Advancing Carbon Market Governance in India: Opportunities, Challenges, and Policy Pathways under the Carbon Credit Trading Scheme (CCTS)

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Abstract

India is at a crucial stage in transitioning to a low-carbon economy with the launch of the Carbon Credit Trading Scheme (CCTS) under the Energy Conservation (Amendment) Act, 2022—the country's first comprehensive framework for carbon pricing and emission trading. This study examines the evolution, structure, and performance potential of India's carbon credit market using secondary data and policy analysis. Valued at USD 4.01 billion in 2023 and projected to surpass USD 49 billion by 2030, the market could drive green investment**,** renewable energy adoption, and revenue generation through carbon farming, afforestation, and industrial efficiency. The CCTS is poised to support India's Paris Agreement and 2070 net-zero goals. However, challenges such as fragmented institutions, weak enforcement, limited MRV (Measurement, Reporting, and Verification) capacity, and low demand may hinder progress. Strengthening policy coherence, digital MRV systems, and MSME capacity is vital. With transparent governance and global alignment under Article 6**,** India can emerge as a regional carbon-market leader**.**

Keywords

Carbon Market Governance, Carbon Credit Trading Scheme (CCTS), Green Finance, MRV, Net Zero 2070

Introduction

India's effort to develop a regulated carbon pricing mechanism, spearheaded by the *Carbon Credit Trading Scheme (CCTS)* and supported by the *Energy Conservation (Amendment) Act,*

2022, marks a pivotal transformation in the nation's climate policy framework. The CCTS represents a structured transition from voluntary offset programs toward a compliance-based carbon market that integrates both flexibility and accountability in emission reduction (Bureau of Energy Efficiency [BEE], 2024). This initiative reflects India's broader strategy to align its domestic climate policy with international best practices while maintaining the balance between economic growth and decarbonization goals.

As global markets evolve and instruments such as the European Union's Carbon Border Adjustment Mechanism (CBAM) begin to impose external competitive pressures, India is strategically reforming its regulatory landscape to safeguard export competitiveness and attract climate-aligned investments (Press Information Bureau [PIB], 2024). The government's emphasis on emissions intensity—rather than absolute emission caps—demonstrates a pragmatic and adaptable approach suited to a developing economy that continues to prioritize energy security and growth alongside environmental sustainability (International Carbon Action Partnership [ICAP], 2024).

The rate-based nature of India's emerging Emissions Trading System (ETS) offers a progressive pathway for integrating market mechanisms into national decarbonization efforts. By encouraging industries to lower their emissions per unit of output, it allows flexibility for expansion while incentivizing innovation and efficiency (Council on Energy, Environment and Water [CEEW], 2023). This design aligns with the nation's commitment to achieving its Nationally Determined Contributions (NDCs) under the Paris Agreement and the long-term objective of net-zero emissions by 2070 (S&P Global Commodity Insights, 2024).

With strong institutional backing, the establishment of robust verification mechanisms, and growing private-sector participation, India is well positioned to emerge as a regional leader in carbon credit markets. If effectively implemented, the CCTS could become a cornerstone of India's green transition—facilitating low-carbon investments, advancing technological innovation, and strengthening India's role in global climate governance (Ecosystem Marketplace, 2024). However, this success will depend on transparent governance, credible MRV systems, market liquidity, and integration with global standards.

Types of Markets

The global carbon market is broadly divided into two categories: the voluntary carbon market (VCM) and the compliance carbon market (CCM). Both markets operate on the principle of trading *carbon credits*, where one credit is equivalent to one metric tonne of carbon dioxide (CO_2) either reduced or removed from the atmosphere (Ecosystem Marketplace, 2024).

Companies and organizations can acquire two primary types of offset credits — removal credits and avoidance credits. Removal credits originate from activities that extract or sequester CO_2 from the atmosphere, such as afforestation, soil carbon enhancement, and direct air capture. Avoidance credits, in contrast, are generated by projects that prevent emissions that would otherwise occur, such as renewable energy deployment, energy efficiency improvements, or methane capture from waste management (Verra, 2023). Before these credits can be traded, projects undergo third-party verification by standard-setting bodies like *Verra*, *Gold Standard*, and *Climate Action Reserve*, which assess project integrity, monitor emission reductions, and validate data using MRV (Monitoring, Reporting, and Verification) protocols (Gold Standard, 2023).

Voluntary Carbon Market (VCM)

The voluntary carbon market is characterized by the absence of legal compulsion. Participants engage in carbon credit transactions voluntarily to demonstrate environmental responsibility, achieve corporate sustainability goals, or align with net-zero pledges (Council on Energy, Environment and Water [CEEW], 2023). Companies such as Google, Microsoft, and Apple have been prominent buyers in the VCM, purchasing credits to offset residual emissions and enhance their green credentials (Ecosystem Marketplace, 2024).

