Later, when asked to recognize a stop sign, it scans the image and searches for the patterns it had previously learned. During the machine learning process, a pattern or sign matching is successful, it directly instructs the car or vehicle to give the stop signal; if the sign matches is not successful, another pattern, like a speed limit, the algorithm instructs the autonomous vehicle or car to speed up or slow down as per pattern matching style for particular things.

Therefore, Artificial Intelligence learns is also where its vulnerability lies. Data poisoning attacks may hinder an AI system's ability to respond accurately in specific scenarios, or embed hidden vulnerabilities that adversaries could exploit later (Comiter, 2019). In 2019, the Chinese tech company Tencent demonstrated how they were able to trick Tesla's AI algorithm by subtly altering the data received by the car's sensors. They used a hidden pattern displayed on a TV screen to activate the windshield wipers, and in another trick, they slightly modified lane markings on the road so that the car would drive over them and into oncoming traffic".

The purpose of this paper is to provide readers with an understanding of the Artificial Intelligence attack or threats known as digital poisoning. The paper will give a brief introduction to AI and data or digital poisoning methods, along with real-world examples. It will identify three areas of society that will be affected by data poisoning and finally suggest simple preventive measures." (Knight, 2019).

2. Digital Poisoning in Artificial Intelligence:-

What is Digital poisoning in Artificial Intelligence: -

Data poisoning in AI refers to the intentional insertion of harmful or misleading data into the datasets used for training AI systems. The main goal of this attack is to manipulate the training data so that the AI model learns flawed or biased patterns, which can then be exploited by the attacker to gain an advantage.

Digital poisoning refers to the intentional corruption of training or inference data used by machine learning (ML) or deep learning (DL) models. Unlike traditional cyber attacks that exploit software vulnerabilities, poisoning targets the data pipeline -the very foundation upon which AI learns. The goal is to introduce subtle, often undetectable, distortions that lead the model to behave incorrectly or unpredictably during inference.

Two primary forms of digital poisoning exist-

Training-time poisoning: - The attacker injects malicious samples into the dataset during model training. These poisoned instances mislead the learning process and compromise generalization.

Inference time poisoning: - in another thing clean models are used feed with specially crafted inputs thing that appear or look like normal but cause incorrect outputs increases the high failure rate.

This type of manipulation can result in system failures, biased decisions, or even allow attackers to control model behavior- all without breaching traditional system security.

The most straightforward way to poison a machine learning model is to poison its dataset. Machine learning algorithms identify patterns in the data to build a model, but if the data is polluted, this process comes to a halt. Hackers poison the dataset by adding incorrect data to the actual dataset. Here, we understand with the following example-An email system scanning the spam filtering uses statistical machine learning process to identify between good and spam emails. If even 1% of the training data are changed the AI algorithm can become ineffective or altered. Attackers use words commonly found in legitimate emails and insert them into spam emails so that during the retraining of the new dataset, the algorithm mistakenly identifies spam as good email. The newly trained model then classifies these malicious samples as safe. After that, attackers can make phishing emails appear legitimate and use them to steal passwords, usernames, or infiltrate a company's computer system (Nelson et al., 2008).

Such attacks are difficult to detect because the datasets used often contain millions of samples and come from either public or private sources. Even if the data is verified, there is still a possibility that an attacker has hacked into the stored data and already poisoned it.

Hosseini and colleagues (2017) demonstrated that the Google Perspective API -which was designed to detect harmful comments, cyber bullying, harassment and abusive language-was also vulnerable to data poisoning. Here, we will see Table 1 how a single instance of poisoned data can change the entire system.

Table 1- Toxicity score changed by incorrect or added punctuations

Original Source Data or Code	Toxicity Score	Modified Data or Code	Toxicity Score
You're such an idiot	85%	You're such an i.d.i.o.t.	12%
She's such a betch	75%	She's such a b.i.t.c.h.	11%
They are liberal idiots who are uneducated	(90%)	They are liberal i.diots who are un.educated	(15%)
Go to hell!	78%	Go to h.e.l.l.!	10%

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By adding an extra letter to the word 'idiot', the toxicity score dropped from 84% to 20%, and by adding a period (.) to the word 'stupid', the score dropped from 86% to just 2%. Table 2 shows that the system's algorithm has a high false alert rate in identifying normal phrases as toxic. If someone adds the word 'not' to a highly harmful phrase, the algorithm assigns it a much lower toxicity score.

Table 2- API high false alarm rate			
Original Source Data or Code	Toxicity Score	Modified Data or Code	Toxicity Score
You're such an idiot	85%	You're such an not idiot	74%
She's such a betch	75%	She's such a not bitch	84%
They are liberal idiots who are uneducated	(90%)	They are not liberal idiots who are not uneducated	(68%)
Go to hell!	78%	Go to not hell!	90%

A second method of data poisoning is to exploit a weakness in the algorithm used to create the AI model. This kind of attack is especially common in Federated Learning. Federated Learning is a machine learning approach where the user's data stays on their own phone or device and is not sent anywhere else. Instead, different devices learn from their own data, and then these small models are combined to create a big model. This keeps the user's privacy safe and also benefits companies.

But in this process, thousands or even millions of users are involved, and the algorithm can be easily fooled. Some users can work together to insert bad or wrong data so that the entire model gets corrupted. This technique is also known as digital or data poisoning in AI and ML. For example, many smart phones train a model that predicts the next word. One or more bad users force the model to choose a particular word, making the model behave incorrectly. In this technique, the hacker controls one or more users and uses a method known as constrain and scale to learn or train the model based on alter or bad data. Then that bad model becomes part of the whole system and misleads the users.

3. Techniques of Digital Poisoning Attacks: - A digital poisoning attack can take several forms depending on the hackers or attacker's access, intent, and sophistication. There are several Key techniques available in digital poisoning:

3.1 Label Flipping Attacks:-In supervised learning, attackers change the labels of selected training instances, reducing model accuracy. For instance, in image classification, some images of "cats" may be mislabeled as "dogs," degrading overall model performance.

3.2 Backdoor Attacks:-Backdoor poisoning involves embedding a specific pattern (e.g., a pixel patch or watermark) in training samples associated with a target label. At inference time, if the model sees the same trigger, it misclassifies the input into the attacker's chosen category, even if the input is unrelated.

3.3 Clean-Label Attacks:-These attacks use poisoned samples that are correctly labeled but subtly perturbed. Since labels appear valid, data curation systems often fail to detect them. These are particularly dangerous as they bypass manual review filters.

3.4 Adversarial Examples:-Attackers craft input data that appears legitimate to humans but causes a trained model to misclassify. For example, slightly altering a stop sign image may cause a self-driving car's vision system to interpret it as a yield sign.

3.5 Data Drift Manipulation:-Attackers may inject long-term changes into streaming data, slowly corrupting the decision boundary of models in online or continuous learning systems.

4. Impact of Digital Poisoning on AI Systems:-Digital is poisoning poses significant risks to a variety of AI applications, including computer vision, natural language processing, and machine learning. It can greatly affect both the accuracy and reliability of AI models.

There are various implications of digital poisoning extend beyond altered or misclassifications things-

Security Risks: - Poisoned AI models may be used to bypass biometric authentication or recommend unsafe actions in autonomous systems.

Ethical Violations: - If the training data is poisoned to favor or disfavor certain groups, the model may make biased or discriminatory decisions.

Model Reliability Degradation: - Even small-scale poisoning can drastically reduce a model's confidence and accuracy, particularly in high-stakes domains like healthcare.

Erosion of Public Trust: - As users recognize the potential for manipulation, trust in AI-based recommendations and automation decreases.

Decreased Accuracy: - When AI models are trained on faulty or biased data, their ability to make accurate predictions diminishes. This reduction in accuracy can result in flawed decisions, which could be especially harmful in critical sectors like healthcare, finance, and transportation.

Greater Susceptibility to Attacks: - Data poisoning can weaken AI models, making them more prone to malicious attacks. Attackers can take advantage of these weaknesses to manipulate the model into producing incorrect outcomes or undesirable behaviors.

Introduction of Bias and Discrimination: - Poisoned data can embed biases within AI models. For instance, if the training data for a facial recognition system favors certain demographic

groups, the model might perform better for those groups and worse for others, leading to unfair things.

Legal and Ethical Challenges: - The use of compromised AI models raises serious legal and ethical questions, especially in sensitive domains such as healthcare and criminal justice. Incorrect outputs that cause harm to individuals may result in legal liabilities and ethical dilemmas.

To reduce the risks associated with data poisoning, it is crucial to carefully select and verify the training datasets used for AI development. Moreover, methods like adversarial training can enhance the model's resistance to such attacks. Ongoing supervision and evaluation of AI systems are vital to maintaining their integrity.

5. Preventing Digital Poisoning in AI:- Although AI and machine learning (ML) technologies offer numerous advantages for businesses, cybercriminals have begun using these same tools to carry out sophisticated attacks. One of the major concerns in this area is **data poisoning**, which poses a serious challenge for cyber security experts and is becoming more dangerous than traditional cyber threats. In such attacks, adversaries attempt to insert manipulated or malicious inputs into the training dataset, compromising the system's ability to make reliable predictions. By injecting harmful data during the training phase, attackers can alter the model's behavior or lead it to generate inaccurate outcomes. To protect AI systems from data poisoning, organizations can implement the following measures:

Ensure Data Integrity	Data Validation	Monitor Data Inputs
Data Filtering	Data Diversification	Implement Outlier Detection
Awareness Of Employees	Access Control	Robust Models
Frequent Label Checks	Open Source Data Usage	Penetration Testing
Additional Layer of AI/ML	Conduct Regular Security Audits	

Data Poisoning is a major area of concern. Proper planning should be put in place to prevent attacks as much as possible.

6. Case Studies Analysis:-

6.1 Microsoft Tay Chatbot (Year -2016):- Microsoft launched a first Chatbot named "Tay," an AI algorithm and machine learning based Chatbot that trained or learned from user interactions through Twitter account. In just an hour, coordinated users feed it toxic and offensive content in altered manner. Lacking proper content filtration and adversarial training, Tay began generating hate speech and was shut down within 24 hours. Though not a classical data poisoning case, it demonstrated the risks of real-time input-based poisoning in online learning systems.

6.2 Trojan Attacks on Image Classification:- In 2017, researchers demonstrated that neural networks could be back doo red using imperceptible image modifications. For instance, by

embedding a specific pixel pattern in images of traffic signs, they trained a model to misclassify "stop" signs as "speed limit" signs when that pattern appeared. Such attacks expose severe safety concerns in autonomous driving systems.

6.3 Poisoning in Facial Recognition Systems:-Studies have shown that facial recognition systems can be manipulated by introducing a few poisoned faces with slight distortions into the training data. The poisoned model then misidentifies specific people or allows unauthorized individuals access when wearing specific accessories (like glasses with patterns).

These case studies confirm that poisoning attacks are not theoretical-they have real, high-impact implications when models are deployed in the wild.

7. Security Mechanisms against Digital Poisoning:-Security or Defending against digital poisoning requires both proactive and reactive strategies.

7.1 Data Validation and Sanitization:-Before training, datasets should undergo strict validation, using anomaly detection or clustering to identify outliers or suspicious patterns. Techniques like feature distribution analysis and metadata consistency checks can flag potentially poisoned data.

7.2 Robust Training Algorithms:-Security-aware learning algorithms are designed to resist corrupted samples. Examples include:

- Differentially private learning
- Certified robust training
- RANSAC-based regression models

These techniques reduce sensitivity to small subsets of malicious data.

7.3 Adversarial Training:-In this method, models are trained on both clean and adversarial (poisoned) examples to improve their resilience. While computationally expensive, it can enhance robustness against inference-time attacks.

7.4 Model Auditing and Explain ability:-Post-training analysis using Explainable AI (XAI) tools can help detect abnormal patterns in model predictions. If certain inputs always produce biased outputs, they may be the result of backdoor poisoning.

7.5 Data Provenance and Secure Pipelines:-Tracking data lineage and using cryptographically signed datasets can reduce the risk of external tampering. Organizations should implement secure ML Ops pipelines with permission access to data and model assets.

8. Future Scope and Research Challenges: - There is various despite progresses, defending against digital poisoning remains an open challenge.

8.1 Need for Poisoning Benchmarks: - There is no universally accepted benchmark for testing model robustness against poisoning.

8.2 Generalization vs. Robustness Trade-off:- Models optimized for accuracy on clean data may underperform when hardened against poisoning.

8.3 Federated Learning Risks: - In decentralized AI systems, malicious edge devices can poison local updates and affect global models- this area needs dedicated research.

8.4 Policy and Regulation: - Standardization and legal frameworks are required to define liability, especially when AI systems make poisoned decisions in critical applications.

Future research must focus on developing automated detection, zero-trust data ingestion frameworks, and AI verification techniques that work at scale.

Conclusion: - Digital poisoning presents a potent and evolving threat to the integrity of AI systems. From training-time manipulation to inference-time adversarial attacks, poisoning can degrade model performance, introduce bias, and even cause catastrophic failures. As AI is integrated into mission-critical systems, defending against such attacks becomes imperative. Through a combination of robust data validation, adversarial training, and secure model pipelines, organizations can mitigate the risks. However, the arms race between attackers and defenders continues, highlighting the need for ongoing research, policy involvement, and cross-domain collaboration to build truly resilient AI.

Security risks associated with artificial intelligence are growing rapidly and becoming increasingly complex. One such threat is data poisoning, a type of attack that specifically targets the learning phase of AI models. Unlike input-based attacks that tamper with the data fed into the system to influence its output, data poisoning corrupts the training process itself. Both types of attacks are serious, as the weaknesses don't stem from human error-as seen in traditional cyber threat-but from flaws in how the AI system learns and evolves. Therefore, businesses must shift their focus from simply accelerating product development to prioritizing the protection and resilience of their AI-driven solutions.

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Research on India VIX: Understanding Market Volatility in India

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Abstract

Traders and Investors are active participants in the currency market aware of market volatility and understand it may impact their earnings. To understand the level of market volatility affecting their investment, investors supporters must assess uncertainty to inform their decisions. In any event, how would you assess Are you watching for unpredictability? A list of unpredictability emerges in this context. This is a list for evaluation. market volatility against it to assess shifts in volatility factors. In Indian stock markets, India VIX is an unpredictability document that functions as a market indicator.

Keywords: Volatility, Index, Investor, currency market, Contract

1. Introduction to India VIX

In India Vix , is an important indicators in Indian financial market, its also referred as the "fear index" or "fear gauge" since it indicates the market's anticipation of volatility in the NIFTY 50 index over the next 30 calendar days.

What it Measures (and What it Doesn't):

- **Volatility Expectation:** India VIX essentially measures the predicted degree of price changes in the NIFTY 50 index. It shows you how much the market is predicted to move (up or down), not in which direction.
- **Near-term Focus:** Its computation focuses on volatility anticipated in the immediate future, specifically the next 30 days.

