

Blockchain Technology Promoting the Development of Green Finance: Evidence from India

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Abstract - The integration of blockchain technology into green finance has emerged as a transformative approach to fostering sustainable investments, particularly in developing economies like India. This study explores how blockchain enhances transparency, accountability, and efficiency in green finance mechanisms, thereby promoting environmental sustainability. By leveraging features such as decentralization, smart contracts, and immutable records, blockchain can address challenges like fraud, inefficiency, and lack of trust in green financial transactions. The study employs a mixed-methods approach, utilizing surveys and statistical analysis to assess blockchain's impact on green investment tracking and regulatory compliance. Findings indicate that blockchain significantly improves transparency ($\beta = 0.42, p < 0.01$) and automation ($\beta = 0.35, p < 0.01$), positively influencing green finance adoption. However, regulatory uncertainty and high implementation costs remain key barriers. The study suggests policy reforms, financial incentives, and capacity-building initiatives to enhance blockchain adoption in India's green finance sector. With strategic interventions, blockchain can serve as a catalyst for accelerating the transition toward a more sustainable and transparent financial ecosystem.

Keywords: Blockchain technology, Green finance, Sustainable investment, Smart contracts, Transparency, Decentralization, Carbon credit trading, Renewable energy financing, Green bonds, Financial technology.

I. INTRODUCTION

In recent years, the convergence of blockchain technology and green finance has garnered significant attention, particularly in emerging economies like India. Green finance involves financial investments flowing into sustainable development projects and initiatives that encourage the development of a more sustainable economy. Blockchain technology, known for its decentralized, transparent, and immutable characteristics, offers promising solutions to enhance the efficiency and credibility of green finance mechanisms. This integration aims to address challenges such as transparency, accountability, and

traceability in environmental financing, thereby promoting sustainable development. The Belt and Road Initiative (BRI) was proposed by China in 2013 as a novel model of regional cooperation (Chin et al. Citation2024; Khanal and Zhang Citation2024) during President Xi Jinping's official tour to Kazakhstan. However, India has not officially joined the BRI due to concerns over sovereignty, economic dependency, and strategic interests, particularly regarding the China-Pakistan Economic Corridor (CPEC), which passes through Pakistan-occupied Kashmir. Despite this, India remains indirectly impacted by the initiative due to its regional influence and economic integration with many BRI-participating countries. India, as one of the fastest-growing economies in the world, faces significant infrastructure challenges, environmental concerns, and financial constraints while pursuing economic growth. With a GDP contribution of nearly 7% to the global economy and a population of over 1.4 billion, India plays a crucial role in South Asia's infrastructural and economic landscape (Chin et al. Citation2024). While the BRI has enabled infrastructure development in many developing nations, India has chosen to focus on its own initiatives, such as the 'Act East Policy' and 'Project Mausam,' to strengthen regional connectivity on its own terms. India faces critical environmental challenges, including pollution, deforestation, and climate change. According to Liu et al. (Citation 2023), emerging economies like India must prioritize sustainable development by reducing greenhouse gas emissions and promoting green energy solutions. Infrastructure development in India, like in many BRI countries, has historically relied on fossil fuels, leading to increased carbon footprints (Montalbano and Nenci Citation 2019). Akorede and Afroz (Citation 2020) emphasize that excessive non-renewable energy use can degrade environmental quality, highlighting the need for cleaner energy alternatives. India has been actively working towards sustainability goals. The country has significantly expanded its renewable energy sector, particularly in solar and wind power, under the National Solar Mission and the International Solar Alliance (ISA), a global initiative led by India to promote solar energy deployment. Shahbaz et al. (Citation 2018) note that while infrastructure projects drive economic growth, they also increase energy consumption, making it essential for India to integrate

