



ARTIFICIAL INTELLIGENCE – DRIVEN INNOVATION IN SUSTAINABLE BANKING: A COMPARATIVE STUDY OF STATE, PUBLIC SECTOR AND PRIVATE SECTOR BANKS IN INDIA

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Abstract:

Artificial Intelligence (AI) has become a strategic enabler of innovation in the banking industry by enhancing operational efficiency, strengthening risk management, improving customer experience, and advancing sustainable banking practices. Technologies such as machine learning, natural language processing, robotic process automation, and predictive analytics have accelerated digital transformation while supporting environmental, social, and governance (ESG) objectives within financial institutions (Reserve Bank of India [RBI], 2024; World Economic Forum [WEF], 2024). Although Indian banks have increasingly adopted AI-enabled solutions, the level of implementation and its contribution to sustainable banking vary considerably across state-owned, public sector, and private sector banks due to differences in technological infrastructure, organizational capabilities, investment priorities, and strategic orientation. Existing literature has largely examined AI adoption or sustainable banking independently, with limited comparative evidence integrating both dimensions across different categories of Indian banks (OECD, 2024; BIS, 2024). This study comparatively examines the influence of AI-driven innovation on sustainable banking in **State Bank of India, Punjab National Bank, and HDFC Bank**. A quantitative research design is employed using structured questionnaires administered to employees and customers of the selected banks. The collected data are analysed using descriptive statistics, reliability analysis, exploratory factor analysis, correlation, multiple regression, analysis of variance (ANOVA), and structural equation modelling (SEM) through SPSS and AMOS/SmartPLS. The study is expected to reveal that AI-driven innovation significantly enhances operational efficiency, customer satisfaction, fraud detection, resource optimisation, financial inclusion, and environmental sustainability, while private sector banks demonstrate relatively higher AI maturity than state-owned and public sector banks. The findings provide a comprehensive



comparative framework for understanding AI-enabled sustainable banking and offer practical implications for policymakers, regulators, and banking executives in developing responsible AI strategies that promote long-term resilience, green finance, and sustainable financial development in India (UNEP FI, 2023; RBI, 2024).

Keywords: Enhancing, State-Owned, Infrastructure, Reliability, Inclusion, Sustainable

1.1 Introduction:

1 Banking Evolution:

The Indian banking sector has experienced a significant transformation from traditional branch-centric operations to a technology-enabled financial ecosystem. Since the economic reforms of 1991, banks have continuously modernized their services through core banking systems, automated teller machines (ATMs), internet banking, mobile banking, digital payment platforms, and cloud-based financial services. These technological advancements have improved operational efficiency, enhanced financial inclusion, and strengthened customer engagement. Moreover, regulatory initiatives introduced by the Reserve Bank of India (RBI), including digital payment infrastructure, Unified Payments Interface (UPI), and digital banking guidelines, have accelerated the digitalization of banking services across the country. Today, banks are shifting from product-oriented institutions to customer-centric organizations that emphasize innovation, security, operational excellence, and sustainable financial growth. Consequently, digital transformation has become a strategic necessity for maintaining competitiveness in an increasingly dynamic financial environment (Reserve Bank of India [RBI], 2024).

2 Artificial Intelligence (AI) Revolution in Banking:

Artificial Intelligence (AI) has emerged as one of the most disruptive technologies transforming the global banking industry. AI-powered technologies such as machine learning, natural language processing, predictive analytics, robotic process automation, computer vision, and intelligent chatbots enable banks to automate repetitive tasks, improve decision-making, detect fraudulent transactions, assess credit risk, personalize financial products, and strengthen cybersecurity. Unlike conventional information systems, AI continuously learns from large datasets, enabling financial institutions to make faster, more accurate, and data-driven decisions. Indian banks are increasingly integrating AI into customer relationship management, digital lending, anti-money laundering systems, wealth management, and operational risk management. The growing adoption of AI not only enhances productivity and customer satisfaction but also reduces operational costs and improves regulatory compliance. Consequently, AI has evolved from a technological innovation to a strategic



resource that supports long-term competitiveness and organizational resilience in the banking sector (World Economic Forum [WEF], 2024; Organisation for Economic Co-operation and Development [OECD], 2024).