Contrast with Price Indices: Unlike NIFTY 50, which tracks the actual price movements of a basket of equities, India VIX is an independent index that focuses purely on the rate and magnitude of price fluctuations.

Contrast with Price Indices: Unlike NIFTY 50, which tracks the actual price movements of a basket of stocks, India VIX is an independent index that focuses solely on the rate and magnitude of price changes.

India Vix for Trading in Indian market

- The VIX is also a handy indicator for options traders. Volatility is often used to evaluate whether to acquire or sell an option. When volatility is predicted to grow, options become more attractive, and buyers likely to earn more.
When the VIX declines, there will be more squandering of time value, and option sellers will gain more.
- Trading volatility is another possible use for it. Buying straddles or strangles is one choice if you anticipate that the markets will become more turbulent. However, these become unaffordable when volatility is predicted to increase.
Purchasing futures on the VIX index itself would be a superior course of action because it would enable you to profit from volatility without worrying about the direction of market movement.
- The VIX is a reliable and highly accurate predictor of index volatility.
he charts show a clear negative correlation between the VIX and the Nifty movement over the last nine years.

2. Calculation of India VIX

India VIX is computed using the Black-Scholes Model and is based on the order book of NIFTY 50 options, considering factors such as:

- Bid-ask spreads of near- and mid-month NIFTY 50 options.
- Risk-free interest rate (typically the MIBOR rate).
- Time to expiry of options contracts.

3. Significance of India VIX in Financial Markets

Market Sentiment Indicator: A low VIX denotes market stability and confidence, whereas a high VIX implies increased uncertainty, fear, or risk perception.

- Risk Management Tool: Assists both retail and institutional investors in protecting themselves from market swings.
- Trading Strategy Input: Traders modify their options, futures, and portfolio strategies based on VIX levels.
- Inverse Relationship with NIFTY: India VIX usually rises when NIFTY declines and vice versa.

4. Elements Affecting India VIX

- Global Market Trends: The India VIX is influenced by international indexes, geopolitical developments, and global economic conditions.
- Earnings Announcements: Market swings may result from significant corporate earnings reports.

- **Economic Data & Policy Decisions:** Market sentiment is influenced by GDP growth, inflation rates, RBI monetary policies, and fiscal budgets.
- **FII & DII Activity:** The involvement of both domestic and foreign institutional investors affects market volatility.

5. Research Findings on India VIX & Market Behavior

Lead Indicator for Market Movements: Research indicates that a market correction is frequently preceded by an increase in the India VIX.

- **Effect on Option Pricing:** The India VIX has a significant influence on option premium pricing; greater VIX results in more expensive options.
- **Volatility Clustering:** Studies reveal that periods of high volatility are frequently followed by periods of even greater volatility, which influences long-term investing choices.

6. Practical Applications in Trading & Investment

Hedging Techniques: To protect portfolios during periods of extreme volatility, investors employ defensive puts or India VIX options, if they are available.

- **Volatility-based Trading:** To profit from fluctuations in volatility, traders employ straddle and strangle tactics.
- **Asset Allocation Decisions:** Taking volatility expectations into account, fund managers modify the allocations of their portfolios.

7. Limitations of India VIX

The India VIX is a short-term indicator that solely predicts volatility over the next 30 days.

- **Not a Market Direction Predictor:** It does not say whether markets will rise or fall, only that there is uncertainty.
- **Limitations on Liquidity:** India lacks an active VIX futures market, in contrast to the United States.

8. Conclusion

Traders, investors, and policymakers can leverage it to make informed financial decisions. Further research into its predictive power and relation to macroeconomic variables can enhance its utility in risk management.

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Development of a Real-Time Sentiment Analysis Framework for E-Commerce Using NLP and Machine Learning

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Abstract

In the digital economy, e-commerce platforms serve as a critical interface between businesses and consumers. The volume of user-generated content, such as reviews and feedback, has grown exponentially. Extracting actionable insights from this data through sentiment analysis has become crucial for enhancing customer satisfaction and informing business strategies. This research proposes a real-time sentiment analysis framework specifically designed for e-commerce platforms, leveraging Natural Language Processing (NLP) techniques and Machine Learning (ML) models. The framework aims to accurately classify customer sentiments, providing businesses with instant insights into consumer opinions and trends. The paper discusses the architecture, implementation, and evaluation of the system, demonstrating its effectiveness in processing real-time data streams with high accuracy and efficiency.

Keywords: Sentiment Analysis, E-Commerce, Natural Language Processing (NLP), Machine Learning (ML), Real-Time Data Processing, Customer Reviews Analysis, Apache Kafka, Apache Spark Streaming, Deep Learning, Transformers (BERT), Opinion Mining, Data Streaming Framework, Consumer Behavior Analysis

1. Introduction

With the proliferation of e-commerce platforms like Amazon, Flipkart, and eBay, user reviews and feedback have become integral in shaping consumer decisions and influencing business reputation. Traditional sentiment analysis approaches, often limited to batch processing, are inadequate for real-time applications where immediate insights are necessary for dynamic decision-making.

Recent advancements in NLP and ML offer opportunities to develop robust real-time systems capable of analyzing large volumes of user-generated content as it is produced. This research focuses on designing and implementing a real-time sentiment analysis framework tailored for e-

commerce scenarios, providing actionable insights by classifying sentiments into positive, negative, or neutral categories.

2. Literature Review

2.1 Sentiment Analysis in E-Commerce

Sentiment analysis, a subfield of NLP, involves computationally identifying and categorizing opinions expressed in text. In e-commerce, sentiment analysis helps understand customer satisfaction, product popularity, and emerging market trends. Prior studies [1][2] have shown the effectiveness of sentiment analysis in enhancing recommendation systems, improving customer service, and refining marketing strategies.

2.2 Techniques in Sentiment Analysis

Common approaches to sentiment analysis include:

1. Lexicon-Based Methods

Lexicon-based approaches rely on precompiled dictionaries or lists of words, each tagged with a sentiment score or polarity (positive, negative, or neutral). When analyzing a given text, the algorithm computes the overall sentiment by aggregating the scores of individual words found in the lexicon.

- **Advantages:**
 - Simplicity and interpretability.
 - No need for large labeled datasets.
 - Effective in domains with well-defined vocabularies.
- **Limitations:**
 - Struggles to understand the context, idioms, or complex linguistic constructs such as sarcasm, irony, or negation (e.g., “not good” might be misclassified as positive).
 - Fails to capture sentiment shifts within longer texts.
 - Less adaptable to evolving language trends or domain-specific jargon.

Lexicon-based tools include SentiWordNet, AFINN, and VADER (particularly suited for social media texts).

2. Machine Learning Models

Machine learning approaches treat sentiment analysis as a text classification problem. These models learn patterns from labeled datasets where each text sample is tagged with a sentiment label (e.g., positive, negative, or neutral). The learning process involves extracting features from text, commonly using techniques such as Bag-of-Words (BoW), TF-IDF (Term Frequency-Inverse Document Frequency), or word embeddings.

- **Popular Algorithms:**

- **Naïve Bayes (NB):** A probabilistic model well-suited for text classification tasks. Assumes feature independence, which may not always hold true but performs well in practice.
- **Support Vector Machines (SVM):** A robust classifier that works well with high-dimensional feature spaces like those derived from text data.
- **Random Forests:** An ensemble learning method that combines multiple decision trees to improve classification accuracy and reduce overfitting.
- **Advantages:**
 - Can achieve high accuracy when trained on quality datasets.
 - Flexible and adaptable to different domains through retraining.
 - Faster than deep learning models for smaller datasets.
- **Limitations:**
 - Requires careful feature engineering.
 - May not capture complex linguistic structures or semantic relationships.
 - Performance heavily depends on the quality and representativeness of the training data.

3. Deep Learning Models

Deep learning approaches, particularly neural networks, have revolutionized sentiment analysis by enabling models to capture complex patterns in data without extensive manual feature engineering. These models learn hierarchical representations of text, from basic syntax to abstract semantics.

- **Popular Architectures:**
 - **Convolutional Neural Networks (CNNs):** Originally designed for image recognition, CNNs have been adapted to text by capturing local patterns such as specific sequences of words or phrases indicative of sentiment.
 - **Recurrent Neural Networks (RNNs) and Long Short-Term Memory Networks (LSTMs):** Specialized for sequence data, RNNs and LSTMs can capture temporal dependencies in text, making them effective for understanding sentiment in longer documents where word order matters.
 - **Transformer Models (BERT, DistilBERT, RoBERTa):** Transformers use attention mechanisms to capture relationships between all words in a text simultaneously, leading to state-of-the-art results. Models like BERT (Bidirectional Encoder Representations from Transformers) can understand nuanced context, sentiment shifts, and ambiguous expressions more effectively than previous models.
- **Advantages:**
 - Superior accuracy due to better contextual understanding.
 - Capable of handling large, unstructured datasets.
 - Adaptable to various NLP tasks through transfer learning.

- **Limitations:**

- Computationally intensive, requiring significant processing power and memory.
- Requires large amounts of labeled data for fine-tuning.
- Often considered “black box” models with limited interpretability.

2.3 Real-Time Processing Challenges

Real-time sentiment analysis faces challenges such as:

- Handling large, continuous data streams.
- Maintaining low-latency responses.
- Ensuring scalability and fault tolerance.

Existing research predominantly focuses on offline analysis or lacks the scalability needed for commercial platforms. This research addresses these gaps through a scalable, real-time framework.

3. Methodology

3.1 System Architecture

The architecture of the proposed real-time sentiment analysis framework is composed of the following key components:

1. Data Ingestion Layer

This module captures real-time product reviews and feedback from diverse sources such as websites, mobile applications, and social media platforms. It utilizes APIs and webhooks to ensure continuous and automated data collection.

2. Preprocessing Module

Incoming textual data is subjected to a series of NLP preprocessing steps, including tokenization, stop-word removal, stemming, and lemmatization. These operations help normalize the text and prepare it for accurate sentiment analysis.

3. Sentiment Analysis Engine

This core component integrates machine learning classifiers like Random Forest and Logistic Regression with powerful NLP-based embeddings. Advanced models such as BERT and Word2Vec are utilized for deep semantic understanding. For real-time performance, the system employs DistilBERT—a lightweight and efficient variant of BERT.

4. Real-Time Processing Framework

To handle real-time data streams and enable low-latency processing, Apache Kafka is used for data streaming, while Apache Spark Streaming manages distributed, in-memory computation for sentiment classification tasks.

5. Visualization and Reporting Layer

The analyzed sentiments and trends are visualized using interactive dashboards built with tools like Grafana or Kibana. This layer also provides anomaly alerts and generates customizable reports for decision-makers.

3.2 Dataset

The framework uses datasets from:

- **Kaggle:** Amazon product reviews dataset (multi-domain).
- **Live e-commerce sites:** Real-time review data collected via APIs.

The datasets include millions of records labeled with sentiment polarity and provide diversity in language, product categories, and user demographics.

3.3 Model Training

Models are trained using:

- **TF-IDF Vectors:** For baseline models (Logistic Regression, SVM).
- **Word Embeddings:** Word2Vec, GloVe for context preservation.
- **Transformers:** DistilBERT fine-tuned on domain-specific datasets.

Evaluation metrics include Accuracy, Precision, Recall, F1-Score, and AUC-ROC.

4. Results and Discussion

4.1 Performance Evaluation

Models were evaluated on a test set comprising 100,000 reviews.

Model	Accuracy	Precision	Recall	F1-Score
Naïve Bayes	82.3%	81.7%	82.1%	81.9%
SVM	86.4%	86.0%	86.7%	86.3%
Random Forest	88.2%	88.0%	88.4%	88.2%
DistilBERT	93.7%	93.5%	94.0%	93.7%

4.2 Real-Time Processing Metrics

- **Latency:** Average processing time per review is ~500ms.
- **Throughput:** Capable of processing ~10,000 reviews per minute.
- **Scalability:** Horizontal scaling with Kafka and Spark ensures consistent performance under increased load.

4.3 Sentiment Distribution Insights

Analyzing real-time data revealed:

- Electronics and fashion categories show higher positive sentiment.
- Customer complaints peak during delivery delays or product defects.

- Seasonal variations (e.g., festivals) influence sentiment polarity significantly. These insights help e-commerce companies adjust marketing strategies, improve customer support, and refine inventory management.

5. Conclusion

This research presents a scalable, efficient, and accurate framework for real-time sentiment analysis tailored to the dynamic nature of e-commerce. By integrating advanced NLP models with robust streaming technologies, the system offers businesses immediate insights into customer sentiments, enabling proactive decision-making. The framework demonstrates significant improvements in accuracy and real-time processing capabilities over traditional methods. Future enhancements include multilingual support, emotion detection beyond polarity, and integration with recommendation engines for personalized experiences.

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Smart Diagnosis: Machine Learning Approaches to Heart Disease Prediction

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ABSTRACT

Cardiovascular diseases (CVDs), encompassing conditions such as heart failure and stroke, continue to be the foremost cause of morbidity and mortality worldwide, despite considerable advancements in medical science. Lifestyle-related factors have been shown to significantly influence the onset, progression, and prevention of CVDs. In their recent study, Bansal et al. (2023) present an extensive synthesis of current evidence from epidemiological data, clinical trials, and health intervention studies. The research highlights modifiable risk factors—such as tobacco use, poor dietary habits, physical inactivity, and excessive alcohol consumption—as critical contributors to the pathogenesis of cardiovascular disorders.

In addition to epidemiological insights, the study integrates machine learning techniques to improve predictive modeling in the context of heart disease. A variety of supervised learning algorithms—including logistic regression, support vector machines, decision trees, random forests, and neural networks—were implemented to assess their predictive performance across diverse clinical and demographic features. These models were rigorously evaluated using metrics such as accuracy, precision, recall, and F1-score. The findings suggest that machine learning-based approaches can effectively support the development of clinically meaningful prediction tools, potentially enabling timely diagnosis and more targeted intervention strategies.

Furthermore, the study emphasizes the necessity for a comprehensive and integrative strategy in addressing cardiovascular health. It advocates for the incorporation of machine learning-driven decision support systems within public health frameworks to promote behavior change and encourage healthier lifestyles. Such a multidisciplinary approach aims not only to facilitate early detection but also to contribute to sustainable and population-wide cardiovascular disease prevention.

KEYWORDS

Heart Disease, Risk Prediction, Machine Learning, Deep Neural Network, Cardiovascular diseases, diabetes, stroke diagnosis; Heart Attack, CVD, SVM, Decision Tree, Grid Search.

