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Carbon Credit and Carbon Trading as a Climate Change Mitigation Strategy in India: An Economic and Policy Perspective

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Abstract
Climate change has emerged as a major environmental and economic challenge with implications for production, consumption, investment, employment and human welfare. The accumulation of greenhouse gases in the atmosphere is largely associated with fossil-fuel use, industrial production, transportation, electricity generation and changes in land use. Since the environmental costs of greenhouse-gas emissions are not fully reflected in market prices, climate change represents a significant negative externality and a major challenge for environmental economics. Carbon credits and carbon trading have emerged as market-based instruments designed to create an economic value for greenhouse-gas emission reductions and encourage low-carbon investment. This paper examines the role of carbon credits and carbon trading as climate-change mitigation instruments from an economic and policy perspective. Based on secondary data, this paper analyses the economic rationale of carbon trading, its potential contribution to emission reduction, technological innovation and investment, and the major environmental and institutional challenges associated with carbon markets. Here, this paper discusses India's emerging carbon-market framework and the Carbon Credit Trading Scheme (CCTS). The analysis indicates that carbon trading can improve the cost-effectiveness of climate mitigation by allowing emission reductions to take place where marginal control costs are comparatively lower. The effectiveness of carbon markets depends on environmental integrity, credible measurement and verification, additionality, prevention of double counting, transparent governance and an adequate carbon price. Well-designed carbon markets can become an important component for strategy for achieving sustainable economic development perspective.

Keywords: Carbon credits, Carbon trading, Carbon pricing, Climate change, Emissions trading, Mitigation, Environmental Economics, CCTS, BEE GEI, CBAM, DMRC, Renewable Energy, Public Transportation, Carbon Credit and Carbon Trading Scheme, IRR, CCUS, IoT, CEEW, Sustainable Development.

Introduction

Climate change has emerged as the one of the most important environmental and developmental challenges facing the global economy in the 21st century. Increasing concentrations of greenhouse gases, particularly carbon dioxide (CO_2), are changing the climate system and creating risks for agriculture, water resources, ecosystems, infrastructure, human health and economic productivity. The problem is closely

connected with economic activities because modern economies produce goods & services and consume energy. Fossil fuels remain an important source of energy for electricity generation, transportation and industrial production, while changes in land use and other economic activities also contribute to greenhouse-gas emissions.

The economic dimension of climate change can be explained through the context of negative externality. This is particularly important because greenhouse-gas emissions create costs that are not fully borne by the individuals or firms responsible for producing them. A firm using petroleum, natural gas and coal for production have been generally considered the private cost of energy, coal, labour, machinery and other inputs, but the climate-related damage associated with its emissions may be distributed across society and future generations. The difference between private and social costs represents a negative environmental externality. From the perspective of environmental economics, the problem can be expressed as Social cost which is equal to Private cost plus External environmental cost. When the external cost is not incorporated into economic decisions, the market may generate excessive levels of pollution. Climate policy provides mechanisms through which the environmental cost of emissions can be incorporated into production and consumption decisions. There are two types of pollution control methods. One approach is direct environmental regulation (like, Liability Laws, Property rights and emission Standard), in which governments establish emission standards. Another approach is Market based approach (Like, Effluent Charge / Pollution Taxes, Tradable Pollution Permit System, Environmental Subsidies, Deposit /Refund System and Government Investment Programme). For example, if we take Carbon Tax which is imposes on the basis of per unit of Tax on Carbon Emission. In carbon taxation, price is imposed on greenhouse-gas emissions. Similarly in the case of emissions trading, emission units or carbon credits can be traded between market participants.

Carbon credits have become an important component of this market-based approach. A carbon credit generally represents one tonne of carbon dioxide equivalent of greenhouse-gas emission reduction, avoidance or removal, subject to the rules of the relevant carbon-market system. Such credits may originate from renewable-energy projects, energy-efficiency improvements, methane capture, afforestation, forest conservation and other mitigation activities.