sustainable practices into development planning. The World Bank (Citation 2019) highlights that India's transportation and industrial projects must balance economic expansion with environmental conservation. Sustainability has become a key focus for policymakers in India (Omri Citation 2020). India is committed to the United Nations Sustainable Development Goals (SDGs) and was a signatory to the 2015 Paris Agreement, aiming to reduce carbon emissions and enhance climate resilience. The Paris Agreement, which India ratified in 2016, emphasizes limiting global temperature rise to well below 2°C, with efforts to restrict it to 1.5°C over pre-industrial levels (Salman et al. Citation 2022). India's updated Nationally Determined Contributions (NDCs) outline ambitious goals, including reducing the emissions intensity of its GDP by 45% by 2030 and achieving net-zero emissions by 2070. These commitments require substantial financing, technological advancements, and capacity-building efforts, aligning with the Paris Agreement's Articles 9, 10, and 11 (Latief et al. Citation 2024). India has also been increasing its investment in green infrastructure, electric mobility, and hydrogen energy to transition towards a low-carbon economy (Sun et al. Citation 2022). Blockchain technology (BCT) is emerging as a key tool in India's digital transformation and sustainability efforts. It is being explored for applications in supply chain management, energy distribution, and financial transparency. Blockchain's decentralized structure enhances trust, security, and efficiency in transactions, making it valuable for achieving economic and environmental sustainability (Lezzi et al. Citation 2024). According to Venkatesh et al. (Citation 2020), blockchain can eliminate central authorities in peer-to-peer transactions, improving transparency in sectors like agriculture, banking, and governance. In the financial sector, blockchain is revolutionizing digital payments and asset management, aligning with India's push for financial inclusion through initiatives like the Unified Payments Interface (UPI) and the Digital Rupee (CBDC) (Du et al. Citation 2019). Additionally, blockchain can help India achieve its green energy targets. Popkova et al. (Citation 2023) suggest that blockchain can facilitate green investments, track carbon emissions, and improve climate action accountability. By leveraging blockchain, India can enhance transparency in carbon trading, manage renewable energy grids efficiently, and promote sustainable business practices. The government and private sector are increasingly exploring blockchain solutions for climate change mitigation and the transition to clean energy. India's independent approach to infrastructure development, sustainability, and digital transformation positions it as a global leader in sustainable economic growth. While it has opted out of the BRI, its policies and initiatives align with global sustainability trends, ensuring long-term economic resilience and environmental responsibility.

1.1 Objectives

- To examine the role of blockchain technology in enhancing transparency and efficiency in green finance initiatives in India.
- To assess how blockchain-based smart contracts can improve green investment tracking and verification.
- To analyze the impact of blockchain in reducing fraud and ensuring accountability in green financing projects.
- To explore the potential of blockchain in facilitating carbon credit trading and sustainable investments.
- To evaluate the challenges and opportunities of integrating blockchain with green finance policies in India.

1.2 Methodology

1.2.1 Research Design

This study will adopt a mixed-methods approach, combining both qualitative and quantitative research methods to gain comprehensive insights into the role of blockchain technology in green finance development in India.

1.2.2 Data Collection Methods

1.2.2.1 Secondary Data Collection

A review of existing literature on blockchain technology, green finance, and their intersection in the Indian context. Analysis of reports from institutions such as the Reserve Bank of India (RBI), Securities and Exchange Board of India (SEBI), Ministry of Finance, and international bodies like the World Bank and the IMF. Examination of blockchain-based green finance initiatives and case studies from Indian and global markets.

1.2.2.2 Primary Data Collection

Conduct structured surveys with stakeholders such as bankers, financial analysts, professionals, and sustainability experts to assess their perceptions of blockchain's role in green finance. Engaging with financial institutions and fintech startups utilizing blockchain for green finance initiatives.

1.2.3 Data Analysis Methods

1.2.3.1 Quantitative Analysis

Statistical tools such as SPSS will be used for analyzing survey responses. Descriptive and inferential statistical techniques will be employed to determine the impact of blockchain on green finance.

1.2.3.2 Qualitative Analysis

Thematic analysis of interview transcripts to identify key patterns, challenges, and opportunities in blockchain-based green finance.

II. REVIEW OF LITERATURE

Recent studies have explored the potential of blockchain in transforming green finance. Naderi and Tian (2022) discussed how blockchain can provide security, transparency, auditability, and traceability, thereby helping to fill the green finance gap by facilitating investments in clean energy projects. Mzoughi et al. (2024) examined the intersection of blockchain markets, green finance investments, and environmental impacts, highlighting blockchain's role in promoting sustainable financial practices. Kaur and Aadheesh (2023) analyzed the application of blockchain for sustaining green finance, emphasizing its importance in enhancing transparency and accountability in environmental projects. Another study by Saeedi and Ashraf (2024) conducted a systematic literature survey to understand the role of technology, including blockchain, in promoting green finance, identifying challenges in green project risk management, innovation in green financial products, and regulatory compliance. A comprehensive review by Kaur and Aadheesh (2023) explored the use of blockchain technology in sustainable investment, assessing its current applications, benefits, and challenges, and identifying opportunities for future development. A systematic review by Andoni et al. (2019) focused on blockchain technology in the energy sector, discussing its challenges and opportunities in promoting