The VCM originated in the 1990s, gained momentum in the 2000s, and expanded rapidly in both transaction volume and diversity of credit types (World Bank, 2023). However, the 2008–2009 global financial crisis led to a temporary decline in credit issuance and trading volumes. From 2018 onward, renewed corporate climate commitments revitalized the market, and between 2020 and 2021, the global VCM expanded fourfold, reaching an estimated valuation of USD 2 billion (Ecosystem Marketplace, 2024). Despite this growth, the market's momentum moderated in 2022 and 2023 due to macroeconomic disruptions such as the Russia–Ukraine conflict, volatile energy prices, and global inflationary pressures (International Carbon Action Partnership [ICAP], 2024). Regulatory uncertainty surrounding both voluntary and compliance carbon markets also contributed to slower expansion.

Nevertheless, analysts project continued long-term growth, estimating the VCM's value to reach between USD 10 billion and USD 40 billion by 2030, driven by corporate climate commitments and stricter ESG disclosure requirements (Grand View Research, 2024). In India, the VCM has shown increasing participation from renewable energy, agriculture, and forestry projects, reflecting growing investor interest and emerging opportunities for co-benefits such as rural income and biodiversity conservation (CEEW, 2023).

Compliance Carbon Market (CCM)

In contrast, the compliance market functions under legally binding emission reduction obligations, where entities are mandated by law or regulation to limit their greenhouse gas (GHG) emissions (International Carbon Action Partnership, 2024). Compliance markets typically operate through a *cap-and-trade* or *baseline-and-credit* mechanism. Under a cap-and-trade system, regulatory authorities establish a maximum permissible emission limit (the "cap") for specific sectors or entities. Companies that emit below their allocated limit can sell excess allowances, while those exceeding their cap must purchase additional allowances or credits from others (Press Information Bureau [PIB], 2024).

For example, if a steel company's emissions per tonne of steel fall below the benchmark set by regulators, it earns tradable carbon credits. Conversely, companies emitting above the allowable limit are obligated to purchase credits to comply with regulatory standards. Such mechanisms create financial incentives for companies to invest in emission-reducing technologies and energy-efficient operations (Bureau of Energy Efficiency [BEE], 2024). The *allowance market*—a subset of the compliance system—facilitates these transactions, often through centralized exchanges or government-accredited platforms.

India's planned *Carbon Credit Trading Scheme (CCTS)*, under the *Energy Conservation Act*, 2022, exemplifies the compliance market model tailored to national conditions. The CCTS uses a rate-based Emission Trading System (ETS), wherein credits are issued based on emission intensity improvements rather than absolute reductions. This framework provides flexibility for developing economies, balancing industrial growth with decarbonization efforts (ICAP, 2024). Globally, the European Union Emissions Trading System (EU ETS), California's Cap-and-Trade Program, and China's National ETS serve as key reference points for the design of India's evolving compliance carbon market (World Bank, 2023).

Literature Review

Carbon credit trading in India holds immense potential to balance economic growth and environmental sustainability. With India's commitment to the *Paris Agreement* (2015) and its pledge to achieve net-zero emissions by 2070, carbon markets have emerged as an essential policy instrument to align industrial development with climate goals (Manjunatha & Ravi Kumar, 2023). Carbon trading provides a market-based mechanism to incentivize emission reductions across key sectors by assigning a monetary value to carbon mitigation activities. The establishment of transparent Monitoring, Reporting, and Verification (MRV) systems and integration with global carbon trading frameworks can enhance the credibility and liquidity of

India's carbon market, while also facilitating international investment in clean energy and green technologies (World Bank, 2023).

Empirical studies highlight that a robust domestic carbon credit platform could significantly increase India's participation in global climate finance flows and attract foreign direct investment into renewable energy, waste management, and forestry projects (Council on Energy, Environment and Water [CEEW], 2023). Manjunatha and Ravi Kumar (2023) further emphasize that India can strengthen its position as a regional carbon trading hub by fostering inter-sectoral linkages and ensuring transparent verification mechanisms.

Moreover, India's extensive agricultural base and soil carbon potential offer promising opportunities for *carbon farming credits*. According to Zirkande and Tawade (2023), emission reductions from agricultural and land-use practices could reach approximately three metric tons of CO_2 per acre, and if scaled nationally, could generate a market value exceeding USD 5 billion. The growing focus on carbon farming and agroforestry can therefore contribute both to rural income diversification and to national carbon sequestration targets. The literature converges on the idea that an effective carbon credit system can serve as a dual driver of sustainable development—encouraging low-carbon investments while enabling inclusive economic participation. However, successful implementation will depend on institutional coherence, pricing stability, and alignment with global carbon standards (International Carbon Action Partnership [ICAP], 2024; Ecosystem Marketplace, 2024).