Carbon trading creates a market in which eligible emission credits or units can be bought and sold. The basic economic argument is that firms differ in their costs of reducing emissions. Some firms can reduce emissions at relatively low cost, while others face substantially higher costs. Allowing trading can therefore enable emission reductions to occur where they are economically less expensive. The economic mechanism can be represented as carbon price which are used as economic incentive which again create emission reductions.

The development of carbon markets has accelerated internationally. The Paris Agreement provides a framework for international cooperation on climate mitigation, including mechanisms under Article 6 for countries to cooperate in achieving their climate goals.

India has also taken several steps towards developing a domestic carbon market. The Government of India notified the Carbon Credit Trading Scheme (CCTS) in 2023, establishing a framework for the development of an Indian carbon market. The Bureau of Energy Efficiency plays an important role in the development and implementation of this framework. This paper examines the economic rationale of carbon credit and carbon trading, the role of carbon credits and carbon trading in climate change mitigation strategies, Global development of carbon market, carbon market in Indian scenario, potential benefits of India's carbon market, tales of carbon trading and India's experience, challenges of carbon

credit and carbon trading, India's carbon market potential for mitigating greenhouse-gas emission reduction, technological innovation and low-carbon investment, and carbon trading and sustainable development.

Literature Review

The World Bank (2026) assessed recent developments in global carbon pricing and carbon markets. The report indicates that direct carbon pricing now covers nearly one-third of global greenhouse gas emissions and that carbon-pricing systems are becoming increasingly diverse in their design and application. It also highlights the continuing expansion of emissions trading systems and carbon-credit markets. The report identifies challenges related to carbon-credit supply, price levels, market quality and the credibility of emission reductions. The study suggests that the future effectiveness of carbon markets will depend on stronger market institutions, credible measurement and verification systems, appropriate pricing and greater international cooperation. These findings are more relevant for evaluating carbon markets as a long-term climate change mitigation strategy.

Malode and Singh (2025) critically examined India's emerging emissions-trading framework and its implications for energy sustainability. The study discussed several challenges which is associated with policy design, market functioning, monitoring and verification. It emphasized that a credible carbon market requires clear emission-reduction objectives, effective monitoring and reporting systems, appropriate institutional mechanisms and adequate enforcement. The study is particularly relevant to the present research because it highlights that the environmental effectiveness of India's carbon market depends on the quality of its policy and institutional framework.

Pan et al. (2024) reviewed the literature on carbon taxes and emissions trading systems and compared their environmental and economic implications. The theory examined different forms of carbon-pricing policies and their implementation across countries. Market based instruments especially, carbon pricing may need to be supported by complementary policies such as technological development, renewable energy promotion and energy-efficiency measures. The study, therefore, highlights the importance of integrating carbon markets with broader climate policy.

Ahmad, Li and Wu (2024) conducted a meta-analysis of empirical research on carbon-pricing policies. Their study analysed a large number of estimates from previous studies to assess the effectiveness of carbon taxes and emissions trading systems in reducing carbon emissions. The findings indicated that carbon-pricing policies can reduce emissions, but their effectiveness varies according to institutional, economic and policy conditions. The study also identified several factors that influence the performance of carbon-pricing mechanisms. This evidence is important because it demonstrates that the success of carbon markets cannot be assessed independently of their policy and institutional context.

The International Monetary Fund (2023) examined India's climate policy and the country's movement towards a carbon-market-based approach. The study discussed India's existing policy instruments, including the Perform, Achieve and Trade (PAT) Mechanism, and the development of a broader carbon-credit trading framework. It suggested that carbon markets could provide India with an additional instrument for promoting energy efficiency and reducing greenhouse gas emissions. The study emphasized the need to consider economic growth, competitiveness and distributional implications while developing carbon-pricing policies in India.

Singh and Chaturvedi (2023) examined the prospects of carbon markets in India and discussed the perspectives of different stakeholders regarding the development of an Indian carbon market. The study

creates the difference between project-based carbon markets and emissions-trading-based mechanisms. It highlighted the importance of market design, environmental integrity, monitoring, reporting and verification in ensuring the credibility of carbon-market mechanisms. The study suggests that the success of India's carbon market depend on the existence of a trading mechanism and effective institutions and stakeholder participation.

