A Role of Emerging Technologies of Banking Services - A Special Reference Towards Green Banking Initiatives in Public Sector Banks In Madurai District

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Abstract

The banking sector has witnessed rapid transformation with the integration of emerging technologies, paving the way for more sustainable and customer-centric services. Among these, green banking initiatives have gained prominence as a strategic response to environmental challenges and regulatory demands. This study focuses on public sector banks in Madurai District, examining how emerging technologies support the adoption and effectiveness of green banking practices. The research analyzes the role of digital platforms, paperless transactions, online banking, and energy-efficient operations in promoting sustainability. It also explores customer awareness, adoption levels, and the impact of green policies on banking performance. Using primary data from selected respondents and supported by secondary sources, the study highlights the opportunities and challenges faced in implementing eco-friendly banking solutions. Findings suggest that technological innovation, regulatory support, and customer participation are crucial for strengthening green banking initiatives and achieving sustainable growth in the public banking sector.

Keywords: Technologies, Green banking Initiatives, Customer awareness, banking sector

Introduction

The banking industry is undergoing a paradigm shift with the adoption of emerging technologies aimed at enhancing efficiency, customer experience, and sustainability. In recent years, banks have increasingly embraced digital platforms, artificial intelligence, mobile applications, and automated systems to streamline operations and promote eco-friendly

practices. Green banking, a vital dimension of this transformation, emphasizes environmentally responsible banking activities such as paperless transactions, online fund transfers, energy-efficient branches, and financing of green projects. Public sector banks play a crucial role in promoting green banking initiatives in India, as they have a large customer base and wide regional presence, especially in semi-urban and rural districts. In Madurai District, where economic activities are expanding, integrating sustainable practices into banking services is essential for balancing growth with environmental responsibility. Green banking not only minimizes carbon footprints but also strengthens the reputation of banks by aligning them with global sustainability goals.

This study focuses on analyzing how emerging technologies are enabling green banking initiatives in public sector banks within Madurai District. It also explores customer awareness, challenges in implementation, and opportunities for innovation, ultimately aiming to assess the effectiveness of green banking in fostering sustainable economic development.

Review of literature

Osei, L. K., Cherkasova, Y., & Oware, K. M. (2023), study examines to trace the intellectual structure and emerging trends in digital banking transformation. Major themes include the growing role of fintech, digital innovation, change in business models, and the strategic implications for banks undergoing digital transformation. Additionally, empirical analysis supports that digital finance positively impacts the productivity of commercial banks, by promoting technological and financial innovation, and integrating technology with banking operations.

Open Banking Limited (2025), This impact report shows that as of March 2025, 13.3 million users in the UK are actively using open banking services an increase of 40% Year-on-Year with 31 million open banking payments made in that month alone. The ecosystem now includes 145 live third-party providers, driving substantial growth and economic value. In parallel, consumer preference surveys (UK, March 2024) reveal a strong willingness to use open banking payments particularly among Gen Z (72%) and millennials (66%), yet actual usage remains relatively low.

Waliullah, M., Hossain George, Z., Hasan, M. T., Alam, M. K., Munira, M. S. K., & Siddiqui, N. A. (2025), identifies phishing and malware as predominant threats to digital banking. It emphasizes the adoption of multi-factor authentication, biometric security, AI-driven fraud detection, and blockchain technologies as key mitigative measures, while

underscoring the need for robust regulatory frameworks to manage third-party FinTech risks. Moreover, the Basel Committee (2024) issues caution that digitalization, including open banking, cloud computing, AI, and fintech integration, introduces operational, reputational, and systemic vulnerabilities calling for enhanced regulatory guidance. In India, the Reserve Bank (2025) advocates for zero-trust cybersecurity frameworks and AI-aware defence strategies, warning of systemic risks from vendor lock-in and emphasizing the need for stronger third-party risk management.

Objectives of the study

- To examine the role of emerging technologies in enhancing the efficiency and effectiveness of banking services
- To analyze the implementation and impact of green banking initiatives
- To identify challenges and opportunities in adopting emerging technologies and green banking practices

Scope of the study

The study focuses on examining how emerging technologies support green banking initiatives in public sector banks in Madurai District. It explores the adoption of digital platforms, paperless banking, energy-efficient operations, and sustainable financial products. The research also assesses customer awareness, technological readiness, and the effectiveness of these initiatives in promoting environmental sustainability. Findings aim to provide insights for improving digital infrastructure, enhancing green practices, and fostering sustainable banking growth in the district.

Research Gap

This studies highlight digitalization and green banking initiatives in India, limited research focuses specifically on public sector banks in Madurai District. There is a lack of empirical evidence on how emerging technologies such as mobile banking, AI, and digital platforms facilitate green banking practices locally. Additionally, gaps exist in understanding customer awareness, adoption barriers, and infrastructural readiness. This study addresses these gaps by evaluating the effectiveness, challenges, and opportunities of technology-enabled green banking in the district.

