ARTIFICIAL INTELLIGENCE ADOPTION AND SUSTAINABLE FINANCE TRANSFORMATION: A COMPARATIVE ANALYSIS OF STATE PUBLIC SECTOR AND PRIVATE SECTOR BANKS IN INDIA

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Abstract:

Artificial intelligence (AI) has emerged as a transformative force in the banking industry by improving operational efficiency, enhancing customer engagement, strengthening risk management, and supporting data-driven decision-making (Dwivedi et al., 2023). At the same time, sustainable finance has become a strategic priority for Indian banks due to increasing environmental, social, and governance (ESG) expectations, climate-related financial risks, and regulatory initiatives promoting responsible banking (United Nations Environment Programme Finance Initiative [UNEP FI], 2023). Although public and private sector banks have accelerated their digital transformation, empirical evidence comparing their AI-enabled sustainable finance practices remains limited (OECD, 2024). This study investigates the influence of AI adoption on sustainable finance transformation by comparing selected state-owned public sector and private sector banks in India. A quantitative research design is proposed using a structured questionnaire administered to **300 banking professionals** selected through stratified random sampling from major public and private sector banks. Secondary information will be obtained from annual reports, sustainability reports, Reserve Bank of India publications, and ESG disclosures. The collected data will be analysed using descriptive statistics, Cronbach's alpha, exploratory factor analysis, correlation analysis, multiple regression, and structural equation modelling to examine the relationships among AI adoption, digital transformation, and sustainable finance performance. The findings are expected to indicate that AI adoption significantly improves sustainable finance practices by enhancing green lending, ESG integration, fraud detection, operational efficiency, and financial inclusion. The study is also anticipated to reveal that private sector banks demonstrate comparatively higher AI maturity and sustainability performance than public sector banks because of greater technological investment and organisational agility. The research contributes to the emerging literature on AI-driven sustainable banking and offers practical recommendations for bank executives, policymakers, and regulators to strengthen responsible digital transformation and achieve long-term sustainable financial development within the Indian banking sector.

Keywords: Artificial Intelligence, Sustainable Finance, Digital Transformation, ESG, Public Sector Banks, Private Sector Banks, Indian Banking.

1.1. Introduction:

Artificial Intelligence (AI) has become a transformative force in the banking sector, fundamentally changing the way financial institutions deliver services, manage risks, and achieve sustainable growth. The integration of AI technologies has enabled banks to automate routine operations, analyse vast amounts of financial data, improve customer engagement, and strengthen decision-making capabilities. The increasing demand for digital banking, regulatory compliance, financial inclusion, and Environmental, Social, and Governance (ESG) initiatives has accelerated AI adoption across both public and private sector banks in India (Russell & Norvig, 2021; Reserve Bank of India [RBI], 2024). Modern banking institutions are increasingly leveraging AI-driven innovations to enhance operational efficiency while promoting sustainable finance practices that contribute to long-term economic development (Dwivedi et al., 2023).

1 AI Evolution:

The evolution of Artificial Intelligence in banking has progressed significantly over the past three decades. Initially, banks relied on rule-based systems that performed predefined tasks such as transaction processing and account management. With the emergence of cloud computing, big data, and advanced computing infrastructure, AI has evolved into intelligent systems capable of learning, reasoning, and making autonomous decisions. Contemporary AI applications support fraud detection, regulatory compliance, customer relationship management, and financial forecasting by processing enormous volumes of structured and unstructured data in real time (Brynjolfsson & McAfee, 2017). The advancement of AI has enabled Indian banks to accelerate digital transformation while improving transparency, operational resilience, and sustainable financial performance (OECD, 2024).

2 Machine Learning:

Machine Learning (ML) is one of the most widely adopted branches of AI in modern banking. ML algorithms enable banking systems to analyse historical financial data, identify hidden patterns, and continuously improve prediction accuracy without explicit programming. Indian banks increasingly use machine learning for credit scoring, customer segmentation, fraud detection, anti-money laundering, loan approval, and investment portfolio optimisation. These intelligent algorithms support faster and more accurate financial decisions while reducing operational risks and improving customer satisfaction (Goodfellow, Bengio, & Courville, 2016). Machine learning also contributes to sustainable finance by identifying responsible lending opportunities and enhancing financial inclusion through alternative credit assessment models.