Current Status of the Carbon Credit Market in India

India is currently transitioning from a fragmented voluntary carbon offset framework to a regulated and structured national carbon credit market. The government's flagship initiative—the *Carbon Credit Trading Scheme (CCTS)*—was officially notified in June 2023 and subsequently revised in December 2023 under the *Energy Conservation (Amendment) Act, 2022* (Bureau of Energy Efficiency [BEE], 2024). The scheme introduces two complementary mechanisms: a compliance mechanism, applicable to regulated and obligated entities, and an offset mechanism, designed for voluntary participation and credit generation.

Under the CCTS framework, the Bureau of Energy Efficiency (BEE) serves as the administrative authority responsible for issuing carbon credit certificates and accrediting verification agencies. The Central Electricity Regulatory Commission (CERC) regulates the trading component, while the Grid Controller of India Limited (GRID-INDIA) maintains a *meta-registry* that records all participating entities, verified credits, and trading transactions. In addition, a National Steering Committee for the Indian Carbon Market (NSCICM)—

comprising secretaries from relevant ministries, joint secretaries, and domain experts—oversees policy coordination and implementation (ICAP, 2024).

The regulatory architecture of the CCTS is still evolving. Guidelines for accrediting verification agencies and eligibility criteria for project registration have been issued, though methodologies for the offset mechanism are in the final stages of development (Press Information Bureau [PIB], 2024). Full-scale trading under the compliance mechanism is expected to commence in FY 2026–27, with preliminary carbon reduction obligations starting in select sectors as early as 2025–26 (S&P Global Commodity Insights, 2024).

The compliance mechanism will initially target nine energy-intensive sectors: aluminum, cement, chlor-alkali, fertilizer, iron and steel, petrochemicals, petroleum refineries, pulp and paper, and textiles (BEE, 2024). Meanwhile, the offset mechanism expands coverage to a wide array of activities including renewable energy, industrial processes, agriculture, waste management, forestry, transportation, construction, and carbon capture, utilization, and storage (CCUS) (ICAP, 2024).

In terms of market valuation, India's carbon credit market was estimated at USD 4.01 billion in 2023 and is projected to grow at a compound annual growth rate (CAGR) of 43.2% from 2024 to 2030, potentially reaching USD 49.4 billion by 2030 (Grand View Research, 2024). Within this, the voluntary carbon credit segment—valued at approximately USD 122.7 million in 2023—is expected to expand nearly tenfold to USD 1.16 billion by 2030 (Ecosystem Marketplace, 2024). Market analysts forecast initial carbon credit prices under the compliance mechanism to hover around USD 10 per tonne of CO_2 equivalent (tCO_2e), with gradual adjustments based on demand and regulatory benchmarks (S&P Global Commodity Insights, 2024).

To safeguard investor confidence and ensure market stability, the government is reportedly considering the establishment of a carbon price stabilization fund, which would set floor and ceiling prices for credits to prevent excessive volatility (World Bank, 2023). Furthermore, in 2025, the Ministry of Power approved eight new methodologies for voluntary carbon crediting, including frameworks for renewable energy, green hydrogen, and industrial energy efficiency (PIB, 2024).

Parallel to the CCTS, India has also introduced the Green Credit Programme Implementation Rules, 2023, under the *Environment (Protection) Act*. While conceptually similar to carbon credits, green credits encompass a broader range of environmental activities beyond greenhouse gas reduction. The programme currently recognizes eight categories: tree

plantation, water conservation, sustainable agriculture, waste management, mangrove restoration, air pollution reduction, eco-labeling for goods, and sustainable construction and services (Ministry of Environment, Forest and Climate Change [MoEFCC], 2023). Unlike the CCTS, the Green Credit Programme is purely voluntary, designed to promote environmental stewardship among individuals, corporations, and institutions without regulatory compulsion.

Collectively, these developments reflect India's determination to position itself as a key participant in global carbon markets. The dual emphasis on compliance and voluntary mechanisms demonstrates an adaptive approach—combining regulatory discipline with innovation—to mobilize climate finance, drive decarbonization, and align domestic policy instruments with international sustainability goals.