The IPCC (2022) examined emissions trading systems within the broader framework of climate change mitigation policies. It explained that an emissions trading system establishes an overall limit on emissions and allows participating entities to trade emission allowances. The market determines the price of allowances, while governments may introduce mechanisms such as price floors and ceilings. The IPCC also emphasized that the effectiveness of emissions trading depends on number of factors such as the coverage of the system, monitoring and reporting, enforcement, allocation of allowances and the stability of carbon prices. Thus, appropriate policy design is essential for achieving meaningful emission reductions.

The International Monetary Fund (2022) compared carbon taxes and emissions trading systems as alternative carbon-pricing instruments. The study highlighted that carbon taxes provide greater certainty regarding the price of carbon, whereas emissions trading provides greater certainty regarding the quantity of emissions. The study also discussed administrative capacity, distributional effects, competitiveness and political economy considerations. It concluded that carbon pricing can play an important role in climate mitigation, but its effectiveness depends on institutional capacity and appropriate policy implementation.

Newbery, Reiner and Grubb (2019) examined carbon pricing as an instrument for achieving long-term climate objectives. The study discussed the economic logic behind carbon pricing and emphasized the importance of establishing credible and predictable policy frameworks. According to the authors, uncertainty regarding future carbon prices can reduce incentives for firms to undertake long-term investments in low-carbon technologies. Therefore, a well-designed carbon market should provide sufficient price signals while maintaining flexibility for businesses. The study highlights the importance of policy credibility and long-term investment incentives in evaluating the effectiveness of carbon markets.

Stavins (2003) examined the economic rationale of market-based environmental policies and highlighted the importance of tradable permits as an instrument for achieving environmental objectives at relatively lower costs. The study explained that emissions trading allows firms with lower costs of emission reduction to undertake greater reductions and sell excess permits to firms facing higher abatement costs. This flexibility can improve the overall cost-effectiveness of environmental regulation. The study provides an important theoretical foundation for understanding carbon markets as market based instrument for climate change mitigation.

Objectives of the Study:

The study has four objectives:

1. To explain the economic rationale of carbon credits and carbon trading.
2. To discuss the role of carbon credits and carbon trading in climate change mitigation strategy.
3. To analyse the India's carbon markets potential for mitigating greenhouse-gas emission reduction, technological innovation and low-carbon investment.
4. To discuss the Indian experiences and tales of carbon trading in Indian scenario.

Research Methodology:

The study adopts an analytical research design based on secondary data which have been obtained from International Organisations, Research Journals, Government Institutions, Regulatory Agencies, Policy Documents and Published Academic Literature. Regarding this context major sources like, United Nations Framework Convention on Climate Change (UNFCCC), World Bank, Government of India, and Bureau of Energy Efficiency have been taken.

This paper applies conceptual analysis, policy analysis and interpretation of secondary data sources. It examines carbon credits and carbon trading in relation to economic efficiency, emission reduction, technological innovation and environmental integrity.

The paper does not use descriptive statistics. The paper examines the functioning and policy relevance of carbon markets rather than statistically estimate their causal effect on emissions. The analysis focuses on three interconnected dimensions-Economic efficiency, Environmental integrity, and Institutional effectiveness. The Carbon market plays an important contribution in climate mitigation only when these dimensions are sufficiently addressed.

Economic Rationale of Carbon Credit and Carbon Trading

The economic foundation of carbon trading is based on the theory of environmental externalities. Pollution occurs when economic activities (production and consumption) impose costs on others that are not reflected in market prices. Greenhouse-gas emissions are a particularly important externality because their effects are global and extend over long periods. The economic rationale of carbon trading is based on differences in the marginal costs of emission reduction. Consider two firms. Firm A can reduce one tonne of carbon dioxide equivalent (1 tonne CO2e) at a cost of ₹1,000, whereas Firm B requires ₹3,000 to achieve the same reduction. Under a rigid regulatory system, both firms may be required to undertake the same amount of reduction regardless of their respective costs. Under a trading system, Firm A can undertake additional reductions and sell eligible carbon units to Firm B.