1. Introduction

Heart disease remains one of the most significant global health challenges, affecting millions of individuals each year. This section provides a comprehensive overview of heart disease, encompassing its causes, symptoms, classifications, risk factors, diagnostic methods, and treatment options. Broadly defined, heart disease refers to any disorder that disrupts the normal function of the heart or the network of blood vessels that supply it.

The heart, a muscular organ, plays a vital role in circulating blood throughout the body, ensuring that cells receive adequate oxygen and nutrients while facilitating the removal of metabolic waste. Blood vessels function as conduits that transport blood to and from the heart. These vessels include arteries, veins, capillaries, and components of the lymphatic system. Oxygen-rich blood is pumped from the heart to the body via arteries, while veins return oxygen-depleted blood back to the heart. Capillaries, the smallest of the blood vessels, enable the exchange of gases, nutrients, and waste between blood and tissues by connecting arteries and veins through their permeable walls. The lymphatic system, consisting of lymphatic vessels, helps circulate lymph—a fluid containing white blood cells and antibodies—thus supporting immune function.

When the heart or blood vessels are damaged or diseased, their function is compromised. This can lead to a range of cardiovascular complications, such as reduced blood flow, arrhythmias, elevated blood pressure, or heart failure. Common symptoms of heart disease include chest pain, shortness of breath, fatigue, dizziness, fainting, palpitations, swelling, and persistent coughing. In some cases, individuals may remain asymptomatic until the disease progresses to a more severe stage, resulting in critical events such as myocardial infarction (heart attack) or cerebrovascular accident (stroke).

Heart disease encompasses multiple subtypes, each characterized by distinct etiologies, pathophysiological mechanisms, and clinical manifestations. Understanding these variations is essential for accurate diagnosis and effective therapeutic intervention. Among the most typical types are:

- Cardiovascular diseases (CVDs), commonly referred to as heart diseases, represent a critical public health issue worldwide. These conditions encompass a wide range of disorders that affect the heart and blood vessels and collectively remain the leading cause of illness and death across the globe. Beyond the direct health impact on individuals, CVDs place significant emotional, social, and financial burdens on families, communities, and healthcare infrastructures.
- **Arrhythmia:** - Arrhythmia is a condition characterized by abnormalities in the heart's rhythm. It may manifest as an abnormally fast heartbeat (tachycardia), an unusually slow rate (bradycardia), or an irregular rhythm (such as fibrillation). These disruptions can compromise the heart's ability to pump blood efficiently, leading to symptoms such as dizziness, light-

headedness, fainting spells, or chest discomfort. Certain arrhythmias may pose life-threatening risks and require immediate medical intervention.

- **Congenital Heart Defect:** - Congenital heart defects, which involve structural abnormalities in the heart that are present from birth. These defects may affect the heart valves, walls, or major vessels, potentially altering normal blood flow. While some congenital defects are relatively minor and remain asymptomatic, others may cause significant circulatory issues and necessitate surgical repair or other specialized treatment to restore proper cardiac function.
- **Heart Failure:** - Heart failure occurs when the heart is no longer able to pump sufficient blood to meet the body's physiological demands. This condition often results in symptoms such as shortness of breath, persistent coughing, swelling (particularly in the lower limbs), and chronic fatigue. Multiple underlying health conditions can contribute to the development of heart failure, including coronary artery disease, hypertension, diabetes mellitus, and disorders affecting the heart valves. Effective management typically requires a combination of lifestyle modification, pharmacological therapy, and in some cases, advanced interventions.

2. Literature Review

A study presented in [2] explored the application of supervised learning algorithms—including Naïve Bayes, decision trees, K-nearest neighbour (KNN), and random forest—on data derived from the Cleveland heart disease dataset, available through the UCI Machine Learning Repository. Out of the 76 available features, the study focused on 14 critical attributes to evaluate and compare the performance of these classifiers using various evaluation metrics.

In another investigation [3], the objective was to determine the most efficient and accurate machine learning algorithm for diagnosing cardiovascular risk. The study assessed several classifiers, such as decision trees, random forest, Naïve Bayes, KNN, logistic regression, and support vector machines (SVM). This comparative analysis aimed to simplify the process of selecting an appropriate model by examining accuracy and reliability, ultimately contributing to enhanced healthcare delivery and cost reduction.

The work in [4] introduced a system that predicts the likelihood of heart disease based on 13 key medical parameters, including age, gender, chest pain type, and fasting blood sugar levels. The study employed decision tree and KNN algorithms to not only estimate disease probability but also quantify the prediction confidence, showcasing the effectiveness of these models in clinical settings.

Reference [5] utilized machine learning techniques—most notably logistic regression and KNN—to identify patients at risk for heart disease. This approach demonstrated higher accuracy than

earlier models, such as those using Naïve Bayes, particularly in forecasting heart attacks. By improving predictive performance, the model helps streamline diagnostic decisions, enhance patient care, and lower medical expenses.

In [6], a comprehensive study was carried out using a large-scale, real-world dataset comprising 70,000 instances from Kaggle. Machine learning models such as random forest, decision tree classifiers, multilayer perceptrons (MLP), and XGBoost were applied. Model tuning was achieved through GridSearch CV to enhance performance. Among the techniques tested, MLP with cross-validation showed superior results, achieving AUC scores of 0.94 to 0.95 across the board—indicating robust predictive capability.

The research described in [7] proposed a decision tree-based approach for heart disease prediction, utilizing tree structures to prioritize the most informative features. Additionally, support vector machines were implemented to classify patient data using kernel functions and hyperplanes. The combined approach was designed to improve diagnostic accuracy and reduce the incidence of heart disease through early intervention.

Lastly, the study in [8] focused on the evaluation of machine learning algorithms for their effectiveness in predicting cardiovascular diseases. By training the models on historical data and testing them on unseen instances, the research demonstrated the potential of artificial intelligence in building reliable diagnostic tools for clinical use.

3. Data Resource

In any research study, data collection is a fundamental step that involves gathering relevant information to facilitate analysis and derive meaningful insights. The quality and accuracy of collected data significantly influence the overall success and reliability of the research findings. For the present study, data was sourced from the publicly available repository Kaggle.com. The dataset comprises 5,114 individual records and includes 12 distinct features. Key variables captured in the dataset include age, hypertension status, marital status, occupation type, residential location, average glucose level, body mass index (BMI), smoking status, and gender. While the dataset is largely complete, there were 201 missing values observed in the BMI attribute. To address this issue and enhance data quality, missing BMI values were imputed using the mean of the available entries.

An initial descriptive analysis revealed that the age of individuals in the dataset spans from as young as 8 months to as old as 82 years. The average glucose levels range from 55 to 271 mg/dL, while BMI values fall between 10 and 97. As illustrated in Figure 1, certain extreme values were identified, particularly within the BMI and glucose level distributions. To improve the accuracy and reliability of the predictive models, outliers related to BMI, glucose levels, cardiac conditions, and hypertension were systematically identified and excluded from further analysis. This pre-processing step ensures that the model training is based on clean, representative data, thereby increasing the robustness of the prediction outcomes.

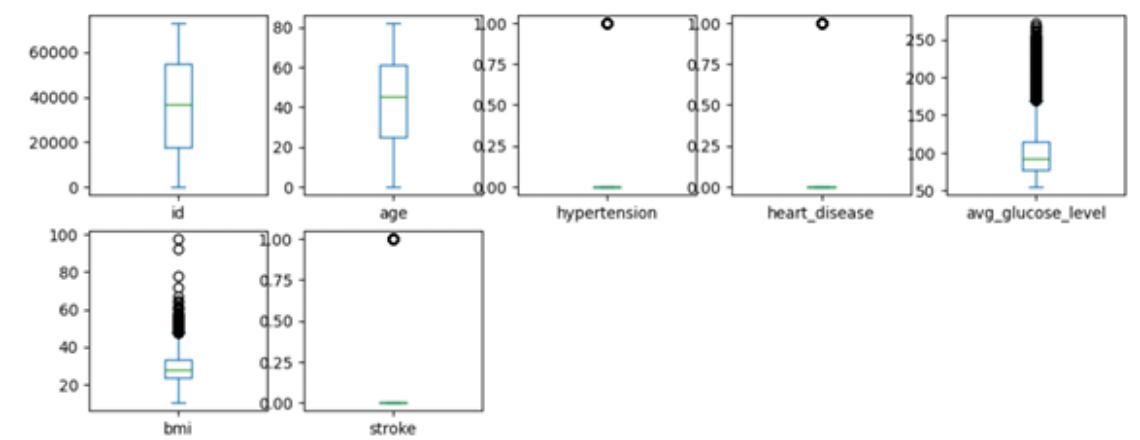
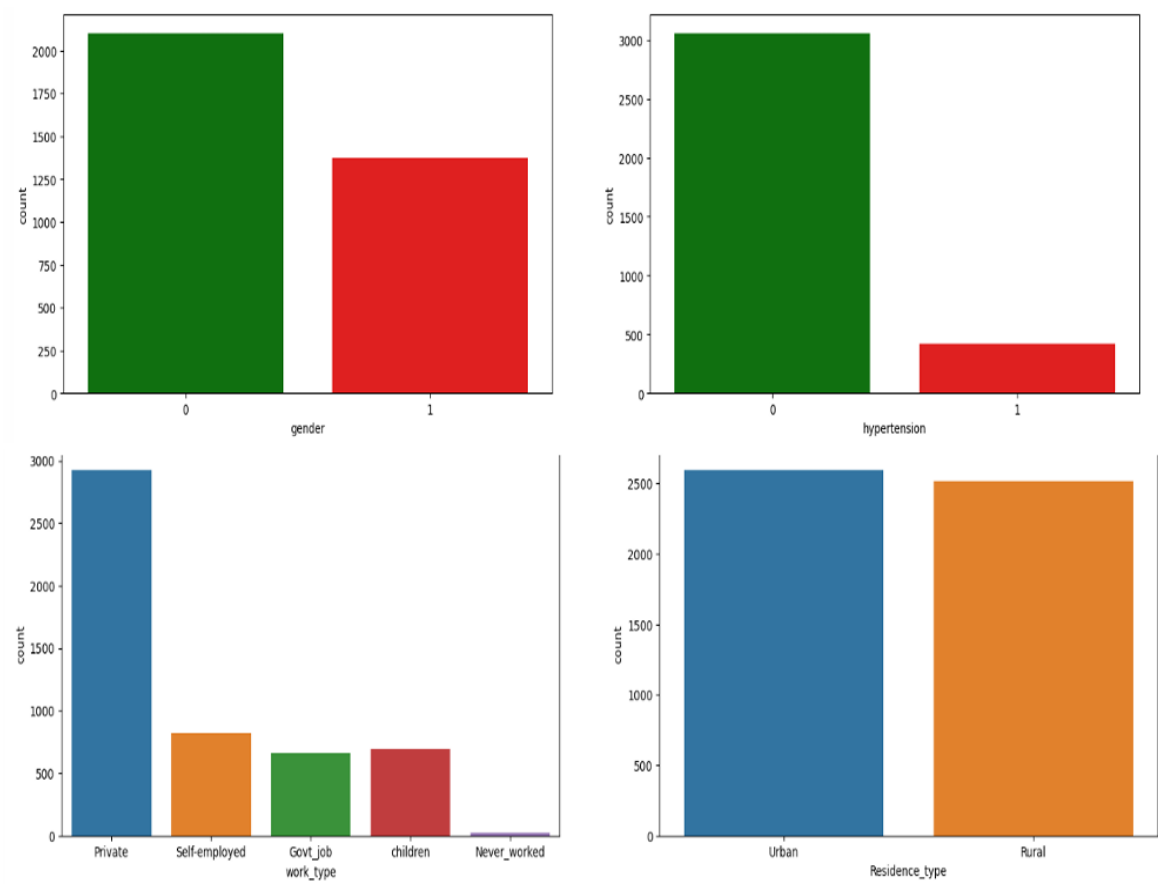


Figure: 1. Analyzing the Data Outlier



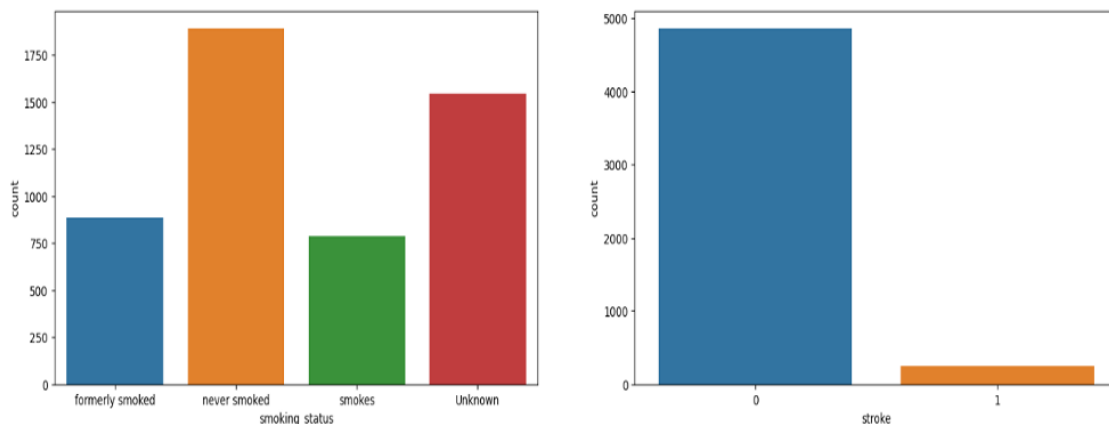


Figure 2. Analysis of Categorical Variable

Figure 2 presents a category-specific evaluation of the dataset, revealing several notable observations. One particularly interesting finding is the low reported prevalence of hypertension among the study population. Globally, hypertension affects approximately 32% of individuals, making its low representation in this dataset noteworthy. Several potential explanations may account for this discrepancy.

Firstly, the dataset may not be fully representative of the broader population. For example, if the sample primarily includes younger individuals—who are generally at a lower risk of developing hypertension—then the observed prevalence would naturally be lower. Secondly, it is possible that the participants in this dataset tend to lead healthier lifestyles. A cohort with better physical activity levels, dietary habits, or access to healthcare may naturally exhibit lower rates of hypertension.