Objectives and Hypotheses of the Study

Objectives of the Study

Based on the reviewed literature and current policy developments, the present study aims to investigate the evolution, structure, and prospects of India's carbon credit market, focusing on its regulatory, economic, and environmental dimensions. The specific objectives are as follows:

1. To analyze the existing regulatory and institutional framework governing carbon credit trading in India under the *Carbon Credit Trading Scheme (CCTS)* and related mechanisms. *Rationale:* Literature by the Bureau of Energy Efficiency (2024) and ICAP (2024) emphasizes that the CCTS represents a major policy innovation, but its success depends on the coherence of administrative institutions and integration with pre-existing schemes such as PAT and RECs.
2. To assess the effectiveness and potential of carbon credit trading as a market-based tool for promoting emission reduction and attracting green investment. *Rationale:* Prior research (Manjunatha & Ravi Kumar, 2023; CEEW, 2023) indicates that an efficient carbon market can encourage private-sector participation and enhance transparency in climate finance flows.
3. To evaluate the challenges and barriers—technical, institutional, and economic—that hinder the full operationalization of carbon credit trading in India. *Rationale:* Studies by Ecosystem Marketplace (2024) and the World Bank (2023) reveal that data quality, MRV capacity, and price volatility remain major obstacles to market maturity and credibility.
4. To examine the role of voluntary and compliance markets in fostering inclusive participation, particularly among MSMEs, agriculture, and rural communities. *Rationale:* Zirkande and Tawade (2023) highlight India's agricultural and forestry sectors as

untapped opportunities for carbon farming, yet entry barriers persist due to low awareness and technical limitations.

5. To propose policy recommendations for strengthening India's carbon market through improved governance, digital infrastructure, and alignment with global carbon pricing mechanisms. *Rationale:* The literature (BEE, 2024; Press Information Bureau, 2024) underscores that India's success in carbon trading will hinge on institutional transparency, MRV standardization, and market stability.

Hypotheses of the Study

Based on the review of literature and theoretical framework, the following hypotheses are formulated to guide empirical analysis and policy evaluation:

- H_1: There is a significant positive relationship between the strength of India's regulatory framework (under the CCTS) and the growth potential of its carbon credit market. *(Supported by BEE, 2024; ICAP, 2024; World Bank, 2023.)*
- H_2: Effective implementation of MRV systems and data transparency significantly enhances investor confidence and participation in carbon credit trading. *(Supported by Ecosystem Marketplace, 2024; CEEW, 2023.)*
- H_3: The integration of voluntary and compliance markets contributes to higher market liquidity and a more inclusive carbon trading ecosystem. *(Supported by Manjunatha & Ravi Kumar, 2023; Zirkande & Tawade, 2023.)*
- H_4: Market instability, price volatility, and institutional fragmentation have a statistically negative impact on long-term investment and the environmental integrity of carbon credits. *(Supported by World Bank, 2023; S&P Global Commodity Insights, 2024.)*
- H_5: Policy coherence and international linkage (alignment with global carbon pricing and Article 6 mechanisms) significantly enhance the competitiveness and sustainability of India's carbon market. *(Supported by ICAP, 2024; Press Information Bureau, 2024.)*

The literature reviewed provides strong conceptual justification for the above objectives and hypotheses. Manjunatha and Ravi Kumar (2023) and the CEEW (2023) highlight the economic potential of carbon trading as a market-based solution for emission reduction. The BEE (2024) and ICAP (2024) reports establish the institutional foundation of India's CCTS, while Ecosystem Marketplace (2024) and World Bank (2023) identify data integrity, MRV transparency, and price volatility as critical determinants of market success. Moreover, Zirkande and Tawade (2023) extend the discussion to agricultural and forestry participation, demonstrating the potential for inclusive growth through carbon farming credits. Collectively,

these studies provide empirical and conceptual support for the hypothesis that robust policy design, transparent governance, and integration between voluntary and compliance mechanisms are essential for realizing India's carbon market potential.

Conceptual Framework

The conceptual framework of this study is derived from the literature on carbon market development, environmental economics, and policy design (World Bank, 2023; ICAP, 2024; CEEW, 2023). It integrates institutional, economic, and technical dimensions that collectively determine the effectiveness of carbon credit trading in India. At the core of the framework lies the dependent variable — *Effectiveness of India's Carbon Credit Market* — measured in terms of market growth, participation, investment attraction, and emission reduction outcomes. The independent variables include:

1. Regulatory Framework Strength – quality and clarity of policies, institutional roles, and enforcement mechanisms (BEE, 2024; PIB, 2024).
2. MRV Transparency and Data Integrity – robustness of monitoring, reporting, and verification systems ensuring credit authenticity (Ecosystem Marketplace, 2024).
3. Market Structure and Liquidity – interaction between voluntary and compliance mechanisms and their influence on participation and pricing (Manjunatha & Ravi Kumar, 2023; ICAP, 2024).
4. Investment and Financial Incentives – access to green finance, participation of private investors, and stability of carbon credit prices (S&P Global Commodity Insights, 2024).
5. Institutional and Technical Challenges – data gaps, low awareness among MSMEs, and lack of verification capacity (CEEW, 2023; World Bank, 2023).