Suppose, the market price of a carbon unit is ₹1,800. Firm A has an economic incentive (Surplus Carbon Unit) to reduce emissions because the revenue from selling the unit exceeds its reduction cost. Firm B can purchase the unit at a lower cost than the cost of achieving the additional reduction internally. This produces a potential efficiency gain. Here, the central principle is that when emission reduction occurs where the marginal abatement cost is lowest. This flexibility is one of the main economic advantages of emissions trading.

Carbon trading can therefore achieve a given environmental objective at potentially lower economic cost than a system in which all firms face identical reduction requirements. However, the result depends on the existence of reliable measurement systems and a credible regulatory framework.

The Role of Carbon Credits and Carbon Trading in Climate Change Mitigation Strategy

Carbon credits create an economic value for emission reductions. A project that reduces greenhouse-gas emissions can potentially generate eligible credits. Potential carbon-credit-generating activities include renewable-energy projects, energy-efficiency improvements, methane recovery, waste-management projects, afforestation, reforestation and certain industrial efficiency measures. These credits may then be purchased by another entity according to the rules of the relevant carbon market.

The economic importance of this process is that climate mitigation becomes associated with a financial value. For example, an industrial firm that invests in energy efficiency may reduce its energy costs while

also potentially obtaining carbon-market benefits where the activity is eligible. On one side it creates lower operating cost and on other side gives carbon-market benefit also. Similarly, renewable-energy projects can potentially obtain additional revenue from carbon markets, improving their financial attractiveness. Carbon credits should not be regarded as automatically equivalent to genuine climate benefits. Their value depends on the quality of the underlying mitigation activity and the carbon-accounting methodology. Carbon trading can contribute to climate mitigation through several channels- (i) Carbon trading creates a price signal for greenhouse-gas emissions, (ii) Carbon trading can encourage energy efficiency, (iii) Carbon trading can encourage renewable-energy adoption, (iv) Carbon markets can stimulate technological innovation, (v) Carbon markets can mobilise private finance, and (vi) Carbon trading provides flexibility.

Carbon price creates incentive which increases investment in new technological change which decrease emission reduction. The effectiveness of this chain depends on the carbon price and the credibility of the market. If carbon prices are too low, firms may have little incentive to make substantial technological changes. If prices are unpredictable, long-term investment decisions may be harmful and complex.

Global Development of Carbon Markets

Carbon markets have expanded across different countries and regions, but there is no single global carbon market with identical rules. Instead, the international carbon-market landscape includes national and regional emissions-trading systems, international mechanisms and voluntary carbon markets.

Carbon prices differ substantially across jurisdictions because countries have different climate targets, economic structures and regulatory systems. A carbon price provides an economic signal to firms. A higher and more credible carbon price generally provides a stronger incentive for emission reduction, although excessively high carbon costs can raise concerns regarding competitiveness and distributional effects. A very low carbon price may not significantly alter investment decisions. Therefore, carbon-market policy requires an appropriate balance between environmental ambition and economic feasibility.

International cooperation is particularly important because greenhouse-gas emissions are global. Article 6 of the Paris Agreement provides a framework for countries to cooperate in achieving mitigation outcomes while establishing accounting and reporting requirements.

Carbon Market and Indian Scenario

India is developing a domestic carbon market as part of its broader climate and energy policy framework. The Government of India notified the Carbon Credit Trading Scheme (2023) for issuance authority of Carbon credit Certificates (CCTs). The scheme provides a framework for the establishment and operation of India's carbon market. The regulatory foundation of India's domestic carbon market is established under the Energy Conservation (Amendment) Act. The architecture introduces two distinct frameworks administered by the Bureau of Energy Efficiency:

Compliance Mechanism: A mandatory Rate-based Emissions Trading System targeting energy-intensive sectors (including Cement, Aluminum, Iron & Steel, Pulp & Paper, Chlor-Alkali, Petroleum Refineries, Petrochemicals, Fertilizers, and Textiles). Obligated entities carry legally binding Greenhouse Gas Emission Intensity (GEI) targets.