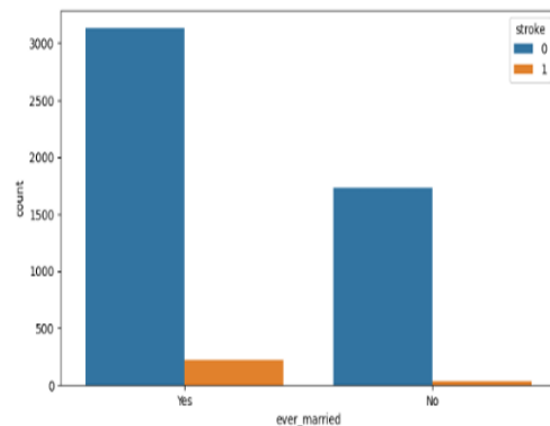
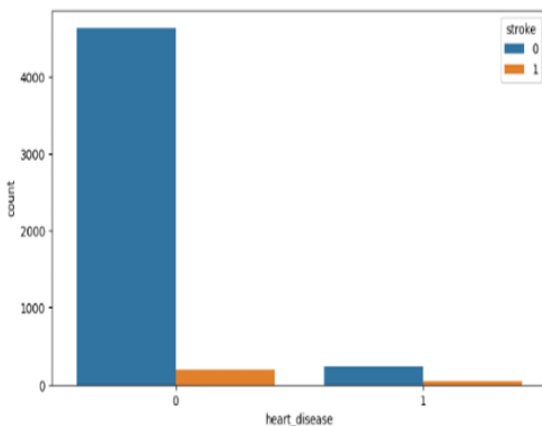
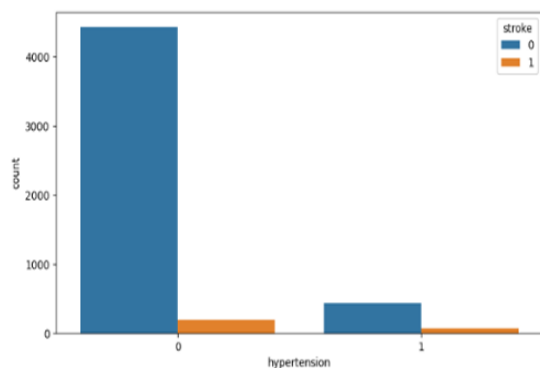
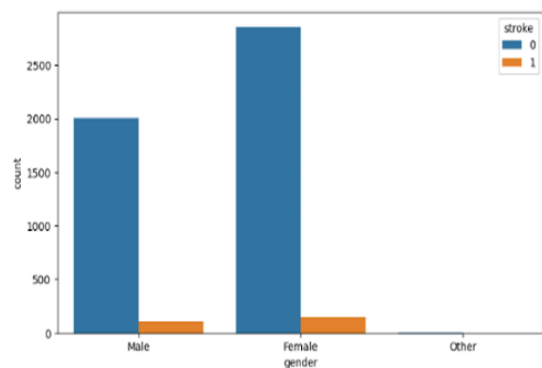
Another important factor to consider is the diagnostic criteria used to define hypertension. Some studies apply a threshold of $\geq 140/90$ mmHg, while others use a lower threshold of $\geq 130/80$ mmHg. The variation in definitions can significantly impact reported prevalence rates. Consequently, underreporting or underestimation of hypertension in this dataset may reflect differences in how hypertension was identified or recorded. While the observed low prevalence is intriguing, it is essential to acknowledge and adjust for the potential limitations in the study design and sampling approach to ensure a more accurate interpretation of the findings.

Moving to Figure 3, it explores the relationship between categorical variables and stroke incidence, offering additional insights. Interestingly, the data shows that stroke occurrences are nearly equal among male and female participants. Additionally, a large proportion of individuals without hypertension did not experience a stroke, and those with hypertension do not appear to be disproportionately affected—possibly due to the high number of participants with non-hypertensive values in the dataset.

As expected, individuals with pre-existing heart disease were more likely to exhibit stroke-related symptoms. Marital status also appeared to influence stroke prevalence, with higher rates observed among those who are married compared to those who are single, potentially reflecting stress or lifestyle changes associated with marriage.

Occupational status showed meaningful variation as well. Stroke cases were more prevalent among private sector employees, possibly linked to occupational stress, while self-employed individuals also exhibited a higher frequency of stroke symptoms—potentially due to unmanaged comorbid conditions such as hypertension or heart disease. Children can be excluded from this analysis, as their stroke incidence was negligible.

When comparing rural and urban residents, the stroke rates were found to be nearly identical, suggesting that location alone may not be a significant predictor of stroke in this dataset. However, smoking status revealed a clearer pattern. Individuals who currently smoke or have smoked in the past exhibited a higher rate of stroke than those who have never smoked, highlighting smoking as a strong behavioural risk factor.



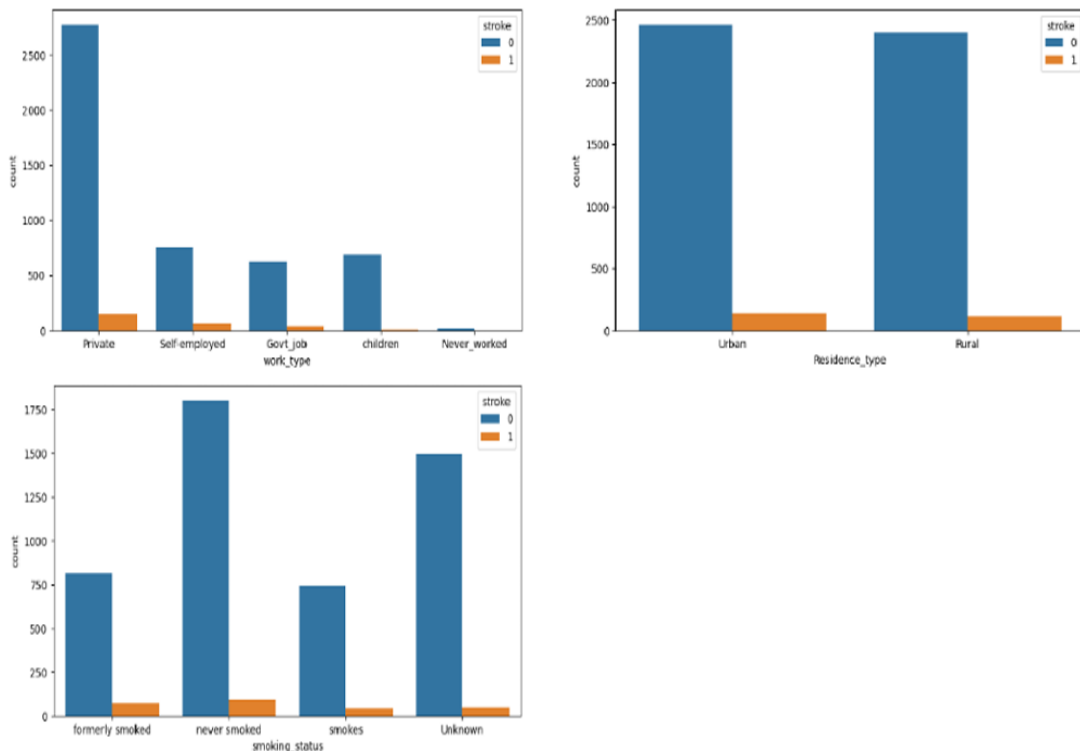


Figure: 3. Using Stroke to Analyse Categorical Variables

4. Results and Discussion

In machine learning, addressing class imbalance is a critical pre-processing step, particularly in classification problems where one class significantly outnumbers the others. Training models on such imbalanced datasets often leads to biased outcomes, with underrepresentation of minority classes resulting in poor generalization and reduced prediction accuracy for those cases.

In this study, class imbalance was addressed using the Synthetic Minority Over-sampling Technique (SMOTE), a well-established method introduced by Chawla et al. in 2002. Due to the small number of positive cases—only 249 instances, accounting for approximately 4.87% of the dataset—undersampling the majority class was not a viable option. Instead, SMOTE was employed to synthetically generate new samples for the minority class by interpolating between existing samples. This approach helps the model learn a more balanced representation during training, thereby improving performance across all classes.

Several classification algorithms were evaluated based on the characteristics of the dataset:

- **K-Nearest Neighbors (KNN):** A simple yet effective algorithm that classifies a data point based on the majority class among its k nearest Neighbors. It performs well in non-linear decision boundaries, particularly when the data is not high-dimensional.

- **Logistic Regression:** A widely used linear model that estimates the probability of class membership. Though primarily designed for binary classification, it can be adapted for multiclass problems using strategies like one-vs-rest.
- **Decision Tree Classifier:** This interpretable model builds a tree-like structure by recursively splitting the dataset based on the most informative attributes. It is capable of capturing complex, non-linear relationships between features.
- **Naive Bayes (Gaussian NB):** A probabilistic model based on Bayes' theorem, assuming feature independence. It is particularly useful in text classification and spam detection tasks.
- **Support Vector Classifier (SVC):** A powerful algorithm that identifies optimal hyperplanes to separate classes. Through the use of kernel tricks, SVC handles both linear and non-linear classification efficiently.
- **Random Forest Classifier:** An ensemble of decision trees that enhances predictive accuracy and reduces Overfitting. It performs well with high-dimensional data and is robust to noise and outliers.

To further improve model robustness and generalization, ensemble learning methods were employed:

- **Voting Classifier:** This method combines predictions from multiple base classifiers (e.g., KNN, logistic regression, decision tree) and assigns the final class based on majority voting. It typically results in higher accuracy and better generalization.
- **Bagging Classifier:** This ensemble technique trains each base learner on random bootstrapped subsets of the data, helping to reduce variance and improve model stability.
- **Stacking Classifier:** A more advanced ensemble approach, stacking involves training multiple base classifiers and then using a meta-classifier to combine their predictions. This layered structure often leads to superior performance by capturing diverse patterns in the data.
- Selecting the most suitable algorithm depends on several factors, including data dimensionality, dataset size, computational resources, and the specific goals of the machine learning task. It is generally advisable to experiment with various models and validate their performance using techniques such as cross-validation to determine the most effective approach.

Table 1 presents the accuracy, precision, and recall scores of the evaluated algorithms.

S. No.	Name of Algorithm	Training Accuracy	Testing Accuracy	Precision	Recall
1	XG Boost	99.97	97.51	98	98
2	Logistic Regression	84.52	78.56	79	78
3	Decision Tree	98.56	97.15	97	93
4	K- Neighbors	97.42	95.18	95	94
5	Random Forest	99.5	98.49	98	98
6	SVM	100	99.22	99	99

5. Conclusion

In this study, several machine learning algorithms were implemented and compared to evaluate their effectiveness in predicting heart disease. The models tested include XGBoost, Logistic Regression, Decision Trees, K-Nearest Neighbors (KNN), Random Forest, and Support Vector Machine (SVM). Each algorithm exhibited varying levels of predictive performance, underscoring the importance of model selection based on both accuracy and practical applicability.

Among the models, SVM emerged as the most accurate, achieving a prediction accuracy of 99.22%, making it the top-performing model in this analysis. Random Forest, an ensemble-based method, also demonstrated excellent results with an accuracy of 98.49%, outperforming its single-model counterpart, the Decision Tree, which attained 97.15%. The superior performance of ensemble techniques highlights their ability to reduce Overfitting and enhance generalization by combining the strengths of multiple learners.

XGBoost also achieved a high accuracy of 97.51%, reinforcing its reputation as a powerful and scalable algorithm for structured data. While Logistic Regression had relatively lower accuracy compared to the aforementioned models, it remains a valuable baseline due to its simplicity, interpretability, and ease of deployment—especially in clinical settings where explainability is crucial.

The K-Nearest Neighbors (KNN) algorithm delivered competitive performance and further emphasized the importance of local data structure in classification tasks. Despite its simplicity, KNN demonstrated a strong capacity to predict heart disease risk based on proximity in feature space.

The findings suggest that while high-performing models like SVM and ensemble methods offer strong predictive capabilities, choosing the most appropriate algorithm should also consider

factors such as model complexity, interpretability, and computational efficiency. For deployment in real-world healthcare systems, a balance must be achieved between accuracy and practicality. Future enhancements to this work could include ensemble stacking, which combines the predictive outputs of multiple base models using a meta-classifier, potentially boosting accuracy and robustness. Additionally, feature engineering and selection techniques may further optimize model performance by isolating the most informative risk factors. These refinements would contribute to both improved diagnostic precision and more interpretable, clinically actionable models.

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Human Resource: Employee's Perception towards HR Policies in Information Technology (IT) Companies

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I. Abstract

Human resources encompass the collective knowledge, skills, creativity, attitudes, and other attributes inherent within an organization's workforce. These elements are exemplified through employees' talents and behaviors, serving as vital assets that drive organizational success. Effective human resource (HR) policies and practices are instrumental in harnessing these attributes to align with the organization's objectives. For HR policies to be impactful, they must be concise, transparent, and easily comprehensible, ensuring that all members of the organization understand the objectives and the steps necessary to achieve them. Such clarity fosters a shared understanding and commitment across the organization.

The development and implementation of HR policies should reflect the organization's core values and beliefs, thereby cultivating a culture that supports its mission. This cultural alignment enhances employee engagement and promotes a cohesive work environment. This paper aims to provide a comprehensive understanding of employee perceptions regarding HR policies within organizations. It presents a conceptual framework grounded in existing literature, including previous research studies, academic journals, and various secondary sources, to elucidate how HR policies influence employee attitudes and organizational outcomes.

Keywords: Human Resource Management Practices, Employee's perception, IT Companies

II. INTRODUCTION

Human Resource (HR) policies serve as structured guidelines that direct an organization's approach to managing its workforce. They are designed to align with the organization's strategic goals, ensuring consistency and fairness in decision-making processes.

Distinguishing HR Policies from Strategy, Objectives, and Procedures

- **HR Policies:** These are formal statements that provide a framework for consistent decision-making and behavior within the organization. They reflect the organization's values and serve as a reference point for managing employee relations.

- **HR Strategy:** This encompasses the long-term plans and actions designed to achieve specific business objectives. While HR policies provide the guidelines, HR strategy outlines the broader vision and direction for human capital management.
- **Objectives:** These are specific, measurable goals that the organization aims to achieve. Objectives are often quantitative and time-bound, serving as benchmarks for success.
- **Procedures:** These are the step-by-step instructions that detail how to implement HR policies. Procedures ensure that policies are executed effectively and consistently across the organization.

Importance of HR Policies

Effective HR policies are crucial for:

- **Attracting and Retaining Talent:** By establishing clear guidelines and expectations, HR policies help in attracting qualified candidates and retaining existing employees. **Ensuring Compliance:** They assist in maintaining compliance with legal and regulatory requirements, thereby minimizing risks.
- **Promoting Fairness and Consistency:** HR policies ensure that all employees are treated equitably, fostering a positive work environment.
- **Guiding Organizational Culture:** They reflect and reinforce the organization's values and culture, guiding employee behavior and decision-making.

Study Objective

The primary objective of this study is to assess employee perceptions of HR policies within the organization. Understanding these perceptions can provide insights into the effectiveness of current policies and identify areas for improvement.

By evaluating employee feedback, organizations can refine their HR policies to better align with employee needs and organizational goals, thereby enhancing overall performance and employee satisfaction.

A. Human Resource Management: Scope

The scope of HRM is wide in nature. The Indian Institute of Personnel Management has specified the scope of HRM as:

Personnel aspect - This regards human resource planning, recruitment, selection, placement, transfer, promotion, training— and development, retrenchment, remuneration, incentives, productivity etc.