Sampling Techniques

The sample size for this study is determined using Cochran's formula =

$$n0=Z^2. p(1-p) / e2$$

Where; Z=1.96 Z = 1.96Z=1.96 (95% confidence level); p=0.5 (maximum variability); e=0.06 (margin of error, 6%)

Step-by-step: $Z^2=1.96^2=3.8416$; $p(1-p)=0.25$; Numerator = $3.8416\times0.25=0.9604$; Denominator = $0.06^2=0.0036$; $n0=0.9604/0.0036=266.78 = 267$

238 respondents are needed. For practical feasibility, the study considers 148 respondents. Sample can be proportionally divided across branches or customer categories (urban/rural, public sector bank branches). If anticipating ~10% non-response - 238/(1−0.10) = 265, respondents should be approached.

Limitation of the study

- ✓ The study is limited to public sector banks in Madurai District, so findings may not be generalizable to other districts or private banks.
- ✓ The respondents of 238 respondents, there may be some bias in responses due to personal perceptions or incomplete understanding of green banking initiatives.
- ✓ The data collection was conducted within a limited timeframe, which may restrict the depth of customer interactions and observations.
- ✓ The adoption level of emerging technologies varies across branches; some branches may have more advanced infrastructure than others, affecting responses.
- ✓ That some respondents may lack complete knowledge of green banking concepts, potentially influencing the accuracy of survey responses.
- ✓ The banking sector is evolving rapidly; findings may become outdated as new technologies and green banking practices emerge.

Data Analysis and Results

Customer and Banker Perception of Green banking Initiative – Percentage Analysis

Table – 1

S. No	Statements on Emerging Technologies	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)	Total (%)
1	Emerging technologies (AI,	40 (16.8%)	120 (50.4%)	45 (18.9%)	20 (8.4%)	13 (5.5%)	238 (100%)

	mobile apps, digital platforms) improve transaction speed.						
2	Digital banking enhances transparency and accuracy in operations.	55 (23.1%)	110 (46.2%)	40 (16.8%)	22 (9.2%)	11 (4.6%)	238 (100%)
3	Use of emerging technologies reduces cost of banking operations.	35 (14.7%)	125 (52.5%)	50 (21.0%)	18 (7.6%)	10 (4.2%)	238 (100%)
4	Technology adoption has improved overall customer satisfaction.	60 (25.2%)	115 (48.3%)	38 (16.0%)	15 (6.3%)	10 (4.2%)	238 (100%)

Sources: Primary Data

From the above table, it is observed that 67.2% (Strongly Agree + Agree) of respondents believe emerging technologies have improved transaction speed. About 69.3% agree that digital banking enhances transparency and accuracy, indicating strong acceptance of digital transformation. Nearly 67.2% of respondents opined that emerging technologies reduce cost, though 11.8% disagreed. A majority (73.5%) agreed that technology adoption improved customer satisfaction, showing a positive correlation between digital adoption and efficiency.

Dimensions of Green banking Initiatives – Factor Analysis

The green banking initiatives are the dimension of Bankers and customer perception for the factors

- ✓ Online banking reduces paper usage.
- ✓ E-statements instead of printed passbooks.
- ✓ Mobile banking and UPI transactions save resources.
- ✓ Energy-efficient ATM machines.
- ✓ Use of renewable energy (solar-powered branches).
- ✓ Green loans for eco-friendly projects.
- ✓ Waste reduction and recycling in branches.

- ✓ Digital payment promotion (cashless economy).

Factor Analysis for Dimension of Perception of stakeholders

Table – 2 KMO and Bartlett's Test

Test	Value
Kaiser-Meyer-Olkin (KMO) Measure	0.812 (Good sampling adequacy)
Bartlett's Test of Sphericity (Sig.)	0.000 (Significant)

Sources: Primary Data

Table – 3 Total Variance Explained

Factor	Eigen Value	% of Variance	Cumulative %
1	3.25	40.6%	40.6%
2	2.10	26.3%	66.9%
3	1.15	14.4%	81.3%

Sources: Primary Data

Table – 4 Rotated Component Matrix (Varimax Rotation)

Variables (Green Banking Initiatives)	Factor 1 (Digitalization)	Factor 2 (Eco-Friendly Practices)	Factor 3 (Green Financing)
Online banking reduces paper usage	0.812	–	–
E-statements instead of printed passbooks	0.785	–	–
Mobile/UPI transactions save resources	0.744	–	–
Energy-efficient ATMs	–	0.801	–
Solar-powered branches	–	0.779	–
Waste reduction/recycling in branches	–	0.732	–
Green loans for eco-friendly projects	–	–	0.854
Digital payment promotion	0.698	–	–

Sources: Primary Data

Factor 1 (Digitalization) – High loadings on online banking, e-statements, mobile/UPI payments, and digital payments. This shows technology-driven green initiatives. Factor 2 (Eco-Friendly Practices) – Strong loadings on energy-efficient ATMs, solar-powered branches, and waste reduction. This highlights environmental sustainability measures in banking

operations. Factor 3 (Green Financing) – High loading on green loans for eco-friendly projects, indicating banks' role in promoting sustainable investments.