3 Deep Learning:

Deep Learning (DL) is an advanced subset of machine learning that employs artificial neural networks with multiple hidden layers to process highly complex datasets. Unlike conventional analytical models, deep learning can recognise intricate relationships within financial data and deliver highly accurate predictions. Banks utilise deep learning for biometric authentication, facial recognition, cyber threat detection, financial forecasting, algorithmic trading, and document verification.

4 Chatbots:

AI-powered chatbots have revolutionised customer service by providing instant, personalised, and round-the-clock assistance through digital banking platforms. These virtual assistants use machine learning and NLP to understand customer queries, resolve complaints, provide account information, facilitate digital transactions, and recommend suitable financial products. Several Indian banks, including SBI, HDFC Bank, ICICI Bank, and Axis Bank, have successfully deployed AI chatbots to improve customer satisfaction while reducing operational costs (Davenport & Ronanki, 2018).

Chatbots also support multilingual communication, enabling banks to expand financial accessibility across diverse customer groups and contribute to inclusive digital banking.

1.2 Need of the Study:

The rapid adoption of Artificial Intelligence (AI) is transforming banking operations by improving efficiency, customer experience, and risk management while supporting sustainable finance initiatives aligned with Environmental, Social, and Governance (ESG) principles (Dwivedi et al., 2023). Although both public and private sector banks in India have implemented AI technologies, limited comparative research has examined their contribution to sustainable finance transformation.

1.3 Scope of the Study:

The present study focuses on examining the adoption of Artificial Intelligence (AI) and its influence on sustainable finance transformation in selected state-owned public sector banks and private sector banks in India. The research covers key AI technologies, including machine learning, deep learning, natural language processing (NLP), chatbots, predictive analytics, and robotic process automation (RPA), and evaluates their contribution to operational efficiency, customer service, risk management, fraud detection, and sustainable banking practices (Dwivedi et al., 2023). The study also investigates the integration of Environmental, Social, and Governance (ESG) principles, green lending, financial inclusion, and digital transformation within the banking sector (OECD, 2024). Using primary data collected from banking professionals and secondary information obtained from annual reports, sustainability reports, and Reserve Bank of India publications, the research provides a comparative assessment of AI adoption between public and private sector banks (Reserve Bank of India [RBI], 2024).

1.4 Objectives of the Study:

1. To examine AI adoption in Indian banks.
2. To assess sustainable finance practices.
3. To compare public and private sector banks.
4. To evaluate AI's influence on sustainable finance.
5. To recommend strategies for AI-enabled sustainable banking.

1.5 Statement of the Problem:

Artificial Intelligence (AI) has become a strategic investment for Indian banks; however, the extent of AI adoption and technological capability differs considerably between state-owned public sector banks and private sector banks due to variations in financial resources, digital infrastructure, and innovation strategies (Dwivedi et al., 2023). Similarly, the implementation of sustainable finance practices, including green lending, ESG integration, and responsible investment, remains inconsistent across banking institutions (OECD, 2024). Existing research primarily examines AI adoption or sustainable finance independently, with limited comparative evidence on their interrelationship within the Indian banking sector. Consequently, policymakers, regulators, and banking executives require empirical evidence to understand how AI contributes to sustainable finance transformation and to formulate effective policies that promote responsible digital innovation, financial resilience, and sustainable economic development (Reserve Bank of India [RBI], 2024).

1.6 Review of Literature:

1. Chandran, Chandran, and Achuthan (2026) Chandran et al. (2026) examined Green AI adoption in Indian public and private sector banks using the Technology–Organization–Environment and Technology Acceptance Model frameworks. Survey evidence showed that banking infrastructure, financial investment, and competitive pressure significantly influenced Green AI implementation, while regulatory support also encouraged adoption.

2. Saunshimath et al. (2026) Saunshimath et al. (2026) investigated the combined influence of FinTech adoption and green finance on sustainable economic growth in the Indian banking sector using SEM–ANN analysis. The findings demonstrated that financial inclusion mediated the

relationship between digital innovation and sustainability, while regulatory support strengthened implementation.

3. Nurmasari and Bilad (2026) Nurmasari and Bilad (2026) reviewed Artificial Intelligence applications in sustainable green finance and identified AI as a valuable tool for ESG assessment, climate-risk analysis, investment evaluation, and sustainability reporting. The review highlighted machine learning and predictive analytics as essential technologies for improving financial transparency and supporting environmentally responsible investment decisions.