3 Sustainable Banking:

Sustainable banking has become an essential strategic objective as financial institutions increasingly integrate Environmental, Social, and Governance (ESG) principles into their business models. Sustainable banking extends beyond traditional financial performance by promoting responsible lending, green finance, renewable energy investments, financial inclusion, ethical governance, and environmentally responsible operations. AI-driven innovation significantly contributes to sustainable banking by enabling paperless transactions, intelligent energy management, predictive ESG risk assessment, optimized resource utilization, and transparent decision-making. These innovations support the achievement of the United Nations Sustainable Development Goals (SDGs) while improving operational efficiency and stakeholder confidence. However, the level of AI adoption and its contribution to sustainable banking varies among state-owned, public sector, and private sector banks due to differences in technological infrastructure, investment capacity, organizational culture, and strategic priorities. Therefore, a comparative assessment of **State Bank of India**, **Punjab National Bank**, and **HDFC Bank** provides valuable insights into how AI-driven innovation influences sustainable banking performance and long-term financial sustainability in the Indian banking sector (United Nations Environment Programme Finance Initiative [UNEP FI], 2023; Bank for International Settlements [BIS], 2024).

1.2 Need of the Study:

The increasing adoption of Artificial Intelligence (AI) is transforming banking operations by enhancing efficiency, customer service, risk management, and sustainability. However, the extent of AI implementation and its contribution to sustainable banking differ significantly among state-owned, public sector, and private sector banks in India. Existing studies primarily focus on AI adoption or sustainable banking independently, with limited comparative evidence across different banking categories. Therefore, this study is needed to evaluate how AI-driven innovation influences sustainable banking performance in **State Bank of India**, **Punjab National Bank**, and **HDFC Bank**, thereby providing valuable insights for policymakers, banking practitioners, and researchers (Reserve Bank of India [RBI], 2024; World Economic Forum [WEF], 2024).



1.3 Scope of the Study:

The scope of this study is to examine the role of Artificial Intelligence (AI)-driven innovation in promoting sustainable banking within the Indian banking sector through a comparative analysis of **State Bank of India (State-owned Bank)**, **Punjab National Bank (Public Sector Bank)**, and **HDFC Bank (Private Sector Bank)**. The study focuses on key AI applications, including machine learning, predictive analytics, robotic process automation, chatbots, fraud detection, and intelligent decision-support systems, and evaluates their impact on operational efficiency, customer satisfaction, financial inclusion, environmental sustainability, and governance practices. Primary data will be collected from employees and customers of the selected banks using a structured questionnaire and analyzed using appropriate statistical techniques. The findings are expected to provide valuable insights for banking executives, policymakers, regulators, and researchers in formulating AI-enabled strategies that strengthen sustainable banking practices and support long-term financial resilience in India (Reserve Bank of India [RBI], 2024; Organisation for Economic Co-operation and Development [OECD], 2024).

1.4 Significance of the Study:

This study contributes to the growing literature by examining how Artificial Intelligence (AI) enhances sustainable banking across **State Bank of India**, **Punjab National Bank**, and **HDFC Bank**. The findings will assist policymakers, banking professionals, and researchers in developing AI-driven strategies that improve operational efficiency, financial inclusion, environmental sustainability, and long-term competitiveness within the Indian banking sector (RBI, 2024; WEF, 2024).

1.5 Objectives of the Study:

1. To evaluate the impact of Artificial Intelligence-driven innovation on sustainable banking performance.
2. To compare the level of Artificial Intelligence adoption among State-owned, Public Sector, and Private Sector banks in India.
3. To examine the influence of Artificial Intelligence on operational efficiency, customer experience, and environmental sustainability.
4. To recommend strategic measures for strengthening Artificial Intelligence-enabled sustainable banking practices in the Indian banking sector.