These independent variables are expected to influence the performance and credibility of India's carbon market. Moderating variables such as *global carbon price trends*, *policy coherence*, and *technological readiness* may further strengthen or weaken these relationships.

Conceptual Model

The framework posits that the regulatory and institutional framework sets the foundation for market legitimacy, while MRV transparency ensures credibility and investor trust. A well-designed market structure, encompassing both compliance and voluntary mechanisms, enhances liquidity and participation. Financial incentives and stability attract long-term investment in emission reduction projects, and the degree of institutional capacity moderates how effectively these mechanisms translate into measurable emission reductions.

Ultimately, the effectiveness of India's carbon credit market depends on the interplay between regulatory governance, technological systems, market design, and stakeholder inclusivity — leading to improved environmental and economic outcomes.

Conceptual Framework (Textual Flow)

Regulatory Framework Strength

↓

MRV Transparency & Data Integrity

↓

Market Structure & Liquidity

↓

Investment & Financial Incentives

↓

Institutional & Technical Capacity

↓

Effectiveness of India's Carbon Credit Market (Dependent Variable)

Research Methodology

Research Design

The study employs a mixed-method research design, integrating both qualitative and quantitative approaches to achieve a holistic understanding of India's carbon credit market. This design aligns with previous research methodologies used by international agencies such as the World Bank (2023) and ICAP (2024) in carbon market assessment studies.

- **Qualitative Component:** Focuses on the analysis of policy documents, government notifications, and regulatory frameworks (e.g., Energy Conservation Act, 2022; CCTS notifications, 2023–2025). Expert interviews and content analysis of reports from BEE, CEEW, and ICAP are conducted to identify institutional challenges, governance issues, and market perceptions.
- **Quantitative Component**: Utilizes secondary data from verified databases such as *Grand View Research (2024)*, *Ecosystem Marketplace (2024)*, and *World Bank Carbon Pricing Dashboard*. Market indicators (credit prices, volumes, growth rates, and sectoral participation)

are analyzed using descriptive statistics, correlation analysis, and trend projection models to examine the relationships between regulatory strength, MRV efficiency, and market performance.

Type of Study

This is an exploratory-cum-descriptive study, as it aims both to explore the emerging carbon credit market in India and to describe its present structure, challenges, and growth potential.

Data Sources

1. **Primary Data:**

   Semi-structured interviews with policymakers, BEE officials, environmental economists, and carbon project developers.

   Expert opinions collected through online questionnaires and virtual consultations.

2. **Secondary Data:**

   Government reports (Ministry of Power, MoEFCC, BEE, PIB)

   International databases (World Bank, ICAP, Ecosystem Marketplace)

   Peer-reviewed journals and market analytics reports (S&P Global, Grand View Research, CEEW, etc.)

Sampling Design

- Sampling Method: Purposive sampling (for experts and key stakeholders).
- Sample Size: Approximately 20–30 respondents from government agencies, academic institutions, and private carbon market participants.
- Selection Criteria: Minimum of three years of professional experience in energy, environment, or carbon markets.

Data Analysis Techniques

- Qualitative Analysis: Thematic content analysis for policy and interview data, coding for key themes such as “institutional barriers,” “pricing mechanisms,” and “MRV transparency.”
- **Quantitative Analysis:**

  Descriptive statistics for market trends and sectoral participation.

  Pearson correlation to test relationships among variables (e.g., regulatory strength vs. market growth).

  Regression analysis to validate hypotheses (H_1–H_5) related to MRV, investment incentives, and market effectiveness.

Research Scope and Delimitation

The study focuses on the period 2020–2025, encompassing India's transition from voluntary to regulated carbon trading. Geographical scope includes national-level markets and selected pilot projects across industrial, energy, and agricultural sectors. While international linkages are discussed, the study primarily examines domestic mechanisms under the *CCTS* and *Green Credit Programme Rules, 2023*.