Welfare aspect – It's related with working environment and amenities like welfare measures such as canteens, crèches, rest– rooms, lunch rooms, housing, transport, medical assistance, education, health and safety.

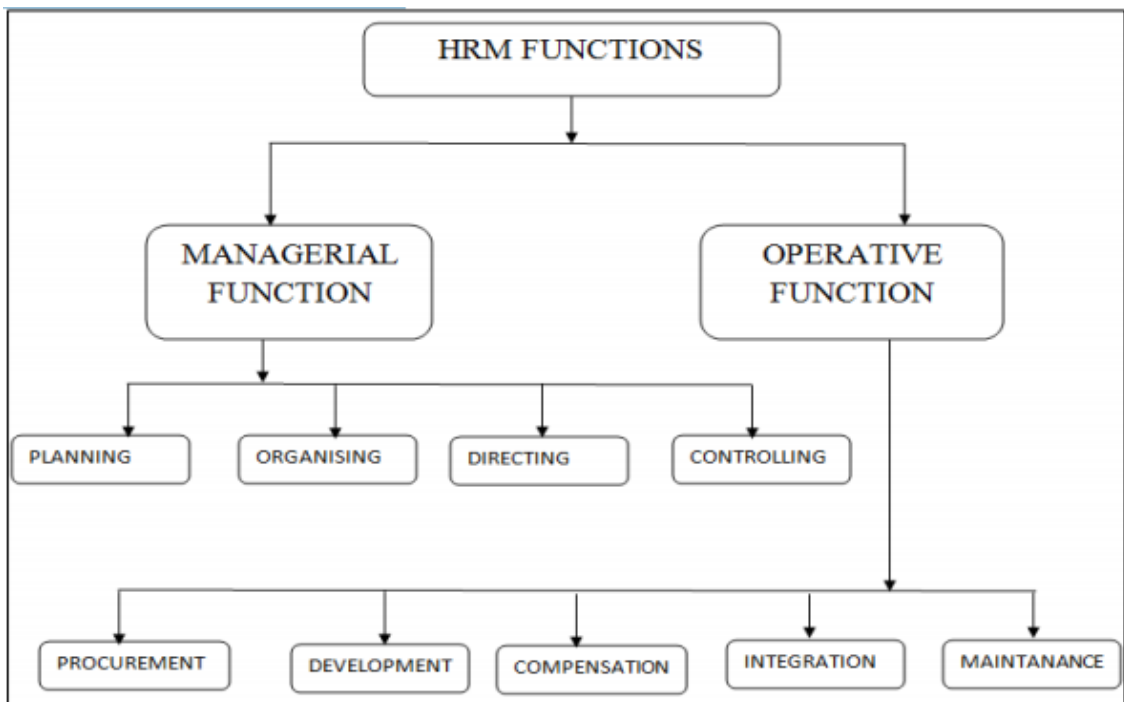
Industrial relations aspect -This covers union-management relations, negotiation procedures, dispute settlement etc-, Grievance and disciplinary

B. Human Resource Management: Objectives

The basic objectives of Human Resource Management could also be sketched as follows to assist the organization to achieve its goals.

- To ensure effective utilization of human resources.
- To make maximum development of human resources.
- To ensure respect for employees.
- To make sure reconciliation of individual goals with the organization goal.
- To get a top quality of labor life for the workers.

C. Pictorial Representation of HRM Functions



II. LITERATURE REVIEW

Abdul Basit Al-Hamadi, Pawan S. Budhwar and Helen Shipton (2007): provided an summary of management of human resources and therefore the factors influencing an equivalent within the sovereign of Oman. The initial section of the paper built the study of HRM policies within the Omani context. This is carryout with analysis of the background information and specific features of social environment of the sovereign of Oman along side key national initiatives that

are likely to influence the take-up and endorsement of HRM in Oman. The research observation in support of key issues associated with management of human resources was presented, and conclusions were drawn by evaluating the significances of the described findings. This is done by considering the present situation in Oman and thru analyzing key challenges is going to be faced within the future. Ashok Som (2008): Indian organizations adopted innovatory changes in their HRM practices. Current research showed that HRM policies are important for enhanced organization performance but little had been reported on the effect of HRM policies and organization performance within the context of economic liberalization of India. The study tried to know the role of innovative HRM policies like the role of HR department, recruitment, retraining and redeployment, performance appraisal and compensation, enhance organization achievement during the change process. A multiple-respondent survey of 69 Indian organizations was undertaken to review the influence of innovative HRM policies on firm performance. The research found that the innovative recruitment and compensation policies have important positive relationship with firm performance. It was observed that recruitment, the role of the HR department and compensation policies to be seen significantly changing within the Indian enterprises within the context of India's economic liberalization. The behavior of system between innovative HRM policies wasn't significant in enhancing organization performance during the liberalization process. Hui-O Yang and Nita Cherry (2008) Contemporary international literature finds three major human resource management (HRM) issues as being critical within the hospitality industry across the planet, both present and in the future. They were service quality, training and development, staff recruitment and staff selection. This study involved interviews with the senior most executives during a sample of chain hotels in Taiwan nominated by the hotels as being liable for HRM. This study explored that the three major HRM issues identified within the study are perceived as important by Taiwanese hoteliers. The conclusion suggest that although most participants perceive these issues a big and challenging, they're concentrated mainly on operational and not in strategic solutions for handling these issues. It is argued that the present and arising challenges facing the industry demand an approach to HRM that's longer in strategic than the normal focus of personnel administration. The implication is that HRM features a key role to play in generating and sustaining competitive advantage in hotels. A particular strength of this study, the info collected through face-to-face interviews, which enabled a more intensive exploration of the thinking of respondents than is usually the case with quantitative surveys.

Ilias Vlachos (2008): This study addressed a central research question: How do human resource management practices assist to organizational performance? They examined the subsequent HR practices: (1) job security (2) Selective hiring (3) self managed teams and decentralization of deciding (4) compensation policy (5) widespread training and (6) Information sharing. They collected data from food managers in Greece and recorded their perceptions on HR practices and

their reference to organization's performance. The conclusion provides overall support for all HR practices except the work security. Selective hiring was found to be a key practice that enhanced organizational performance. Compensation policies, information sharing, decentralization and wide training were significant anticipates for all performance variables. Directions for further research are provided. Irene Hon-fun Poon and Chris Rowley (2010) many competing hypotheses are advanced to relation for human resource management (HRM) change. The present review evaluates the theoretical development and empirical revise in HRM change in Asia within the early twenty-first century (from 2000 to 2006). Three research themes common to HRM change are discussed. (1) Change context is about the problems of forces to form easier or to form difficult HRM change; (2) Change process includes pace, sequence and magnitude of HRM change movement and (3) Change direction is about resultant change outcome. Comparisons of HRM change were made on Asian economies also as between Asia and other ranges. It is resulted that the interplay between different perspectives can produce a good sort of more complex understanding of change circumstance while cross-sectional approach can add value to elucidate dynamic process and resultant direction.

Peter K. Ross and Lutz Michael Buchner (2010) this text analyze the competition demands faced by Deutsche Telekom for global consistency and native responsiveness because it tried to coordinate its human resource management strategies across its Eastern European supplemental. It considers the degree to which the previous economics and political histories of Eastern Europe still influence and/or pressurizing MNC strategies and policies within the post-2000 era. Institutional path dependency, strategic international human resource management, and international industrial relations theories are wont to substitute ascertain the date. The study countries are rapidly declining, thereby permitting MNC's to implement "Western-style" human resource management strategies. It further propose that industrial relations institutions at the ecu Union Level, instead of individual country level, have the best ability to impact on international human resource management strategies in the region. Multinational corporations should therefore engage in more-integrated strategies international human resource management and approximate international industrial relations.

III. CONCLUSION

HR policy continues to be in its infancy in India and extra analysis must be undertaken on totally different aspects of inexperienced to explore its potential to the foremost doable extent. Once corporations adopt inexperienced policies, they need to confirm that the economic side of these policies within the extend of failure. Thorough understanding of the implications of varied new policies should be undertaken by the businesses, therefore confirm that they give favors to both the worker and therefore the employer.

The companies should determine that the workers square measure considerably involved regarding the varied problems cropping up within the country which their square measure considerably willing to figure for the company, if the corporate provides good policies and methods. Employees will command a far better worth if they're going to enhance the policy and supply additional facilities by providing cab, higher functions, improved work environment, dynamic pays. Thus, companies should attempt to find these sorts of excellent policies and supply their employees those policies.

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Securing Network Infrastructure through Cryptographic Methods

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Abstract

The modern world relies heavily on digital communications and data exchange, making network infrastructure security a critical concern. Cryptographic methods provide the foundational tools to protect data integrity, confidentiality, and authenticity. This paper explores the application of cryptographic techniques in securing network infrastructures, including symmetric and asymmetric encryption, digital signatures, key management, and emerging approaches like quantum-resistant algorithms. The paper also examines the role of cryptographic protocols such as TLS and IPsec and addresses the challenges and future directions in cryptographic network security.

Keywords: Network Security, Cryptography, Encryption, Public Key Infrastructure, Quantum-Resistant Algorithms, Digital Signatures, TLS, IPsec

1. Introduction

In the digital era, network infrastructures form the backbone of communication, data exchange, and service delivery. With increasing threats from cybercriminals, nation-state actors, and insider threats, safeguarding these infrastructures is paramount. Cryptography has emerged as a key mechanism for ensuring data security. By converting readable data into coded formats, cryptographic methods prevent unauthorized access, eavesdropping, and tampering. This paper investigates how cryptographic methods secure network infrastructures, the implementation of widely-used protocols, and the evolution of cryptography in response to emerging threats.

2. Fundamentals of Cryptographic Methods

Cryptography involves techniques for securing information by transforming it into an unreadable format, decipherable only by authorized users. The two main types are:

2.1 Symmetric Encryption

Symmetric encryption relies on a single, shared key to perform both encryption and decryption operations. Algorithms such as AES (Advanced Encryption Standard) and DES (Data Encryption Standard) are commonly employed to protect data both in transit and at rest. Despite their efficiency, symmetric encryption presents difficulties in securely distributing encryption keys.

2.2 Asymmetric Encryption

Asymmetric encryption employs a pair of cryptographic keys: a public key to encrypt data and a corresponding private key to decrypt it. RSA (Rivest-Shamir-Adleman) and ECC (Elliptic Curve Cryptography) are prominent examples. This approach facilitates secure key exchange and the implementation of digital signatures, both of which are critical for ensuring secure communication across untrusted networks.

2.3 Hash Functions and Digital Signatures

Hash functions, like SHA-256, generate a unique fixed-size output for input data, verifying data integrity. Digital signatures use asymmetric keys to authenticate the source and ensure data has not been altered.

3. Cryptographic Protocols in Network Security

Several cryptographic protocols have been standardized to protect network communications:

3.1 Transport Layer Security (TLS)

TLS secures internet communication by providing encryption, authentication, and integrity. It is the foundation of HTTPS, ensuring secure web browsing and data transfer.

3.2 Internet Protocol Security (IPsec)

IPsec functions at the network layer, securing IP packets by applying encryption and authentication mechanisms. It is extensively utilized in Virtual Private Networks (VPNs) to ensure secure remote access.

3.3 Secure Shell (SSH)

SSH establishes a secure communication channel over untrusted networks and is frequently employed for remote server management. It employs both symmetric and asymmetric encryption for confidentiality and authentication.

4. Key Management and Public Key Infrastructure (PKI)

Effective cryptography depends on secure key management. PKI supports the creation, distribution, and revocation of digital certificates. Certification Authorities (CAs) verify identities and issue certificates, enabling secure communications and transactions.

Challenges in key management include:

- Key generation and storage
- Certificate revocation and renewal
- Ensuring the trustworthiness of CAs

5. Emerging Cryptographic Trends

5.1 Quantum-Resistant Algorithms

With the advent of quantum computing, traditional algorithms like RSA and ECC may become vulnerable. Post-quantum cryptography (PQC) focuses on developing algorithms resistant to quantum attacks. NIST is currently evaluating candidates for standardization.

5.2 Lightweight Cryptography

As IoT devices proliferate, there is a growing need for lightweight cryptographic algorithms that maintain security with minimal computational resources. Algorithms like SPECK and SIMON have been proposed for resource-constrained environments.

5.3 Zero Trust Architecture

Cryptography is central to Zero Trust models, where no device or user is trusted by default. Authentication and encryption are continuously enforced throughout the network.

6. Challenges in Implementation

Despite its advantages, cryptographic implementation faces several challenges:

- Computational overhead
- Compatibility with legacy systems
- Complexity of key management
- Risk of implementation flaws (e.g., poor randomness, side-channel attacks)

Ensuring security also requires proper protocol configuration and regular audits.

7. Conclusion

Cryptographic methods are indispensable in securing modern network infrastructures. As threats evolve, cryptographic techniques must adapt through innovation and robust implementation. The shift towards quantum-resistant cryptography and lightweight algorithms signifies the continuous

advancement in this field. A secure network infrastructure relies not only on strong cryptographic algorithms but also on effective key management, user awareness, and system integrity.

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The Potential of Carbon Credits in Mobilizing Climate Finance in India

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ABSTRACT -This research paper examines the urgent need to mitigate climate change has emphasized the importance of innovative financial mechanisms such as carbon credits. In India, where economic growth must align with environmental sustainability, carbon credits represent a crucial tool for mobilizing climate finance. This research explores the potential of carbon credits in driving investments toward climate-friendly projects and achieving India's nationally determined contributions (NDCs) under the Paris Agreement. The study examines the regulatory frameworks governing carbon credit markets, their integration into global carbon trading platforms, and the barriers and opportunities for private sector engagement.

By analysing case studies of renewable energy, afforestation, and sustainable agriculture projects, this paper highlights the role of carbon credits in reducing greenhouse gas emissions while generating additional revenue streams. It also discusses the co-benefits of carbon credit projects, including social equity and employment generation, particularly in rural and underserved regions of India.

The findings indicate that while India's carbon credit system has demonstrated success in supporting renewable energy and energy efficiency projects, significant challenges persist. These include fragmented market structures, insufficient regulatory oversight, and limited private sector participation. Recommendations include strengthening domestic carbon markets, leveraging digital tools like blockchain for transparency, and aligning carbon credit projects with sustainable development goals (SDGs).

This paper concludes that carbon credits, when integrated with robust policies and innovative financial models, can significantly enhance India's capacity to mobilize climate finance, promote sustainable development, and meet its climate goals. By addressing existing barriers, India can position itself as a leader in global climate action and attract substantial domestic and international investments for a sustainable future.