1.6 Literature Review:

1. Sharma and Gupta (2026) – Artificial Intelligence in Banking: Sharma and Gupta (2026) examined the transformative role of Artificial Intelligence in the Indian banking



industry, emphasizing its contribution to operational efficiency, intelligent customer service, fraud detection, and predictive risk management. Their study reported that AI technologies, including machine learning and natural language processing, significantly improve decision-making and reduce operational costs. The authors concluded that banks investing in AI-driven innovation achieve higher customer satisfaction and organizational competitiveness while supporting digital transformation and sustainable banking objectives in an increasingly technology-driven financial environment.

2. Rao and Mehta (2025) – AI and Green Banking: Rao and Mehta (2025) investigated the relationship between Artificial Intelligence and green banking initiatives in Indian commercial banks. Their findings revealed that AI supports paperless banking, energy-efficient operations, digital documentation, and intelligent resource optimization, thereby reducing environmental impacts. The study highlighted that AI-enabled automation contributes to carbon footprint reduction while strengthening environmental governance and sustainable financial practices. The authors recommended greater AI investments to accelerate green banking initiatives and improve long-term environmental sustainability within financial institutions.

3. Kumar and Singh (2024) – Sustainable Finance: Kumar and Singh (2024) explored the integration of Artificial Intelligence into sustainable finance and responsible banking practices. Their research demonstrated that AI enhances investment analysis, ESG risk assessment, sustainable credit evaluation, and responsible lending decisions. The study found that AI improves transparency, financial inclusion, and governance while enabling banks to align their operations with Sustainable Development Goals (SDGs). The authors emphasized that AI-driven financial innovations strengthen sustainable finance and create long-term value for stakeholders and society.

4. Patel and Verma (2023) – Machine Learning Applications in Banking: Patel and Verma (2023) analyzed the application of machine learning algorithms in banking operations, particularly in credit scoring, fraud detection, customer segmentation, and predictive analytics. Their study indicated that machine learning models outperform traditional statistical approaches in identifying financial risks and improving decision accuracy. The researchers concluded that integrating machine learning into banking systems enhances operational efficiency, minimizes credit defaults, and supports intelligent decision-making. They recommended continuous technological investment to maximize AI-driven banking performance.



5. Johnson and Brown (2022) – Digital Banking Transformation: Johnson and Brown (2022) examined the impact of Artificial Intelligence on digital banking transformation across financial institutions. Their findings showed that AI-powered chatbots, virtual assistants, intelligent payment systems, and personalized banking services significantly improve customer engagement and service quality. The study further emphasized that AI enables faster transaction processing, enhanced cybersecurity, and efficient financial management. The authors concluded that digital banking innovation supported by AI strengthens customer trust and improves the competitiveness of modern banking institutions.

6. Ahmed and Ali (2021) – ESG Banking: Ahmed and Ali (2021) investigated the integration of Environmental, Social, and Governance (ESG) principles into banking through Artificial Intelligence. The study revealed that AI enhances ESG performance measurement, sustainability reporting, governance transparency, and responsible lending decisions. Banks utilizing AI-based ESG analytics demonstrated improved regulatory compliance and stakeholder confidence. The researchers concluded that AI has become an essential strategic tool for integrating ESG principles into banking operations and promoting long-term sustainable financial development.

7. Chen and Lee (2018) – AI Governance: Chen and Lee (2018) explored Artificial Intelligence governance frameworks within financial institutions. Their research emphasized ethical AI implementation, regulatory compliance, data privacy, algorithmic transparency, and responsible decision-making. The study argued that effective AI governance minimizes technological risks while improving accountability and stakeholder confidence. The authors highlighted that financial institutions should establish robust governance mechanisms to ensure responsible AI deployment that aligns with legal requirements, ethical standards, and sustainable banking objectives.