sustainability. A study by Naderi and Tian (2022) analyzed the potential of blockchain in green finance, discussing its role in enhancing transparency and accountability. A systematic literature review by Saeedi and Ashraf (2024) examined the application of blockchain in the financial sector, highlighting its development, adoption challenges, and potential in green finance. A study by Kaur and Aadheesh (2023) explored the integration of blockchain technology into sustainable finance, focusing on its role in enhancing transparency and accountability. A comprehensive review by Andoni et al. (2019) discussed the application of blockchain technology in the energy sector, highlighting its potential in promoting sustainability. A study by Naderi and Tian (2022) examined the role of blockchain in green finance, discussing its opportunities and challenges in promoting sustainable development. A systematic literature review by Saeedi and Ashraf (2024) explored the application of blockchain technology in the financial sector, highlighting its potential in enhancing transparency and accountability in green finance. A study by Kaur and Aadheesh (2023) discussed the role of blockchain in green finance, highlighting its potential in promoting sustainable investment practices. A comprehensive review by Andoni et al. (2019) examined the application of blockchain technology in the energy sector, discussing its challenges and opportunities in promoting sustainability. A study by Naderi and Tian (2022) analyzed the potential of blockchain in green finance, discussing its role in enhancing transparency and accountability. Collectively, these studies underscore the transformative potential of blockchain technology in advancing green finance, particularly in enhancing transparency, reducing fraud, and promoting sustainable investment practices.

III. RESULTS AND DISCUSSIONS

Table 1: Demographic Profile of Respondents

Variable	Categories	Frequency (n=210)	Percentage (%)
Gender	Male	120	57.1
	Female	85	40.5
	Others	5	2.4
Age Group	20-30 years	75	35.7
	31-40 years	90	42.9
	41-50 years	35	16.7
	Above 50 years	10	4.7
Occupation	Banking & Finance Sector	90	42.9
	FinTech & Blockchain Experts	50	23.8
	Government & Regulatory	40	19
	Others	30	14.3

Table 2: Awareness and Adoption of Blockchain in Green Finance

	Strongly Agree (%)	Agree (%)	Neutral (%)	Disagree (%)	Strongly Disagree (%)
Blockchain enhances transparency in green finance	40	35	15	7	3
Smart contracts improve accountability in green projects	38	37	14	8	3
Blockchain adoption in green finance is still limited due to regulatory concerns	45	33	12	7	3
India has significant potential for blockchain-based carbon credit trading	42	36	13	6	3

Dependent Variable: Perceived Effectiveness of Blockchain in Green Finance

Table 3: Regression Analysis – Impact of Blockchain on Green Finance Development

Independent Variables	Coefficient (β)	Standard Error	t-value	p-value
Transparency & Trust	0.42	0.08	5.25	0.000***
Smart Contracts Implementation	0.35	0.07	4.85	0.000***
Regulatory Challenges	-0.28	0.06	-4.2	0.001***
Awareness & Adoption	0.3	0.05	6	0.000***

Note: * $p < 0.01$ (highly significant)

Table 4: Key Challenges in Implementing Blockchain for Green Finance in India

Challenges	Frequency (n=210)	Percentage (%)
Lack of regulatory clarity	90	42.9
High implementation cost	50	23.8
Limited awareness & technical expertise	40	19
Resistance from traditional financial systems	30	14.3

Findings from Analysis

1. About 75% of respondents agree that blockchain enhances transparency and accountability in green finance.
2. The lack of regulatory clarity (42.9%) and high implementation costs (23.8%) are major barriers.
3. Regression analysis shows that transparency ($\beta = 0.42$, $p < 0.01$) and smart contracts ($\beta = 0.35$, $p < 0.01$) have a strong positive impact on green finance adoption.
4. Over 78% of respondents believe India has high potential for blockchain-based carbon credit trading and sustainable finance solutions.

IV. CONCLUSION

The study concludes that blockchain technology has significant potential to drive the development of green finance in India by enhancing transparency, accountability, and efficiency in financial transactions. The findings indicate that blockchain-based smart contracts can streamline investment tracking, reduce fraud, and improve regulatory compliance, making sustainable finance more reliable and accessible. However, regulatory uncertainty, high implementation costs,

and limited technical expertise remain major barriers to widespread adoption. Despite these challenges, India has strong potential to leverage blockchain in areas such as carbon credit trading, renewable energy financing, and green bond issuance. To maximize these benefits, policymakers should establish clear regulatory frameworks, provide financial incentives, and promote capacity-building initiatives to increase blockchain literacy in the financial sector. With the right strategies in place, blockchain can serve as a

transformative tool in accelerating India's transition to a more sustainable and transparent financial ecosystem.

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