Under the compliance mechanism, designated entities are subject to greenhouse-gas emission-intensity targets. Entities that perform better than their required targets can potentially receive carbon-credit certificates, while entities that do not meet their obligations may need to purchase eligible certificates

according to applicable rules.

Offset Mechanism: This mechanism provides an opportunity for eligible non-obligated entities to generate carbon credits from approved mitigation activities. This framework is significant because it attempts to integrate emission reduction into industrial decision-making.

Instead of focusing only on absolute production reductions, an emission-intensity approach can encourage firms to reduce greenhouse-gas emissions per unit of output. This is particularly relevant for a developing economy. The desired transition can be expressed as higher economic output with lower emission intensity can boost up sustainable industrial development. India's carbon market can therefore potentially support the transformation of energy-intensive industries while allowing continued economic development.

Potential Benefits of India's Carbon Market: India's carbon market can potentially generate several economic and environmental benefits which are:

- **Improved Industrial Energy Efficiency:** Firms facing carbon-related obligations may have greater incentives to reduce energy consumption per unit of output.
- **Technological Innovation:** Firms may invest in cleaner production technologies to reduce future carbon-market costs.
- **Renewable-Energy Development:** Carbon-market incentives can potentially complement renewable-energy investment.
- **Improved Resource Efficiency:** Reducing energy and material consumption creates lower economic and environmental impacts.
- **Development of a Domestic Carbon Market:** This ecosystem involves verification, certification, measurement and trading services.

The potential success of these benefits depends on the credibility and effectiveness of the market.

Tales of Carbon Trading and Indian Experiences

India's experience with carbon trading provides several examples of how environmental problems have been connected with economic incentives. Before the development of India's domestic carbon market, Indian companies and project developers participated in international carbon-market mechanisms, particularly the Clean Development Mechanism (CDM) under the Kyoto Protocol. These experiences covered renewable energy, industrial gas destruction, energy efficiency, waste management and urban transportation. They provide necessary evidence for understanding both the potential and limitations of carbon markets.

Delhi Metro Rail Corporation: Carbon Finance through Urban Public Transport: The Delhi Metro Rail Corporation provides an important example of how carbon-market mechanisms can be connected with urban transportation. The expansion of mass rapid transit in Delhi was primarily intended to provide efficient public transportation and reduce congestion. However, the project also generated climate-related benefits because metro transportation can reduce dependence on individual fossil-fuel-based vehicles.

The Delhi Metro Rail Corporation (DMRC) obtained carbon credits under the Clean Development Mechanism for emission reductions associated with regenerative braking technology. Regenerative braking allows a portion of the energy generated during braking to be recovered rather than lost as heat. The recovered energy can subsequently be used within the metro system, reducing electricity requirements.

This example is particularly interesting from an environmental-economics perspective because the environmental benefit originated from a technological improvement within an existing transportation

system. The carbon-market mechanism provided an economic value to the resulting emission reduction. It also multiple environmental benefits. The climate benefit from lower greenhouse-gas emissions occurs through improvements in public transportation, reduced dependence on private vehicles and potentially lower local air pollution. So, we can say that an investment designed primarily for transportation infrastructure can also contribute to climate mitigation.

The important lesson from this experience is that carbon markets can create economic recognition for emission reductions that may otherwise remain outside conventional financial calculations. However, the actual quantity of carbon reduction depends upon appropriate baseline determination and reliable measurement. The Delhi Metro experience clearly explain that the carbon finance can support technological efficiency within urban infrastructure while connecting climate benefits with economic decision-making.

Gujarat Fluorochemicals: Industrial Greenhouse-Gas Reduction

The experience of Gujarat Fluorochemicals provides a very different carbon-market story. Industrial GHGs comes from heavy industry rather than public transportation or renewable energy. Gujarat Fluorochemicals participated in a Clean Development Mechanism project involving the reduction of HFC-23 emissions. HFC-23 is a greenhouse gas with a very high global warming potential. The project involved the destruction of HFC-23 generated as a by-product of industrial production through thermal oxidation.