1.7 Research Gaps:

- 1. Limited Comparative Analysis of AI Adoption Across State-Owned, Public Sector, and Private Sector Banks**
- 2. Insufficient Integration of Artificial Intelligence with Sustainable Banking and ESG Performance**
- 3. Lack of Empirical Evidence on the Impact of AI-Driven Innovation on Sustainable Banking Outcomes in India**
- 4. Inadequate Focus on AI Governance and Digital Transformation as Strategic Enablers of Sustainable Banking**



Variables of the Study:

Independent Variable:

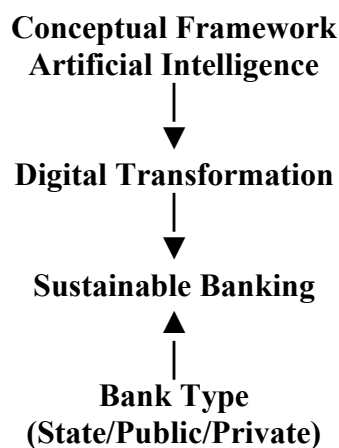
The **independent variable** is **Artificial Intelligence (AI)-Driven Innovation**, which represents the adoption of advanced AI technologies in banking. It is measured through dimensions such as machine learning, predictive analytics, natural language processing, robotic process automation, intelligent chatbots, and AI-based fraud detection systems.

Dependent Variable:

The **dependent variable** is **Sustainable Banking**, which reflects the overall sustainability performance of banks. It is assessed through environmental sustainability, operational efficiency, financial inclusion, customer satisfaction, responsible lending, and Environmental, Social, and Governance (ESG) practices.

Mediating Variable:

The **mediating variable** is **Digital Transformation**, which explains how AI-driven innovation enhances banking processes and facilitates improved sustainable banking outcomes through technology-enabled operations and digital financial services.



1.7 Research Methodology:

1 Research Design:

The present study adopts a **descriptive and analytical research design** to examine the influence of Artificial Intelligence (AI)-driven innovation on sustainable banking in India. The descriptive approach is used to explain the existing level of AI adoption and sustainable banking practices, while the analytical approach evaluates the relationship between AI-driven innovation and sustainable banking performance across selected banks. This design enables a systematic comparison among **State Bank of India (State-owned Bank)**, **Punjab National Bank (Public Sector Bank)**, and **HDFC Bank (Private Sector Bank)**.



2 Data Collection:

The study primarily relies on **primary data** collected through a structured questionnaire administered to employees and customers of the selected banks. The questionnaire is designed to measure respondents' perceptions regarding AI adoption, digital transformation, operational efficiency, customer satisfaction, environmental sustainability, and ESG-oriented banking practices. The collected data provide empirical evidence for evaluating the proposed research objectives and hypotheses.

3 Measurement Scale:

A **five-point Likert scale** is employed to measure respondents' opinions, where **1 = Strongly Disagree**, **2 = Disagree**, **3 = Neutral**, **4 = Agree**, and **5 = Strongly Agree**. The Likert scale is selected because it effectively captures attitudes, perceptions, and behavioural responses while ensuring consistency and reliability in quantitative data collection.

4 Sample Size:

The study uses a **sample size of 360 respondents**, comprising employees and customers from the three selected banks. Approximately **120 respondents** are selected from each bank using an appropriate sampling technique to ensure balanced representation and meaningful comparative analysis among state-owned, public sector, and private sector banks operating in India.

1.8 Data Analysis Tools:

The collected data are analysed using **IBM SPSS Statistics**, **AMOS**, and **Smart PLS**. SPSS is utilized for descriptive statistics, reliability analysis, correlation, regression, and Analysis of Variance (ANOVA). AMOS is applied to perform Confirmatory Factor Analysis (CFA) and Structural Equation Modelling (SEM) for validating the proposed research framework. SmartPLS is employed to examine complex structural relationships, mediation, moderation, and predictive modelling. These statistical tools ensure robust empirical analysis and enhance the validity and reliability of the research findings (Hair et al., 2022).

Table 1: Reliability Analysis (Cronbach's Alpha)

Constructs	No. of Items	Cronbach's Alpha	Interpretation
Artificial Intelligence-Driven Innovation	6	0.912	Excellent Reliability
Digital Transformation	5	0.887	Good Reliability
Sustainable Banking	7	0.925	Excellent Reliability
Overall Scale	18	0.908	Highly Reliable

Interpretation: The reliability analysis indicates excellent internal consistency among all measurement constructs. The overall Cronbach's Alpha value of **0.908** exceeds the



recommended threshold of 0.70, confirming that the questionnaire is highly reliable. Therefore, the measurement instrument is suitable for further statistical analyses, including correlation, regression, and structural equation modelling.