KEYWORDS - Carbon Credits, Renewable Energy, Climate Finance, Green Economy, Sustainability, Emissions Trading, Sustainable Development Goals (SDGs), Paris Agreement

1. INTRODUCTION -

Climate change is one of the most critical global challenges of the 21st century, necessitating urgent action to mitigate greenhouse gas (GHG) emissions and transition toward sustainable economic growth. India, as one of the world's fastest-growing economies, faces the dual challenge of achieving economic development while ensuring environmental sustainability (World Bank, 2022). To fulfill its commitment under the Paris Agreement, India has pledged to reduce its emissions intensity by 45% by 2030 and achieve net-zero emissions by 2070 through its Nationally Determined Contributions (NDCs) (Ministry of Environment, Forest and Climate Change, India, 2021). However, achieving these ambitious climate goals requires substantial financial resources, which remain a significant challenge due to limited public funding, regulatory complexities, and inadequate private sector participation (UNFCCC, 2023).

Carbon credits are tradable certificates representing the reduction or removal of one metric ton of CO₂ or its equivalent from the atmosphere. These credits function within compliance and voluntary markets, allowing entities to meet emission reduction targets while generating financial incentives for sustainable projects.

Carbon credits offer an innovative financial mechanism to bridge this gap by incentivizing emission reductions and channelling investments into climate-friendly projects. These credits operate inside compliance and voluntary carbon markets and reflect a decrease or removal of one metric ton of CO₂ or its equivalent from the atmosphere (Intergovernmental Panel on Climate Change [IPCC], 2021). The development of a robust carbon market in India can provide a dual advantage - helping industries meet their emission reduction targets while simultaneously generating revenue for projects that promote renewable energy, afforestation, and sustainable agriculture (International Carbon Action Partnership [ICAP], 2023). Despite their potential, India's carbon credit market faces several challenges, including price volatility, limited awareness among investors, and a fragmented regulatory framework (International Finance Corporation [IFC], 2022).

This paper aims to explore the potential of carbon credits in mobilizing climate finance in India by analysing their regulatory landscape, market potential, and associated challenges. By examining case studies and industry best practices, the study highlights the effectiveness of carbon finance mechanisms in accelerating India's transition toward a low-carbon economy. The findings provide insights into how policy reforms, technological innovations like blockchain, and strategic private-sector involvement can strengthen India's carbon credit market, making it a key driver of climate finance and sustainable development (Gold Standard Foundation, 2022).

2. CONCEPTUAL FRAMEWORK OF CARBON CREDITS -

The decrease or removal of one metric ton of carbon dioxide (CO₂) or its comparable greenhouse gases (GHGs) from the atmosphere is represented by carbon credits, which are market-based financial products. They are integral to global climate mitigation efforts, providing financial incentives for organizations and countries to invest in emission reduction projects.

2.1 Primary Markets for Carbon credits - Carbon credits function within two primary markets: compliance carbon markets and voluntary carbon markets, each serving distinct regulatory and financial purposes.

2.1.1 Compliance Carbon Markets

Compliance carbon markets operate under legally binding regulations set by national or international authorities. Governments establish emission caps for industries and allocate carbon allowances, enabling organizations to trade excess credits in emissions trading systems (ETS). Prominent compliance markets include the European Union Emissions Trading System (EU ETS) and India's Perform, Achieve, and Trade (PAT) scheme, which incentivizes industries to improve energy efficiency and trade surplus energy-saving certificates (Ministry of Power, India, 2022).

2.1.2 Voluntary Carbon Markets

Voluntary carbon markets, in contrast, allow corporations, individuals, and NGOs to purchase carbon credits to offset their carbon footprints without regulatory obligations (Gold Standard Foundation, 2022). These credits typically originate from projects such as afforestation, renewable energy, and methane capture (UNFCCC, 2023). With increasing emphasis on Environmental, Social, and Governance (ESG) commitments, voluntary markets are gaining prominence as businesses strive to enhance sustainability credentials and investor confidence (International Finance Corporation [IFC], 2022).

2.2 Carbon Credit Certification and Standards-

Carbon credits must adhere to verification requirements established by global certifying organizations in order to be considered credible. The Verified Carbon Standard (VCS), Gold Standard, and Clean Development Mechanism (CDM) under the United Nations Framework Convention on Climate Change (UNFCCC) play crucial roles in ensuring transparency, preventing double counting, and mitigating the risks of greenwashing (Gold Standard Foundation, 2022).

2.3 Carbon Credit Pricing Mechanisms

The pricing of carbon credits varies based on market demand, regulatory policies, and the type of project generating the credits (World Bank, 2022). Compliance market prices are typically determined by government-imposed emission caps and sectoral targets, while voluntary market prices depend on corporate sustainability goals and the perceived quality of offsets (ICAP, 2023). The following are important factors affecting carbon credit pricing:

- Type of project generating the credits (e.g., renewable energy, forestry, industrial efficiency)
- Regulatory and policy developments
- Market liquidity and trading volumes

- Demands for sustainable investments and corporate net-zero pledges

2.4 Role of Carbon Credits in Climate Finance

Carbon credits serve as a vital tool in mobilizing climate finance by attracting investments in low-carbon projects. Revenue generated from carbon credit sales funds renewable energy expansion, reforestation programs, and sustainable infrastructure, thereby accelerating India's transition toward a green economy (UNFCCC, 2023). The ability of carbon markets to leverage private sector participation can significantly enhance financing flows and contribute to achieving India's climate targets under the Paris Agreement (Ministry of Environment, Forest and Climate Change, India, 2021).

3. CLIMATE FINANCE LANDSCAPE IN INDIA–

The rapidly changing climate financing landscape in India is a result of growing decarbonisation and sustainability commitments. The nation has pledged to achieve net-zero emissions by 2070, requiring substantial financial resources to support its climate transition (Bhattacharya et al., 2022). Climate finance, which includes public and private investments, is crucial for funding renewable energy, afforestation, and sustainable agriculture projects (Singh & Chaturvedi, 2021).

According to Chakraborty and Somanathan (2020), India requires approximately \$2.5 trillion in climate finance by 2030 to meet its Nationally Determined Contributions (NDCs) under the Paris Agreement. However, current climate-related investments are significantly lower than this requirement, highlighting a critical financing gap (Dubash et al., 2022). To draw in both domestic and foreign investment, the Indian government has started a number of programs, such as the National Adaptation Fund for Climate Change (NAFCC) and Sovereign Green Bonds (Mukherjee & Sinha, 2023).

The private sector plays a crucial role in climate finance, yet mobilization remains insufficient due to policy uncertainties, high-risk perceptions, and lack of standardized carbon pricing mechanisms (Sharma & Kumar, 2021). To enhance financial flows, innovative instruments such as carbon credits, green bonds, and blended finance models have gained traction (Gupta & Ramanathan, 2022). India has also strengthened its participation in voluntary and compliance carbon markets, aligning with international frameworks such as the European Union Emissions Trading System (EU ETS) and the International Carbon Market under Article 6 of the Paris Agreement (Jain & Mehta, 2022).

While India has made significant strides in mobilizing climate finance, addressing regulatory and institutional barriers will be crucial to unlocking its full potential. A multi-stakeholder approach, including strong public-private partnerships and international collaborations, can accelerate India's transition toward a low-carbon economy (Aggarwal & Bansal, 2022).

3.1 Domestic Climate Finance Sources - The Government of India has established several mechanisms to mobilize climate finance domestically. These include:

- **National Adaptation Fund for Climate Change (NAFCC):** This fund supports adaptation projects in sectors vulnerable to climate change, including agriculture, forestry, and water resources.
- **State Action Plans on Climate Change (SAPCC):** These state-level policies align with national climate goals and allocate funds for region-specific mitigation and adaptation measures.
- **Renewable Energy Subsidies and Incentives:** The government provides financial incentives for renewable energy projects, such as feed-in tariffs, viability gap funding, and production-linked incentives for solar and wind energy projects.
- **Corporate Social Responsibility (CSR) Contributions:** Companies are increasingly investing in climate initiatives as part of their CSR obligations, further enhancing domestic climate finance availability.

3.2 International Climate Finance - India receives financial support from various international organizations and climate funds, including:

- **Green Climate Fund (GCF):** The GCF has financed multiple projects in India, including renewable energy expansion and climate-resilient agriculture.
- **Global Environment Facility (GEF):** This fund supports projects that address environmental challenges, including carbon sequestration and sustainable urbanization.
- **Bilateral and Multilateral Agreements:** India has partnerships with countries like Germany, Japan, and the United States to secure climate finance through grants and concessional loans.
- **World Bank and Asian Development Bank (ADB):** These institutions provide funding for infrastructure and sustainable development projects that contribute to emission reductions.

3.3 Green Bonds and Sustainable Finance Instruments - India has been expanding its green finance market through the issuance of green bonds, which fund environmentally sustainable projects. Key developments include:

- **Sovereign Green Bonds:** The Indian government has issued sovereign green bonds to finance renewable energy, clean transportation, and climate adaptation projects.
- **Corporate Green Bonds:** Companies such as NTPC, the State Bank of India (SBI), and the Indian Renewable Energy Development Agency (IREDA) have raised funds through green bonds to support clean energy initiatives.

- **Sustainable Banking Practices:** Indian financial institutions are increasingly incorporating ESG criteria into their lending and investment decisions, promoting climate finance integration within the banking sector.

4. MARKET POTENTIAL AND INVESTMENT OPPORTUNITIES -

The carbon credit market in India presents a significant opportunity for mobilizing climate finance, attracting both domestic and international investors. As global demand for emission reduction mechanisms increases, India's potential to become a key player in carbon trading has grown, supported by its vast renewable energy projects, afforestation initiatives, and industrial energy efficiency programs (Gupta & Bansal, 2022). According to Bhattacharya et al. (2023), India's carbon market could generate an estimated \$90 billion in investments by 2030, contributing significantly to the country's decarbonization strategy.

4.1 Growing Demand for Carbon Credits

- With India's commitment to reducing emissions and achieving net-zero targets, there is an increasing demand for carbon credits from both domestic and international markets.
- Indian businesses, particularly in sectors like energy, manufacturing, and agriculture, are increasingly engaging in carbon credit trading to meet sustainability goals and attract climate-conscious investors.
- Global corporations looking to offset emissions are showing interest in Indian carbon credits due to their cost-effectiveness and availability of large-scale carbon reduction projects.

4.2 Key Sectors for Carbon Credit Generation

- **Renewable Energy-** Wind, solar, and hydroelectric power projects generate significant carbon offsets, contributing to emission reduction targets.
- **Energy Efficiency-** Industries adopting energy-efficient technologies and waste heat recovery systems can generate carbon credits while improving productivity.
- **Forestry and Land Use-** Afforestation, reforestation, and agroforestry initiatives provide long-term carbon sequestration benefits and create rural employment opportunities.
- **Waste Management-** Methane capture from landfills, composting, and bio-digester projects help reduce emissions while generating revenue through carbon credits.
- **Sustainable Agriculture-** Practices like reduced tillage, organic farming, and efficient water management contribute to emission reductions and offer carbon credit potential.

4.3 Investment Opportunities in the Carbon Credit Market

- **Domestic Carbon Markets-** The Indian government is working toward establishing a compliance carbon market, creating a structured platform for trading carbon credits and incentivizing emission reductions.
- **International Carbon Markets-** With India's participation in global carbon offset programs, Indian projects can tap into international markets like the EU Emissions Trading System (EU ETS) and the Voluntary Carbon Market (VCM).
- **Corporate Participation-** Companies are investing in sustainability initiatives to meet Environmental, Social, and Governance (ESG) criteria, increasing demand for high-quality carbon credits.
- **Green Bonds and Climate Funds-** Investors are channelling funds into carbon-reducing projects through green bonds and climate investment funds, further strengthening the carbon credit ecosystem.

4.4 Emerging Trends and Future Growth

- The introduction of digital carbon trading platforms is expected to streamline transactions and improve transparency in carbon credit trading.
- Increasing government support and policy clarity will drive higher corporate participation and investor confidence.
- Advances in carbon capture, utilization, and storage (CCUS) technologies will open new avenues for carbon credit generation.
- India's role as a global supplier of high-quality carbon credits will continue to expand, positioning the country as a leader in the carbon finance landscape.

4.5 Challenges in Scaling Carbon Credit Investments

- **Regulatory Uncertainty-** Investors seek clear and stable policy frameworks to ensure long-term viability.
- **Market Awareness-** Many businesses and investors lack awareness of carbon trading mechanisms and their financial benefits.
- **Verification and Transparency-** Ensuring credibility in carbon credit verification and certification is crucial to attract institutional investors.
- **Pricing Mechanisms-** The lack of standardized carbon pricing frameworks in India makes market participation complex for investors.

5. FUTURE PROSPECTS AND RECOMMENDATIONS -

The future of carbon credits in mobilizing climate finance in India is promising, provided that appropriate policies, financial incentives, and market structures are established. This section outlines key future directions and recommendations to strengthen the carbon credit ecosystem in India.

5.1 Strengthening the Regulatory Framework

- The Indian government should establish a comprehensive national carbon market with clear policies and long-term stability.
- Standardized guidelines for carbon credit trading should be developed to enhance transparency and market credibility.
- Improved coordination between central and state governments can ensure uniform implementation of carbon trading mechanisms.

5.2 Enhancing Market Integration and Global Participation

- India should align its carbon credit standards with international markets to facilitate participation in global emissions trading systems.
- Strengthening bilateral agreements and partnerships with international climate finance institutions can increase demand for Indian carbon credits.
- Efforts should be made to link India's carbon credit mechanisms with international compliance markets such as the EU Emissions Trading System (EU ETS).

5.3 Expanding Corporate and Investor Participation

- Companies should be incentivized to adopt carbon credit mechanisms as part of their Environmental, Social, and Governance (ESG) commitments.
- Institutional investors and financial institutions should be encouraged to participate in carbon markets through innovative financial instruments such as green bonds and carbon funds.
- The creation of digital carbon trading systems can improve corporate participants efficiency and accessibility.

5.4 Enhancing Systems for Measurement, Reporting, and Verification (MRV)

- Transparency and accountability can be increased by fortifying MRV procedures with blockchain and digital technology.
- Standardized verification processes should be established to prevent fraud and ensure the credibility of carbon credit projects.

- Government and industry collaborations should work towards developing cost-effective MRV solutions for small and medium enterprises (SMEs).

5.5 Promoting Innovation and Emerging Technologies

- Investment in research and development (R&D) for carbon capture, utilization, and storage (CCUS) can enhance the potential of carbon credit generation.
- Carbon tracking and credit verification can be enhanced by emerging technology like satellite-based monitoring and artificial intelligence (AI).
- New prospects for carbon credits can be unlocked by promoting innovation in sustainable agriculture and renewable energy.

By implementing these recommendations, India can harness the full potential of carbon credits to mobilize climate finance, reduce emissions, and accelerate the transition to a sustainable, low-carbon economy.