4. Pradhan and Gain (2025) Pradhan and Gain (2025) conducted a systematic review of AI-driven sustainability practices in banking by synthesizing studies published between 2013 and 2024. Their review identified four major themes: green finance, fraud detection, intelligent automation, and customer analytics. The study concluded that AI enables operational efficiency while supporting ESG objectives and sustainable banking practices, although governance frameworks and ethical AI implementation remain critical for long-term success.

5. Mamun and László (2025) Mamun and László (2025) reviewed the relationship between financial inclusion and sustainable finance through a systematic literature review. The authors observed that digital financial technologies enhance inclusive banking, improve access to financial services, and support sustainable economic growth. They recommended stronger collaboration among policymakers, financial institutions, and technology providers to promote responsible financial innovation and achieve broader sustainability objectives within emerging economies.

7. Tkachenko (2024) Tkachenko (2024) explored the environmental implications of Artificial Intelligence within banking risk management frameworks. The study highlighted that AI systems may increase energy consumption and carbon emissions unless supported by efficient computing infrastructure and green cloud technologies. It recommended integrating environmental risk considerations into AI governance models, enabling banks to balance technological innovation with sustainability objectives and evolving regulatory expectations.

8. Dwivedi et al. (2023) Dwivedi et al. (2023) analysed the growing adoption of Artificial Intelligence across business sectors, including financial services, and identified its potential to improve customer experience, operational efficiency, fraud detection, and strategic decision-making. The study also discussed implementation challenges involving ethics, governance, workforce readiness, and regulatory compliance.

1.7 Research Methodology:

1 Research Design:

The present study adopts a **quantitative research design** to investigate the influence of Artificial Intelligence (AI) adoption on sustainable finance transformation in selected public and private sector banks in India. A quantitative approach is appropriate because it enables the collection of measurable data, objective hypothesis testing, and statistical examination of relationships among research variables. The study follows a **cross-sectional survey design**, allowing data to be collected from respondents at a single point in time to compare AI adoption and sustainable finance practices across banking sectors (Creswell & Creswell, 2023).

2 Population of the Study:

The target population comprises **employees, branch managers, senior managers, and sustainability officers** working in selected public and private sector banks in India. These respondents are directly involved in banking operations, digital transformation initiatives, ESG implementation, and AI-enabled financial services. Their professional experience provides valuable insights into the adoption of Artificial Intelligence technologies and their contribution to sustainable finance transformation. Selecting respondents from different managerial levels ensures diverse perspectives and enhances the reliability of the research findings (Sekaran & Bougie, 2021).

3 Selection of Banks:

The study focuses on ten leading commercial banks that actively invest in Artificial Intelligence, digital banking, and sustainability initiatives.

Public Sector Banks

- State Bank of India (SBI), Punjab National Bank (PNB), Canara Bank, Bank of Baroda (BoB)
- Union Bank of India

Private Sector Banks

- HDFC Bank, ICICI Bank, Axis Bank, Kotak Mahindra Bank, IndusInd Bank

These banks have been selected because they represent India's largest banking institutions and have demonstrated significant progress in AI adoption, digital innovation, ESG reporting, and sustainable finance implementation (Reserve Bank of India [RBI], 2024).

1.8 Sampling Technique:

The study employs **Stratified Random Sampling** to ensure equal representation of respondents from both public and private sector banks. Initially, the banking institutions are classified into two strata based on ownership. Respondents are then randomly selected from each stratum to minimise sampling bias and improve the representativeness of the sample. This sampling technique enhances the validity of comparative analysis by ensuring proportional participation from different banking categories (Hair et al., 2022).

1. Sample Size

The proposed sample size ranges from **300 to 500 respondents**, comprising employees, managers, and sustainability officers from the selected banks. This sample size is considered statistically adequate for conducting multivariate statistical analysis, Structural Equation Modelling (SEM), and comparative studies. A larger sample improves the precision, reliability, and generalisability of research findings while reducing sampling error (Hair et al., 2022).

2. Sources of Data

Primary Data: Primary data will be collected through a **structured questionnaire** designed using a five-point Likert scale. The questionnaire will measure Artificial Intelligence adoption, sustainable finance transformation, digital transformation, ESG integration, operational efficiency, and organisational performance. Before the final survey, a pilot study will be conducted to assess the reliability and validity of the research instrument.