Results:

Table 1. Data-Based Analysis of India's Carbon Credit Market (2023–2030)

Indicator / Variable	2023 (Base Year)	2025 (Projected)	2030 (Projected)	CAGR (2024–2030)	Interpretation / Analytical Insight	Source (APA 7th)
Market Size (Total Carbon Credit Market, USD Billion)	4.01	12.4	49.4	**≈43.2 %**	Market expected to expand rapidly post-CCTS rollout, driven by policy clarity and industrial participation.	Grand View Research (2024)
Voluntary Carbon Credit Market Value (USD Million)	122.7	520.0	1,158.6	**≈37.8 %**	Voluntary market expected to grow steadily due to ESG demand and global corporate offset commitments.	Ecosystem Marketplace (2024)
Average Carbon Credit Price (USD/tCO_2e)	10.0	12.5	15.0	**+7–9% YoY**	Prices likely to rise moderately with regulatory tightening and global linkage under Article 6.	S&P Global Commodity Insights (2024)

No. of Sectors Covered under Compliance Mechanism	0 (pre-launch)	9 (pilot phase)	12+ (expanded)	—	Coverage widening to include power, transport, and construction sectors post-2027.	BEE (2024); ICAP (2024)
Total Estimated Credits Issued (Million tCO_2e)	150	460	1,800	**≈41.5 %**	Rapid growth expected once registry and verification systems are fully operational.	World Bank (2023); BEE (2024)
No. of Registered Verification Agencies (Accredited by BEE)	5	20	50+	—	Institutional capacity building under progress to support MRV transparency.	BEE (2024)
Industrial Sector Participation (No. of Obligated Entities)	0	253	700+	—	Increasing engagement of heavy industries (steel, cement, fertilizer) under compliance system.	ICAP (2024)
Foreign Direct Investment (Clean Energy Projects, USD Billion)	9.4	14.5	30.0	**≈27.5 %**	Green finance inflow correlates with carbon trading readiness and project bankability.	World Bank (2023); CEEW (2023)
Green Credit Programme Projects (No. of Initiatives)	0	150	500+	—	Voluntary environmental activities gaining policy support and private sector interest.	MoEFCC (2023)
Projected Emission Reduction	250	600	2,000	—	Reflects expected efficiency and	BEE (2024);

Potential (Million tCO_2e/year)					renewable adoption due to CCTS incentives.	ICAP (2024)

The analysis of India's carbon credit market highlights a clear transition from policy formulation to measurable economic and environmental outcomes. The data in *Table* reveal strong growth potential, supported by regulatory innovation, institutional development, and increasing market participation. Each major indicator is interpreted below with reference to indexed literature and official sources.

1. Market Expansion and Growth Outlook

The overall market size of India's carbon credit system is projected to rise from USD 4.01 billion in 2023 to approximately USD 49.4 billion by 2030, reflecting a compound annual growth rate (CAGR) of 43.2 percent (Grand View Research, 2024). This rapid escalation signifies the combined impact of the Carbon Credit Trading Scheme (CCTS) and growing participation in both voluntary and compliance segments. The *Bureau of Energy Efficiency* (BEE, 2024) notes that inclusion of nine energy-intensive industries—such as cement, steel, fertilizer, and petroleum—has created a foundational demand for tradable credits. Similarly, *ICAP (2024)* attributes this growth to India's decision to adopt a rate-based Emission Trading System (ETS) that balances industrial productivity with emissions control.

In analytical terms, such exponential growth suggests a strong positive correlation between regulatory maturity and market expansion, validating the study's H_1 hypothesis that policy clarity enhances carbon market effectiveness.

2. Voluntary Carbon Market Development

The voluntary carbon market (VCM), valued at USD 122.7 million in 2023, is forecast to reach USD 1.16 billion by 2030, registering a steady CAGR of 37.8 percent (Ecosystem Marketplace, 2024).

This trend is supported by corporate climate commitments and ESG-driven investment from multinational enterprises such as Google and Microsoft (CEEW, 2023). The VCM's performance complements the compliance mechanism under CCTS, collectively improving market liquidity and inclusiveness. From a data-analysis standpoint, this supports H_3, which predicts that integration of voluntary and compliance markets increases participation and trading volume. As per the *World Bank (2023)*, hybrid markets in developing countries tend to

perform better when both voluntary and mandatory schemes coexist, allowing flexibility and scaling.

3. Carbon Credit Pricing Trends

The average carbon credit price in India is expected to increase from USD 10/tCO_2e in 2023 to about USD 15/tCO_2e by 2030, implying a gradual annual rise of 7–9 percent (S&P Global Commodity Insights, 2024).Price stabilization mechanisms, such as the proposed carbon price stabilization fund, are designed to prevent excessive volatility and sustain investor confidence (PIB, 2024). Economically, this steady price growth indicates that demand under compliance obligations will exceed supply in the early trading phase (2026–2028), creating a favorable investment environment. It also affirms H_2, which posits that transparent MRV and regulatory certainty positively influence market pricing dynamics.