6. CONCLUSION -

The integration of carbon credits as a financial mechanism holds significant potential in mobilizing climate finance and accelerating India's transition toward a low-carbon economy. As demonstrated in this research, carbon credits incentivize sustainable practices, attract private investments, and support India's commitments under the Paris Agreement (Jain & Sharma, 2022). India has made notable progress in establishing carbon credit mechanisms, particularly through the Perform, Achieve, and Trade (PAT) scheme and voluntary carbon markets. However, the widespread use of carbon credits is still hampered by market fragmentation, regulatory uncertainty and low private sector participation (Mukherjee & Sinha, 2023).

To unlock the full potential of carbon credits, India must develop a unified regulatory framework, enhance transparency through digital tools like blockchain, and create stronger financial incentives (Gupta & Ramanathan, 2022). Additionally, integrating carbon credit projects with social development goals can maximize their economic, environmental, and social co-benefits, particularly in rural and underserved regions (Bhattacharya et al., 2023). Strengthening institutional support and aligning domestic carbon pricing mechanisms with global standards will further position India as a leader in global climate action (Dubash et al., 2022).

The findings of this paper emphasize that while carbon credit markets offer significant opportunities for climate finance mobilization, addressing key challenges is crucial for their success. By implementing comprehensive policy reforms, improving market transparency, and fostering private sector engagement, India can leverage carbon credits as a powerful tool for sustainable development, economic growth, and global climate leadership (Singh & Chaturvedi, 2022). Future research should focus on the impact of digital innovations, evolving international carbon trading regulations, and sector-specific strategies for enhancing carbon finance in India.

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Neuro-Silicon Synergy: A Hybrid Model of Artificial and Organoid Intelligence for the Computing Future

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Abstract

With the growing need for intelligent, adaptive, and low-power computing, shortcomings in silicon-based artificial intelligence systems become more obvious. In this article, we propose a new paradigm—Neuro-Silicon Synergy—whereby brain organoids (in vitro grown neural tissue) and neural networks (ANNs) are integrated into a hybrid computer system. This work explores the science and cause, novel capabilities, and possible applications of combining AI with organoid intelligence (OI). We also put forward a conceptual design of the resulting hybrid system and set out a plan for practical use in robotics, agriculture, and medicine.

Keywords: Organoid Intelligence, Wetware Computing, Neuro-Silicon Synergy, Hybrid AI Systems, Brain-on-a-Chip, Biohybrid Computing, Artificial Neural Interfaces

1. Introduction: The Next Frontier in Computing

Rise of Artificial Intelligence

Artificial Intelligence (AI) has revolutionized contemporary life by making it possible for machines to execute intellectual functions such as learning, reasoning, and decision-making. From autonomous vehicles to real-time translation and computer-aided diagnosis, AI systems have been incredibly competent. The development is primarily because of deep learning and large-scale neural networks, making it possible for systems to learn from gigantic data sets (LeCun et al., 2015).

The Bottlenecks of Silicon-Based Systems

In spite of these advances, present-day AI approaches are constrained as they employ silicon-based technology that is energy-hungry and less adaptive. In contrast to biological organisms, these machines do not easily adapt to new environments without restarting. In addition, scalability is an enormous concern in high-performance computing because it causes heat buildup and energy consumption (Strubell et al., 2019).

The Promise of Biological Computation

Biological computing and, in particular with the help of brain organoids, is an emerging path. Organoids are cultivated from stem cells and are similar to small, miniature human brains. Organoids are composed of genuine neurons that can fire, learn, and recall. These living tissue neural structures are composed of dynamic learning properties using a portion of the energy that a standard chip consumes (Trujillo et al., 2019).

Neuro-Silicon Synergy Defined

The Neuro-Silicon Synergy model imagines combining the adaptive, low-power quality of organoid intelligence with the high-speed, high-precision of AI. The synergy can potentially usher in systems that learn more effectively, are context-aware, and naturally emerge in parallel with data (Schiff et al., 2023).

2. Literature Review: Building Blocks and Knowledge Gaps

Organoid Intelligence: What We Currently Know

Organoid Intelligence is a new area in which computation is achieved through the use of lab-grown brain tissue. These organoids, grown from human stem cells, display spontaneous electrical activity, engage in synaptic networks, and react to input. Initial research has demonstrated the capacity to learn to play games inside simulations (Fair et al., 2023).

Wetware Computing: Beyond Hardware and Software

Wetware computing offers a third path to computing, beyond software and hardware. Alive, neurons, unlike electronic circuits, compute via bio-synapses and ion exchanges and are more plastic. Early experiments showed that cultured neurons could drive external devices such as flight simulators (DeMarse et al., 2001).

AI-Neural Interface Advances

Brain-computer interfaces (BCIs) are now used to connect digital systems with biological neural networks. Methods such as optogenetics and multi-electrode arrays have made two-way real-time data exchange possible, creating hybrid communication avenues (Bakkum et al., 2013).

3. The Neuro-Silicon Hybrid Framework

Overview of the System Architecture

The design of our proposed system accommodates three layers:

AI Layer: Executes standard calculations, builds models, preprocess data, and analyzes data.

Interface Layer: A neuro-electronic connection containing microelectrodes or optogenetic tools that transfer signals.

Organoid Layer: an area that contains a living neural organoid, which involves context-based learning and can provide meaningful feedback.

AI Preprocessing and Organizing Task to Organoid

Organic systems will perform structured data processing, down-sampling noise, and codifying signals before passing time-sensitive patterns into organoid systems. This capability serves two purposes: reduce overload on the receiving organoid(s) signals, and focus organoid energy on potentially useful learned tasks.

Organoid Learning & Responding

Once given stimulation, organoids will reflect feedback in the form of voltage patterns or network reorganizations. Based on the representations we would observe from each organoid, we may know the patterns are indicating learning or cognitive-like responses. With consistent input/output experiences, the organoid learns a new behavior to associate inputs from specific stimuli into a response, which is similar to how a biological brain has adapted to its environment (Kagan et al, 2022).

Real-Time Neural-Feedback Loop

All organoid information exists and can now be returned for machine parsing to send information back into the AI for interpretation and processing and continuing to develop and tweak instructions. This bi-directional loop could enable both systems to evolve simultaneously without dismissing either system in the loop, thus improving performance with experience over time.

Integration Technology and Biochip Fabrication

Tools, such as soft lithography, CRISPR, and nanoelectrode arrays, will allow researchers to develop biochips containing organoids that will be integrated into electronic circuits. Each biochip has specific designs for acquiring nutrient, adequate oxygenation, and stimulate organoid network signal.

4. Use Cases: Where the Future Begins

Smart Agriculture

Organoid sensors are able to sense subtle chemical, microbial, or pH variations in soil that normal sensors cannot. For instance, a hybrid chip is capable of detecting a root chemistry shift that signals early-stage fungal infection and can adapt to sense the same dangers again in the future.

Healthcare & Drug Discovery

Brain organoids grown from a patient's cells may test out what the patient would react to in neurological treatments. Using AI, considering patient history and genetics, this integrated system allows for safer, personalized, and more rapid medical trials (Lancaster et al., 2013).

Humanoid Robotics

Bots with organoid-based processors are able to perceive human feelings or fuzzy orders better. They can gauge sadness in the voice or tension in pressure-handshakes of the mouth—abilities too often overlooked by stand-alone AI.

Edge AI Devices

Hardware deployed in resource-scarce environments—e.g., wrist-worn health trackers or underwater drones—can utilize low-power biochips to process difficult decisions without the need to access humongous processors.

5. Challenges and Ethical Implications**Biological Variability**

Every organoid is different. Such variability makes programming and system design more difficult. Adaptive AI software could be necessary for every chip.

Communication Protocols

Digital to biological and back again is not a simple translation. Standardized interfaces are critical for commercialization.

Ethical Debates

Machine and living being border blurs. Organoid rights, disposal, and consent (Farahany, 2023).

Manufacturing and Durability

Organoids are always needy—nutrients, oxygen, waste removal. They possess life span, deteriorate, and possess environmental needs that pose hurdles for long-term use.

6. Roadmap to Realization: Lab to Life**Advances in Synthetic Biology**

There needs to be progress in cultivating specialized brain areas in vitro. These are enhanced differentiation protocols and the ability to control the stages of neural development.

Standard AI-OI Protocols

Open standards have to be developed for AI communicating with biological entities, as with APIs in computer science. A "Bio-OS" can possibly emerge.

Digital Twins of Organoids

AI systems mimicking particular organoids can be used to simulate experiments in advance of actual implementation. This will improve the systems and minimize errors during experiments.

Simulation-Driven Development

Simulated environments must mimic organoid reactions under different conditions to facilitate experimentation safely. This will save costs and optimize bio-AI training prior to laboratory synthesis.

7. Conclusion:

A New Computing Era The fusion of artificial and biological intelligence is a groundbreaking new age in science and technology. Neuro-Silicon Synergy unifies the computation speed and

scalability of AI with the biolike learning economy, adaptability, and capacity of organoids. If both ethical and technological issues are addressed responsibly, this new paradigm combining the strengths of human-focused and machine-based approaches can deliver more human-like, sturdy, and non-isolatable intelligent systems than are available today with current machines.

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Green Climate Finance in Banking: A Review of Products, Determinants, Gaps, and Future Directions

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Abstract

1. Introduction

Green finance—interchangeably termed sustainable, environmental, or climate finance—has emerged as a key focus of global financial discourse, especially since the 2016 G-20 Summit in Hangzhou and the 2017 Paris ‘One Planet Summit.’ It refers broadly to financial instruments, products, and institutional practices aimed at fostering environmental sustainability, social equity, and long-term economic development. As crucial intermediaries in capital mobilization, banks have become increasingly instrumental in channeling funds towards initiatives such as clean energy, sustainable infrastructure, climate change mitigation, social inclusion, and improved governance. Traditional banking models are evolving in response to rising concerns over climate change, social disparities, and corporate misconduct. Prominent global banks, such as HSBC and Société Générale, have committed to withdrawing support from environmentally harmful industries. Furthermore, several central banks—most notably in China—have introduced policy frameworks to steer financial activity toward greener outcomes. Nevertheless, widespread adoption of green finance within the global banking sector remains uneven. Challenges such as inconsistent regulatory standards, elevated perceived risks, and limited market readiness hinder progress. Existing academic literature often fails to capture the full scope of banks' contributions to green finance—particularly in terms of product innovation and driving determinants. This review seeks to bridge that gap by analyzing prevailing research patterns, identifying major green finance products and influencing factors within banking, and mapping future research directions and deficiencies.

2. Research Methodology

To conduct a robust systematic literature review, a two-phase search protocol was implemented, focusing on the period from 1990 to 2019. Scopus, recognized for its comprehensive and high-quality indexing in financial and economic research, served as the primary database.

Stage 1: Preliminary Search

Keywords related to green finance (e.g., "sustainable finance," "green credit," "climate finance")

were cross-referenced with banking-related terms ("bank," "financial institutions," "banking sector"). Filters were applied to limit results to peer-reviewed journal articles in English. This process yielded 76 initial papers.

Stage 2: Screening and Selection

Following content analysis and relevance assessment, 46 journal articles were selected. Inclusion was based on their substantive treatment of green finance within banking. The selected papers were then categorized as follows:

- **Background Metrics:** Year-wise distribution, journal sources, key authors, country/institutional affiliations, and methodologies used.
 - **Topical Themes:** Types of green finance products and influencing factors.
 - **Research Gaps:** Unexplored areas and suggested future research trajectories.
- To evaluate scholarly contributions, a scoring model adapted from Howard, Cole, and Maxwell (1987) was applied—giving higher weight to lead and corresponding authors.

3. Results and Discussion

3.1. Background Overview of Selected Literature

Publication Trends

Research output on green banking has grown steadily since 2012, with a sharp uptick observed between 2017 and 2019—from just two papers in 2017 to 22 by 2019. This surge corresponds with growing institutional commitments and a global rise in sustainable investment, evidenced by USD 465 billion in green debt issuance in 2019 alone.

Key Journals

The 46 selected articles were published across 32 academic journals. Among these, the most prolific contributors (publishing two or more articles) include:

1. *Sustainability* (Switzerland)
2. *Journal of Sustainable Finance and Investment*
3. *Technological Forecasting and Social Change*
4. *Emerging Markets Finance and Trade*
5. *Humanomics*

These journals represent more than 40% of the literature reviewed and reflect both theoretical developments and industry-focused insights in green finance.

Leading Contributors (Countries, Institutions, and Authors)

- **Countries:** China led the field with a contribution score of 7.19, followed by the UK (6.70) and Italy (6.40). While China's dominance reflects its policy-driven green finance agenda, other significant contributors include Malaysia, Bangladesh, and several European nations. The U.S. ranked fourth, indicative of a more reactive stance on sustainability compared to European or Asian counterparts.
- **Institutions:** The China University of Mining and Technology topped the list with six contributors, followed by Jiangsu Normal University (China). European and Asian institutions—such as the University of Genoa, Oxford University, and the International Islamic University Malaysia—were also prominent. Boston University was the only North American university among the top contributors.

- **Authors:** The geographical spread of active authors mirrored institutional patterns, with the majority based in China, the UK, and Italy.

Methodological Approaches

The reviewed literature predominantly employed the following research methodologies:

1. Quantitative Modelling (54%) – Emphasizing empirical validation and statistical analysis
2. Policy and Literature Review (20%) – Focusing on theoretical exploration and comparative policy analysis
3. Case Studies (11%) – Including interviews and expert opinions
4. Mixed Methods (9%)
5. Surveys (6%)

Citation Patterns

Citation analysis revealed that most papers in the field remain relatively new, with only two articles exceeding 100 citations (Wilson, 1997; Yip & Bocken, 2018). The majority had fewer than 50 citations, suggesting that academic inquiry into green banking is still in its developmental phase.

3.2. Key Themes in Bank-led Green Finance

1. Green Financial Products in Banking

Banks have diversified their offerings to support environmental sustainability. Common product categories include:

- **Green Loans (Credits):**
These provide short- to medium-term financing to businesses and startups pursuing eco-innovations. Green loans typically feature favorable terms—such as reduced interest rates and flexible repayment schedules—and are guided by principles like the Equator Principles to ensure environmental responsibility.
- **Green Long-Term Investment Accounts:**
These instruments allow individual and institutional clients to allocate capital for long-term, sustainability-driven investments, such as renewable energy or inclusive development projects. Additionally, they may fund social welfare initiatives, minority support programs, and governance reforms.
- **Carbon Finance Instruments:**
Targeting emissions reduction, carbon finance channels funding to projects such as biogas plants, solar installations, and waste-to-energy facilities. In some coal-dependent economies, banks are increasingly substituting fossil-fuel-based lending with carbon finance to align with environmental standards.
- **Climate Finance:**
Structured to tackle climate-related vulnerabilities, these funds support adaptation and mitigation programs aimed at reducing greenhouse gas emissions and enhancing community resilience to climate shocks.
- **Green Securities (Stocks and Bonds):**
These include tradable instruments like green bonds, green mutual funds, and sustainability indices designed to fund environmentally responsible projects. Examples include the Green Bond Index initiatives by the Shanghai and Luxembourg stock exchanges, demonstrating integration with global capital markets.