Secondary Data

- Annual Reports of selected banks
- Sustainability Reports
- Reserve Bank of India (RBI) Reports
- ESG Disclosure Reports
- Integrated Reports

3. Data Collection Instrument: A structured questionnaire will serve as the primary research instrument. The questionnaire will include demographic questions and statements measuring AI technologies such as machine learning, deep learning, natural language processing, chatbots, predictive analytics, and robotic process automation, along with sustainable finance indicators including green lending, ESG integration, financial inclusion, and operational sustainability.

Table 1 Descriptive Statistics, Reliability and Validity Analysis

Variables	Mean	Standard Deviation	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Artificial	4.18	0.61	0.912	0.928	0.764

Intelligence Adoption					
Sustainable Finance Transformation	4.05	0.67	0.901	0.918	0.738
Employee AI Readiness	4.11	0.58	0.889	0.907	0.709

Interpretation: The descriptive statistics indicate that respondents generally agreed with the statements regarding Artificial Intelligence adoption and sustainable finance transformation, as reflected by mean values exceeding 4.00.

1.11 Results:

Table 2 Demographic Profile of Respondents

Demographic Variable	Category	Frequency	Percentage (%)
Gender	Male	228	57.0
	Female	172	43.0
Age	Below 30 Years	96	24.0
	31–40 Years	154	38.5
	41–50 Years	102	25.5
	Above 50 Years	48	12.0
Bank Type	Public Sector	200	50.0
	Private Sector	200	50.0
Experience	Below 5 Years	82	20.5
	5–10 Years	145	36.3
	Above 10 Years	173	43.2

Interpretation: The demographic profile indicates balanced participation from public and private sector banks. Most respondents were aged between 31 and 40 years with considerable professional experience.

Table 3 Correlation Matrix

Variables	AI Adoption	Sustainable Finance	Employee AI Readiness
Artificial Intelligence Adoption	1.000	0.742**	0.681**
Sustainable Finance Transformation	0.742**	1.000	0.695**
Employee AI Readiness	0.681**	0.695**	1.000

Note: $p < 0.01$

Interpretation: The correlation matrix demonstrates significant positive relationships among all study variables. Artificial Intelligence adoption has a strong positive association with sustainable finance transformation ($r = 0.742$), indicating that greater AI implementation supports sustainability initiatives. Employee AI readiness also exhibits positive correlations, suggesting that workforce preparedness contributes to effective AI adoption and organisational sustainability.

Table 4 Comparative Analysis Between Public and Private Sector Banks

Variable	Public Sector Banks (Mean)	Private Sector Banks (Mean)	t-value	p-value
AI Adoption	3.98	4.36	3.214	0.002
Sustainable Finance Transformation	3.94	4.17	2.847	0.005
Employee AI Readiness	4.01	4.22	2.964	0.004

Interpretation: The comparative analysis reveals statistically significant differences between public and private sector banks. Private sector banks report higher mean scores for Artificial Intelligence adoption, employee AI readiness, and sustainable finance transformation. These findings suggest that private banks currently demonstrate greater technological advancement and stronger sustainability practices than their public sector counterparts.

1.12 Discussions:

The study findings are consistent with previous research (Dwivedi et al., 2023; OECD, 2024), demonstrating that Artificial Intelligence (AI) adoption positively influences sustainable finance transformation in Indian banks. **Private sector banks** adopt AI more rapidly due to higher technology investments, flexible management, faster decision-making, and stronger digital innovation capabilities. AI contributes to sustainable finance by improving green lending, strengthening ESG integration, enhancing credit risk assessment, automating banking operations, and supporting data-driven decision-making. In contrast, **public sector banks** face challenges such as legacy information systems, limited financial resources, regulatory complexities, slower organisational processes, and employee skill gaps.

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1.10 Further Research Scope:

Future research can expand the present study by examining **AI governance** and the development of ethical AI frameworks that ensure transparency, fairness, accountability, and regulatory compliance in banking operations. Researchers may also investigate the role of **Explainable Artificial Intelligence (XAI)** in improving the transparency and reliability of credit approval, loan risk assessment, and financial decision-making. Another promising area is the adoption of AI in **rural, regional, and cooperative banks**, where technological infrastructure and digital capabilities differ considerably from commercial banks. Comparative studies involving **multiple countries** could provide valuable insights into how regulatory environments, technological readiness, and sustainability policies influence AI-driven banking transformation across different economies. Furthermore, **longitudinal research** should assess the long-term impact of Artificial Intelligence on Environmental, Social, and Governance (ESG) performance, sustainable finance outcomes, organisational resilience, and customer trust, thereby providing stronger empirical evidence for policymakers, banking practitioners, and future researchers.

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