4. Sectoral Coverage and Institutional Strength

By 2025, the compliance mechanism will cover nine major sectors, expanding to twelve or more by 2030, potentially including power generation and transport (BEE, 2024; ICAP, 2024). This widening coverage enhances cross-sectoral emission reductions and creates opportunities for *cross-credit trading*. The accreditation of 20 verification agencies by 2025—expected to reach 50+ by 2030—demonstrates progressive institutional capacity-building under BEE supervision (BEE, 2024). Such institutional indicators directly reflect MRV transparency and data reliability, critical variables for evaluating the credibility of the carbon market. As the *World Bank (2023)* emphasizes, MRV integrity determines long-term investor participation and ensures avoidance of double-counting or greenwashing.

5. Investment, Finance, and FDI Inflows

Green-finance inflows linked to carbon projects are projected to increase from USD 9.4 billion in 2023 to USD 30 billion in 2030, corresponding to a CAGR of 27.5 percent (World Bank, 2023; CEEW, 2023). This rise aligns with broader trends in climate-aligned investments, including renewable energy, industrial efficiency, and carbon capture technologies. Financial market analysis indicates a positive relationship between green investment flows and carbon credit price stability, as investors respond to predictable policy signals and market instruments. The empirical implication is that *financial incentives act as an independent predictor of market performance*, reinforcing H_4 that stable finance mechanisms contribute to sustainable carbon-market growth.

6. Green Credit Programme and Co-Benefits

The Green Credit Programme Implementation Rules (2023) introduced by *MoEFCC* expand the concept of carbon markets to encompass broader ecological activities—such as tree plantation, waste management, mangrove conservation, and air pollution reduction (MoEFCC, 2023). Although voluntary, this scheme diversifies India's environmental credit landscape and encourages cross-sector participation. Analytical integration of such green-credit data will provide insight into non-carbon environmental co-benefits, adding multidimensionality to India's carbon-market evolution.

7. Emission Reduction and Environmental Impact

Quantitative projections suggest that verified emission reductions could increase from 250 million tCO_2e (2023) to 2,000 million tCO_2e by 2030, representing an eightfold improvement (BEE, 2024; ICAP, 2024). These reductions result primarily from industrial efficiency upgrades, renewable energy adoption, and emerging carbon-removal projects. The analysis anticipates a positive regression coefficient between credit issuance and verified emission reductions—demonstrating that policy-driven market activity yields tangible climate benefits.

8. Synthesis and Analytical Implications

Collectively, these trends indicate that India's carbon credit market is on a steep growth trajectory, underpinned by strong policy frameworks, rising private-sector involvement, and increasing international engagement. However, the data also reveal transitional challenges, such as the need for MRV modernization, consistent pricing mechanisms, and improved awareness among MSMEs (Ecosystem Marketplace, 2024; CEEW, 2023).

The tentative analysis thus supports all five hypotheses (H_1–H_5):

- Regulatory strength and MRV transparency positively influence market efficiency.
- Integrated markets enhance liquidity and participation.
- Stable financial mechanisms attract investment and reduce volatility.
- International linkages bolster credibility and competitiveness.

Findings and Discussion

The analysis of India's carbon credit market reveals a nation in the midst of an ambitious environmental and economic transition. The introduction of the Carbon Credit Trading Scheme (CCTS) under the *Energy Conservation (Amendment) Act, 2022* represents a major institutional step toward establishing a national framework for carbon pricing and emissions trading. The findings indicate that India's policy direction is aligned with its global commitments under the *Paris Agreement (2015)* and its long-term objective of achieving net-zero emissions by 2070 (Bureau of Energy Efficiency [BEE], 2024; Press Information Bureau [PIB], 2024).

A key finding is that the carbon market offers substantial opportunities for new revenue generation among businesses and project developers. Companies that achieve emissions reductions below their statutory caps can sell surplus credits, while sectors such as renewable energy, waste management, forestry, and agriculture can earn revenue through verified offset projects (Council on Energy, Environment and Water [CEEW], 2023). Furthermore, the rise of carbon farming and agroforestry initiatives holds the potential to diversify rural incomes and improve soil and forest health, linking environmental stewardship to community livelihoods (Zirkande & Tawade, 2023).

The study also finds that the CCTS can act as a catalyst for green investment and climate finance. As per the *World Bank (2023)* and *Grand View Research (2024)*, the value of India's carbon market is projected to exceed USD 49 billion by 2030, supported by a compound annual growth rate of over 43 percent. This expansion is expected to stimulate private and foreign direct investment in clean technology, energy efficiency, and carbon capture systems. Moreover, alignment with global mechanisms such as the Carbon Border Adjustment Mechanism (CBAM) will enhance India's trade competitiveness by rewarding low-carbon industries with improved access to export markets (International Carbon Action Partnership [ICAP], 2024).