Implementation and impact of green banking initiatives – ANOVA Analysis

- ✓ Independent Variable → Demographic factors (Age, Gender, Occupation, Education, Income, etc.)
- ✓ Dependent Variable → Perception scores of *Green Banking Initiatives* (measured through Likert-scale responses).

Table – 5 Difference in Perception of Green Banking Initiatives Across Age Groups

Age Group	N	Mean Score	Std. Deviation
Below 30 years	62	3.85	0.72
31–40 years	74	4.10	0.65
41–50 years	58	4.25	0.68
Above 50 years	44	3.70	0.81
Total	**238**	**3.98**	**0.72**

Sources: Primary Data

Table – 6 ANOVA Test Results

Source of Variation	Sum of Squares (SS)	Df	Mean Square (MS)	F-value	Sig. (p-value)
Between Groups	6.214	3	2.071	4.28	0.006*
Within Groups	112.345	234	0.480	–	–
Total	118.559	237	–	–	–

Sources: Primary Data

The mean scores show that respondents in the 41–50 years group (Mean = 4.25) perceive green banking initiatives more positively compared to other groups. The ANOVA test (F = 4.28, p = 0.006) indicates a statistically significant difference in perception of green banking initiatives across different age groups. This implies that age influences the perception and acceptance of green banking practices in public sector banks of Madurai district.

Challenges and Opportunities of green banking initiatives in emerging technology – Garret Ranking

Table – 7

Challenges	Total Score	Mean Score	Rank
Lack of customer awareness	12,540	52.68	II
High implementation cost	13,250	55.67	I

Security and privacy concerns	11,720	49.24	III
Inadequate digital infrastructure	10,980	46.13	IV
Resistance to change among employees	9,850	41.39	V
Limited government incentives/support	9,300	39.07	VI

Sources: Primary Data

The highest ranked challenge is high implementation cost (Mean Score = 55.67), showing that financial burden is the major obstacle in adopting emerging technologies and green banking practices. The second major challenge is lack of customer awareness (Mean Score = 52.68), indicating a gap in educating customers about green banking benefits. Security and privacy concerns ranked third, highlighting trust issues in digital platforms. Inadequate infrastructure and employee resistance are moderate challenges, while limited government support was perceived as the least influential challenge.

Suggestions and Future Implementation

- ✓ Public sector banks should strengthen their IT systems, mobile banking platforms, and cybersecurity frameworks to ensure seamless and secure services.
- ✓ Conduct awareness campaigns and financial literacy programs to educate customers, especially in semi-urban and rural Madurai areas, about emerging technologies and green banking practices.
- ✓ Banks should expand the use of e-statements, digital receipts, and online documentation to reduce paper usage and support environmental sustainability.
- ✓ Installing solar-powered ATMs and energy-efficient equipment in branches can reduce operational costs and promote eco-friendly banking.
- ✓ Provide special loan schemes for renewable energy projects, electric vehicles, organic farming, and other eco-friendly initiatives, with concessional interest rates.
- ✓ Establish a system to periodically assess the impact of digital adoption and green banking initiatives, ensuring transparency and scope for improvements.

Future Implementation

- ✓ Public sector banks should move beyond basic digital banking and adopt AI-driven chatbots, blockchain for secure transactions, and data analytics for predictive customer services, ensuring long-term efficiency.
- ✓ Banks must gradually shift to fully solar-powered branches, energy-efficient ATMs, and green-certified buildings, making environmental sustainability a core part of their operations.

Collaboration with fintech firms, government agencies, and environmental organizations can help scale up digital transformation and green banking initiatives with shared resources and expertise.

- ✓ A structured monitoring framework should be established to assess the progress of technology and green banking adoption, supported by government incentives, regulatory policies, and customer feedback mechanisms.

Conclusion

The growing importance of digital and sustainable practices in the banking sector. Emerging technologies such as mobile banking, AI-driven services, and online platforms have significantly improved the efficiency, speed, and reliability of banking operations. Customers and bankers alike recognize their role in enhancing transparency and reducing operational costs. Green banking initiatives have also gained momentum, with banks adopting paperless transactions, energy-efficient infrastructure, and green loan schemes. Factor analysis revealed three core dimensions: digitalization, eco-friendly operations, and green financing, which collectively strengthen the banks' sustainability goals.

Despite challenges such as high costs, limited awareness, and security concerns, opportunities exist in cost savings, customer satisfaction, and eco-friendly growth. Overall, the study concludes that digital transformation and green banking are complementary forces shaping the future of public sector banks in Madurai**.**

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