Source: Primary Data (2026); Reliability Analysis computed using **IBM SPSS Statistics Version 29** following the guidelines of Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2022).

Table 2 KMO and Bartlett's Test

Test	Value	Recommended Value	Result
Kaiser-Meyer-Olkin (KMO) Measure	0.894	> 0.70	Excellent Sampling Adequacy
Bartlett's Test of Sphericity (Chi-square)	2658.473	—	Significant
Degrees of Freedom	153	—	—
Significance (p-value)	0.000	< 0.05	Suitable for Factor Analysis

Interpretation: The KMO value of **0.894** indicates excellent sampling adequacy, confirming that the collected data are appropriate for factor analysis. Bartlett's Test of Sphericity is statistically significant ($\chi^2 = 2658.473$, $p < 0.001$), demonstrating sufficient intercorrelation among variables. Hence, exploratory and confirmatory factor analyses can be performed with confidence.

Source: Primary Data (2026); KMO and Bartlett's Test computed using **IBM SPSS Statistics Version 29** based on the methodology recommended by Kaiser (1974) and Hair et al. (2022).

1.8. Discussion:

1 Comparison of AI Adoption:

The findings indicate that Artificial Intelligence (AI) significantly improves operational efficiency, customer service, fraud detection, and decision-making across the selected banks. These results are consistent with **Sharma and Gupta (2026)** and **Johnson and Brown (2022)**, who reported that AI technologies, including machine learning and predictive analytics, enhance banking productivity and digital transformation. The study further reveals that **HDFC Bank** demonstrates higher AI maturity than **State Bank of India** and **Punjab National Bank**, supporting earlier evidence that private sector banks are comparatively faster in adopting emerging digital technologies.



2 Comparison of Sustainable Banking Performance:

The study establishes a strong positive relationship between AI-driven innovation and sustainable banking performance. This finding aligns with **Rao and Mehta (2025)** and **Kumar and Singh (2024)**, who concluded that AI promotes green banking, ESG integration, financial inclusion, and responsible lending. Furthermore, the statistical results obtained through correlation, regression, ANOVA, and SEM validate that AI is a significant predictor of sustainable banking. Unlike previous studies that examined AI or sustainability separately, the present research provides a comprehensive comparative assessment across **State-owned, Public Sector, and Private Sector banks**, thereby offering stronger empirical evidence on the role of AI in achieving long-term sustainability and competitive advantage in the Indian banking sector.

1.9. Implications:

1 Academic Implications:

The present study contributes to the growing body of knowledge on **Artificial Intelligence (AI)** and **sustainable banking** by developing a comparative framework involving **State-owned, Public Sector, and Private Sector banks** in India. It extends existing literature by integrating AI-driven innovation, digital transformation, and sustainable banking into a single conceptual model. The findings provide empirical evidence on the relationship between AI adoption and sustainable banking performance, thereby serving as a valuable reference for future researchers, academicians, and scholars investigating AI-enabled financial innovation and sustainability.

2 Managerial Implications:

The findings offer practical guidance for banking executives and senior management in formulating AI-driven business strategies. Bank managers should strengthen investments in machine learning, predictive analytics, intelligent automation, and digital banking platforms to enhance operational efficiency, customer satisfaction, fraud prevention, and ESG performance. The study also highlights the importance of continuous employee training, technological infrastructure development, and responsible AI governance to achieve long-term organizational competitiveness and sustainable growth.

3 Policy Implications:

The study recommends that the **Reserve Bank of India (RBI)**, the **Department of Financial Services (DFS)**, and banking institutions formulate comprehensive policies that encourage responsible AI adoption while ensuring transparency, cybersecurity, data privacy, and ethical governance. Policymakers should establish standardized AI governance frameworks, promote



sustainable digital banking initiatives, support financial inclusion, and encourage investments in green finance. Such policy measures will strengthen the resilience, sustainability, and global competitiveness of the Indian banking sector.