However, the findings also underscore significant structural and operational challenges that could impede market maturation. One major concern is the demand-supply imbalance: if supply outpaces demand, credit prices could fall, discouraging companies from investing in emission-reduction initiatives. This risk echoes earlier experiences from India's Perform, Achieve, and Trade (PAT) scheme, where *Energy Saving Certificates (ESCerts)* traded consistently at the floor price, limiting the incentive effect (BEE, 2024). Additionally, the market's vibrancy depends heavily on whether the government facilitates sufficient compliance demand and whether secondary speculative trading is permitted in a controlled, transparent manner (PIB, 2024).

Institutional fragmentation is another key challenge. Multiple agencies—such as the BEE, *Central Electricity Regulatory Commission (CERC)*, and *Grid Controller of India Limited (GRID-INDIA)*—share overlapping responsibilities, often leading to coordination gaps. The absence of uniform baseline-setting, verification, and credit-issuance protocols complicates the process of ensuring MRV (Measurement, Reporting, and Verification) integrity (Ecosystem Marketplace, 2024). The risk of double counting and greenwashing remains a persistent integrity issue, especially where voluntary and compliance markets intersect (World Bank,

2023). Limited domestic awareness further constrains participation. Small and medium-sized enterprises (SMEs) and local institutions often lack the technical capacity to engage in carbon trading. This leads to uneven market access and concentration among large industrial players (CEEW, 2023). Weak enforcement mechanisms and the absence of stringent penalties reduce compliance motivation, while gaps in emissions data and digital trading infrastructure delay credit issuance and settlement (ICAP, 2024). Despite these barriers, the discussion suggests that India's carbon credit market possesses transformative potential. By leveraging technological innovations—such as blockchain-based verification, remote sensing, and AI-driven MRV tools—India can improve transparency and efficiency in emissions accounting. Furthermore, synergy with existing policy schemes like the Renewable Energy Certificate (REC) mechanism and Green Credit Programme (MoEFCC, 2023) could accelerate market integration and create a unified environmental trading platform.

Conclusion

The study concludes that India's carbon credit system is at a decisive stage in its evolution. The CCTS, by shifting from a voluntary to a compliance-driven model, provides a structured pathway to institutionalize carbon pricing within the broader framework of sustainable development. The projected expansion of the carbon market, coupled with India's rapidly developing renewable and green finance ecosystem, positions the country as a potential regional leader in low-carbon transition and climate finance (BEE, 2024; ICAP, 2024).

Nevertheless, realizing this potential requires addressing several deep-rooted challenges. Institutional fragmentation, limited MRV infrastructure, insufficient enforcement mechanisms, and low domestic demand represent immediate threats to market credibility. The experience of earlier mechanisms such as the PAT scheme underscores the importance of robust price stabilization measures and government-supported credit demand (World Bank, 2023).

To sustain market confidence, India must also invest heavily in digital MRV infrastructure, emission-data transparency, and capacity-building initiatives for SMEs and rural communities. Establishing floor and ceiling pricing, ensuring cross-sectoral policy integration, and aligning the CCTS with international carbon standards under Article 6 of the *Paris Agreement* will be critical. If executed effectively, the Indian carbon market can simultaneously achieve three national priorities: economic resilience, social inclusivity, and climate sustainability.

Practical Implications

The study holds important implications for policymakers, industries, and researchers. For policymakers, it underscores the need to harmonize institutional functions across ministries

and agencies to prevent regulatory overlap and inefficiency (PIB, 2024). Strengthening MRV systems through digital verification tools and real-time emission tracking will not only build investor confidence but also ensure the integrity of credits traded in domestic and international markets (Ecosystem Marketplace, 2024).

For businesses and project developers, the findings highlight that carbon credits are emerging as new financial assets that can generate alternative revenue streams, especially for industries investing in decarbonization technologies. Rural communities and farmers can benefit from carbon farming and agroforestry initiatives, turning environmental stewardship into an income-generating activity (Zirkande & Tawade, 2023). From an international perspective, India's integration into global carbon pricing systems and alignment with EU CBAM standards could protect export competitiveness and attract green supply-chain partnerships (ICAP, 2024). Finally, for academia and research, this study contributes to the growing body of literature on emerging carbon markets in developing economies, emphasizing the intersection of governance, finance, and sustainability (World Bank, 2023).

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