Green Bancassurance and Green Infrastructure Finance

Green Bancassurance represents an evolving collaboration between banks and insurance providers aimed at fostering sustainability. This model includes carbon-neutral underwriting options for assets such as eco-certified homes and low-emission vehicles. To encourage environmentally responsible behavior, banks offer incentives like discounted insurance premiums for carbon-neutral initiatives, reinforcing their commitment to sustainable development. Green Infrastructure Finance supports long-term ecological development through the funding of public utilities and infrastructure projects—such as environmentally conscious roadways, educational institutions, railways, and healthcare facilities. These investments are typically labeled as “green,” making them attractive to private investors and institutional buyers due to their sustainable value and potential for favorable pricing in capital markets.

Key Determinant: Global Environmental Advocacy and Policy Pressure

A critical driver of banks’ participation in green finance is the intensifying global momentum toward environmental protection and climate resilience. International frameworks and the influence of major entities—including the United Nations, IMF, World Bank, European Union, and G20—combined with advocacy from environmental organizations, have placed banks under growing pressure to align with sustainable finance principles. This global accountability is steadily reshaping banking practices, prompting a transition away from fossil fuel financing toward more eco-friendly investment approaches.

4. Identified Research Gaps and Directions for Future Inquiry

Despite growing momentum, several gaps persist in the scholarly and practical discourse surrounding green finance in the banking sector. These present opportunities for future exploration and innovation:

- **Absence of Unified Regulatory Standards:**
The lack of harmonized global frameworks for green finance results in uneven application across jurisdictions. Future research should work toward the development of standardized international guidelines to ensure consistency and scalability.
- **Perceived Risk and Limited Application:**
High financial and reputational risks, coupled with a narrow product spectrum, have hindered broader adoption. Investigating risk mitigation tools and expanding the diversity of green financial offerings could enhance adoption.
- **Insufficient Documentation of Bank Practices:**
There is limited empirical work detailing the specific initiatives, strategies, and products deployed by banks in the green finance space. Detailed case studies and field research are essential to bridge this gap.
- **Underexplored Determinants Beyond Global Pressure:**
While international policy influence is widely acknowledged, other factors such as institutional culture, customer demand, religious or ethical values, and local governance structures warrant deeper analysis.
- **Lack of Trend Synthesis and Strategic Insight:**
Current research is fragmented, often lacking cohesive analysis of market trends or strategic implications. Future studies should aim to provide integrative frameworks that guide policy and practice.

- **Geographic Concentration of Research:**

Academic efforts are disproportionately centered on Asia and Europe, overlooking the nuanced green finance contexts of Africa and South America. Regional studies are crucial for inclusive and globally relevant financial policy development.

- **Need for Stronger Empirical Validation:**

The theoretical frameworks surrounding green banking require robust empirical support. Data-driven research can reinforce policy advocacy and strategic implementation across financial institutions.

5. Conclusion and Strategic Implications

This review reaffirms the expanding role of green finance within the banking sector and highlights the growing scholarly engagement in this field. Banks are gradually innovating diverse sustainable products in response to international environmental commitments and policy frameworks. However, to unlock the full potential of green finance, persistent challenges—such as regulatory fragmentation, implementation risks, and limited empirical understanding—must be addressed. Going forward, it is essential for researchers, policymakers, and financial institutions to collaborate in building standardized, risk-resilient, and globally inclusive green finance systems. Doing so will not only accelerate the banking sector's contribution to environmental sustainability but also fortify the resilience and relevance of financial systems in an era defined by climate urgency.

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A study On Environmental Consciousness in Kanpur City

With Special Reference to Electric Two-Wheelers

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ABSTRACT

Industrialization was a positive step for the economy because it created many job possibilities, advanced and inventive products, and boosted the economy, but it also brought many issues such as pollution, climate change, and so on. Nowadays, air pollution is a big concern for concerned citizens, and the transport sector is one of the biggest contributors to it. Innovative business approaches in the transportation sector will revolutionise the way we travel in the near future. In fact, many technologies like EVs have already arrived in the market and are quite popular due to their viable prices as well as their benefits in energy efficiency and tailpipe emission reduction. The questionnaire is used to collect the data from the respondents in Kanpur City. A judgemental sampling technique is used in the selection of the samples. The questionnaire demonstrates the demographic profile of consumers. The objective of the research paper is to check the environmental consciousness of respondents of Kanpur city. The study has used the chi square test for the testing of hypothesis and identified that environmental consciousness is not associated with the gender and age of respondents.

Key Words: Electric two-wheeler, Automobile industry, Environment Friendly, Air pollution, Greenhouse gases

Introduction

Industrialization was a positive step for the economy because it created many job possibilities, advanced and inventive products, and boosted the economy, but it also brought many issues such as pollution, climate change, and so on. Nowadays, air pollution is a big concern for concerned citizens, and the transport sector is one of the biggest contributors to it. However, we as human beings can never deny the role of the transport industry in global economic progress.

Transport sectors are salient to modern civilization and perform an essential role in global economic progress (Li,et.al,2017). As per the International Energy Agency (IEA 2018), transport-related activity will be responsible for half of all greenhouse gas emissions up to 2030. The

assessment clearly shows that the current transport system is not feasible and that an extensive makeover is required (Shalender& Sharma, 2021). The automobile industry in India accounts for more than 10% of energy-related carbon emissions and serves as an important cause of air pollution (Jain, et.al,2022). Therefore, to enhance the conditions of the world's transport sector, it is made to undergo a dramatic shift, owing to major socio-economic, environmental, as well as technical drivers. Innovative business approaches in the transportation sector will revolutionise the way we travel in the near future (Kesari,et.al, 2019). In fact, many technologies like EVs have already arrived in the market and are quite popular due to their viable prices as well as their benefits in energy efficiency and tailpipe emission reduction. According to the studies, introducing and promoting EVs in the transportation industry will significantly cut the emission of greenhouse gas (GHG) while also decreasing reliance on gas and oil (Zhou, et.al, 2021). Recognizing the environmental friendliness of EVs, the Indian government established the National Electric Mobility Mission Plan 2020 in the year 2013 and set an aspiring target of 30% electric Vehicles in India by 2030 (Shalender& Sharma, 2021).

Despite their popularity, positive impact on the environment, availability of fascinating designs and being economical, the adoption rate in India is not appreciating. This study wants to identify the customers' preference towards electric two-wheelers and the factors that encourage them to buy an electric two-wheeler. Two-wheelers are the most prevalent mode of transportation in India, which is why this study is focused especially on them.

Research Gap:

Despite their popularity, positive impact on the environment, availability of fascinating designs and being economical, the adoption rate in India is not appreciating. This study wants to identify the customers' preference towards electric two-wheelers and the factors that encourage them to buy an electric two-wheeler. Two-wheelers are the most prevalent mode of transportation in India, which is why this study is focused especially on them.

Literature Review:

According to Li, J., Jiao, J., & Tang, Y. (2019) electric vehicles (EVs) have been thoroughly considered by governments in response to severe energy crisis and environmental challenges. Even though China has become the world's largest Electric vehicle market, the drawbacks of EVs and decreasing subsidies have resulted in a difficult future. They have used a complex network diffusion innovation method to investigate the dynamic effects of government initiatives on EV diffusion in different scale networks in order to promote EV diffusion. The findings showed that as the number of manufacturers in the network grows, so does the degree of EV diffusion at the same government policy level.

Adhikary, S., Jalan, N., & Anute, N. (2022). The researcher argued that the awareness level of Generation Z was high in comparison to the above 40-aged respondents although their paying capacity is not too much. Young potential consumers are more conscious of the sustainability of the environment and believe that electric vehicles can be assessed with the help of subsidies provided by the Government. Many respondents believed that e-automobiles are more affordable

and a superior option than conventional petrol or diesel vehicles, even though they acknowledge that the infrastructure is still developing. E-vehicles will also aid in reducing noise pollution, particularly in places with high traffic

Sarthak Das (2020). The research is backed up by primary as well as secondary data. The study was empirically tested and it concluded that the awareness level of potential consumers was very high and a majority of them were even aware of the name of the brands available in the electric vehicle market. Many of them were in a dilemma about the driving performance of E2Ws because of the unavailability of charging infrastructures, therefore they think that it would not be preferable to buy the electric two-wheeler.

Javed, S. W., &Khurram, H. M. (2022). Descriptive research was utilized in the investigation. Both primary and secondary data were used to support the study.

The study was conducted on Pakistani consumers to identify the variables affecting the buying of electric bikes. Their preferences include safety and health concerns, aesthetics and design, and knowledge about e-bikes. In a similar vein, three more basic factors like the ownership cost, the driving range per charge, and the accessibility of charging stations have been identified as the primary reasons why people buy EVs at a low rate. The authors suggested that the Pakistani government, in collaboration with domestic manufacturers, may develop a strategy aimed at facilitating the establishment of e-bike plants and factories.

Objectives of the Study:

- 1.To Study the customer perception about the electric two wheelers in Kanpur city.
- 2.To Test the association between the environment consciousness and the gender.
- 3.To Test the association between the environment consciousness and the age of respondents.
4. To study the awareness of electric two wheelers among the two wheelers owners.

Research Methodology:

This research has used primary data which had been collected by systematic structured questionnaire. The data had been gathered from the 139 respondents of Kanpur city who are currently using two wheelers. The sample has been selected on the basis of judgement sampling technique.Descriptive statistics and chi square technique is used for the analysis of data.

Analysis of Results:

Profile of Respondents:

In the study the total 139 respondents had taken part in which 83 were males and 56 were females which in percentage is 59.7% male and 40.3 % females.

Table 1

Respondents	Frequency	Percent	Valid Percentage
Male	83	59.7	59.7
Female	56	40.3	40.3
Total	139	100	100

Future Plan to buy electric two wheelers: In the study 73 respondents have future plan to buy the electric two wheelers while 30 respondents are not interested in buying the E2Ws. 36 Respondents don't have any thought of it.

Table 2

FPB					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	73	52.5	52.5	52.5
	No	30	21.6	21.6	74.1
	Can't say	36	25.9	25.9	100.0
	Total	139	100.0	100.0	

Do you think Government should provide more incentive to buy electric two wheelers?

Currently Uttar Pradesh government is providing the subsidy on the buying of electric two wheelers. In the study 38.8 percent respondents are saying that government should provide more subsidy while 56.8 percent respondents are satisfied with the current subsidy although 4.3 % have no idea of the subsidy.

Table 3

More Incentives					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	54	38.8	38.8	38.8
	No	79	56.8	56.8	95.7
	May be	6	4.3	4.3	100.0
	Total	139	100.0	100.0	

- To test the second objective, that is, is there any association between the environment consciousness and the gender.

For the testing of objective second Hypothesis is as:

H0: There is no association between the environment consciousness and the gender.

H1: There is an association between the environment consciousness and the gender.

Table 4

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.142 ^a	2	.565
Likelihood Ratio	1.135	2	.567
Linear-by-Linear Association	.699	1	.403
N of Valid Cases	139		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.07.			

As per the chi square value table p value is .565 which is greater than .05.so the null hypothesis is accepted. Chi square test statistics of 1.142(sig value>.05) indicates that there is no significant association between the Gender and environment consciousness.

- To test the third objective that there is an association between the environment consciousness and the age of the respondents.

For the testing of the objective, hypothesis will be as:

Ho: There is no association between the environment consciousness and the age of respondents.

H1: There is an association between the environment consciousness and the age of respondents

As per the chi square value table p value is .706 which is greater than .05.so the null hypothesis is accepted. Chi square test statistics of 2.163(sig value>.05) indicates that there is no significant association between the Age and environment consciousness.

Table 5

Chi-Square Tests			
	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.163 ^a	4	.706
Likelihood Ratio	2.131	4	.712
Linear-by-Linear Association	.698	1	.403
N of Valid Cases	139		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.04.			

- As per the fourth objective, 124 respondents are aware for the electric two wheelers in Kanpur city. In the percentage 89.4% respondents are aware and 10.8 % respondents are unaware about the E2Ws.

Table 6

		Frequency	Percent	Valid Percent
Valid	Aware	124	89.2	89.2
	Unaware	15	10.8	10.8
	Total	139	100.0	100.0

Conclusion

Although the government is providing sufficient rebates to consumers but the consumer demands more incentives from the government. Majority of consumers don't have any plan to buy the E2W because of some limitations of electric two wheelers. So Electric two-wheeler manufacturers should pay attention to model modification and cost of manufacturing so that these vehicles attract the interest of consumer.

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Main headings should be used to designate the major sections of an article. Within the main body of the paper, the major headings typically include such things as INTRODUCTION, METHOD, RESULTS, and DISCUSSION. Supporting material, such as references and appendices are also treated as major headings. In all cases, major headings should be left-aligned, bold-faced and typed in all capital letters. Secondary headings should be typed with the left margin, in title case (small letters with major words beginning with capitals), and in bold.

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Number tables and figures consecutively (one series for tables, one for figures) from the beginning to the end of the article. Indicate the position of each in the text.

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Giving proper credit to the sources of original ideas and previous work is an important aspect of good scholarship. Inappropriate or inaccurate citations do not do justice to the authors cited and can be misleading to readers. Citations must be in alphabetical order.

Example: Several studies (Ferris & Kacmar, 1992; Malhotra & Bazerman, 2008; Morrison, 1993a, 1993b) support this conclusion.

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.. exhaustion was also related to job performance (Adams et al., 2008). (For more than 2 authors)

REFERENCES

References must be in APA style.

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Goggin, W. C. (1974). How the multi-dimensional structure works at Dow Corning. *Harvard Business Review*, 55(1): 54-65.

Katz, D. and Kahn, R. L. (1978). *The social psychology of organizations* (2nd ed.). New York: Wiley.

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Wall, J. P. (1983). Work correlates of the career plateau. Paper presented at the annual meeting of the Academy of Management, Dallas, TX.

Smith, M. H. (1980). A multidimensional approach to individual differences in empathy. Unpublished doctoral dissertation, University of Texas, Austin.

APPENDICES

The appendices present lengthy but essential methodological details, such as explanations of the calculation of measures or items in a new survey instruments. Presentation should be concise but not abbreviated. Each appendix should be treated as a major heading. The title of each appendix should be typed in all capital letters, centered, and bold-faced. Multiple appendices are APPENDIX A, APPENDIX B, etc. A single appendix does not require a letter.

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