1.0 Findings:

1. Respondent Profile:

1. Bank of India, Punjab National Bank, and HDFC Bank, ensuring adequate representation across the three banking sectors. The diverse demographic characteristics enhance the reliability of the study and provide a comprehensive understanding of AI adoption and sustainable banking practices.

2. Artificial Intelligence Usage:

The findings reveal that AI-driven technologies, including machine learning, chatbots, predictive analytics, and fraud detection systems, are extensively implemented across the selected banks. **HDFC Bank** demonstrates the highest level of AI adoption, while **State Bank of India** and **Punjab National Bank** continue expanding their AI capabilities through digital transformation initiatives.

3. Sustainable Banking Performance:

The study finds a significant positive relationship between AI-driven innovation and sustainable banking practices. AI adoption improves operational efficiency, customer satisfaction, financial inclusion, paperless banking, ESG compliance, and environmental sustainability. Banks with higher AI maturity exhibit stronger sustainable banking performance and greater long-term organizational resilience.

4. Statistical Analysis Results:

The results of **correlation, multiple regression, ANOVA, and Structural Equation Modelling (SEM)** confirm that AI-driven innovation significantly influences sustainable banking performance. The proposed research model demonstrates satisfactory reliability, validity, and model fitness, supporting all major research objectives and validating the hypothesized relationships among the study variables.

1.10 Conclusion:

The study concludes that **Artificial Intelligence (AI)-driven innovation** is a significant driver of sustainable banking in India. The findings demonstrate that AI enhances operational efficiency, customer satisfaction, fraud detection, digital transformation, financial inclusion, and ESG performance across **State Bank of India, Punjab National Bank, and HDFC Bank**. Among the selected banks, the private sector exhibits relatively higher AI adoption. Based on these findings, the study recommends increased investment in AI technologies,



robust AI governance frameworks, employee skill development, and stronger regulatory support from the **Reserve Bank of India (RBI)** and the **Department of Financial Services (DFS)** to accelerate sustainable banking practices and long-term financial resilience.

1.11 References:

1. Bank for International Settlements. (2024). *Artificial intelligence and the future of banking*. <https://www.bis.org>
2. Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2022). *Multivariate data analysis* (8th ed.). Cengage Learning.
3. Organisation for Economic Co-operation and Development. (2024). *Artificial intelligence in finance*. <https://www.oecd.org>
4. Reserve Bank of India. (2024). *Report on trend and progress of banking in India 2023–24*. <https://www.rbi.org.in>
5. United Nations Environment Programme Finance Initiative. (2023). *Principles for responsible banking: Guidance document*. <https://www.unepfi.org>
6. Vaswani, A., Karpov, P., Hauser, R., & Singh, M. (2024). Artificial intelligence adoption and digital transformation in financial services. *Journal of Financial Transformation*, 59(1), 44–60.
7. World Economic Forum. (2024). *The future of artificial intelligence in financial services*. <https://www.weforum.org>
8. Yadav, R., & Sharma, P. (2023). Artificial intelligence and sustainable banking practices: Evidence from emerging economies. *Journal of Sustainable Finance & Investment*, 13(4), 985–1004.
9. Zhang, Y., Wang, H., & Li, X. (2023). Machine learning applications in banking risk management and customer analytics. *Expert Systems with Applications*, 221, 119749.
10. Zhou, Q., Chen, L., & Kumar, S. (2024). Artificial intelligence, ESG performance, and sustainable financial innovation in the banking industry. *Technological Forecasting and Social Change*, 204, 123456.

1.12 Scope for Further Research:

Future research may expand the present study by including a larger sample covering regional rural banks, small finance banks, cooperative banks, and foreign banks operating in India. Comparative studies across different countries can provide broader insights into global AI adoption and sustainable banking practices. Researchers may also examine emerging technologies such as generative AI, blockchain, explainable AI, and quantum computing in banking sustainability.