The project was registered under the UNFCCC Clean Development Mechanism framework. The importance of this case lies in the fact that a relatively small quantity of a highly potent greenhouse gas can have a substantial climate impact. Capturing and destroying such emissions can therefore produce significant climate benefits.

From an economic perspective, the project demonstrates how carbon-market incentives can influence investment in emission-control technology. Without an economic value attached to the emission reduction, the financial attractiveness of installing additional destruction technology could be different.

This case also reveals an important lesson about carbon-credit markets. The climate significance can vary according to every tonne of greenhouse gases. Various greenhouse gases have unique capabilities to trap heat in the atmosphere. Different greenhouse gases have different global warming potentials, that is why carbon markets generally use carbon- dioxide equivalent as a common accounting unit.

At the same time, industrial gas projects have generated debate concerning the design of carbon-credit incentives and the possibility that crediting arrangements can influence production incentives. This demonstrates why carbon-market rules must be designed carefully to ensure that financial incentives genuinely support additional climate mitigation.

The Gujarat Fluorochemicals experience therefore illustrates both the potential and the complexity of using carbon markets to address industrial greenhouse-gas emissions.

Renewable Energy Projects: Turning Clean Electricity into Carbon Value

Renewable-energy projects represent one of the most widespread areas of India's early carbon-market experience. Wind, solar, biomass and small-hydropower projects participated in international carbon mechanisms by demonstrating reductions in greenhouse-gas emissions compared with fossil-fuel-based electricity generation.

The basic economic logic is relatively simple. When renewable electricity replaces with electricity

(Traditionally operated) that would otherwise have been generated from carbon-intensive sources, the associated greenhouse-gas emissions can be reduced. If the project satisfies the requirements of the relevant carbon-market mechanism, the emission reduction may be converted into carbon credits.

For project developers, carbon-credit revenue can provide an additional financial benefit. Electricity sales remain the primary source of revenue, but carbon finance can improve the overall economics of a project. This is particularly relevant in developing economies where renewable-energy projects may face high initial capital costs. An additional revenue stream can potentially improve project viability and attract investment.

The experience also demonstrates the importance of the baseline concept. For calculation of emission reduction, it is necessary to estimate the emissions that would have occurred without the renewable-energy project. If the baseline assumes highly carbon-intensive electricity generation, the estimated emission reduction may be relatively large and in opposite case the credited reduction will be smaller.

Experiences of Tales of Carbon Trading

The Indian experiences reveal that carbon trading is not a single type of intervention. It has been associated with industrial technology, renewable energy, public transportation, waste management and energy efficiency. The experiences also demonstrate that carbon markets can create a bridge between environmental objectives and economic incentives. A company that reduces emissions may obtain a financial benefit, while a company facing higher mitigation costs may obtain flexibility through market mechanisms. However, these experiences also shows the limitations of carbon markets. A carbon credit is valuable only when the underlying emission reduction is credible. Poor baselines, weak verification, lack of additionality or double counting can reduce the actual climate benefit.

The central lesson is that the success of carbon trading should not be measured by the number of credits issued or the monetary value of transactions alone. It should be measured by the amount of genuine, additional and verifiable greenhouse-gas reduction achieved.

India's earlier experiences provide a foundation for its emerging domestic carbon market. The Carbon Credit Trading Scheme represents a transition towards a more structured national framework. The lessons from earlier projects can help India strengthen its carbon accounting, verification systems and market governance.

For India, carbon trading can become an important climate-mitigation instrument, but it should operate alongside renewable-energy policies, energy-efficiency programmes, technological innovation, direct environmental regulation and public investment. The greatest potential of carbon markets lies not in creating a market per se but in using economic incentives to accelerate genuine decarbonization of the Indian economy.

Challenges of Carbon Credit and Carbon Trading: Carbon markets face several important challenges which are:

- **Additionality:** If credits are issued for projects that would have occurred without carbon incentives, the environmental benefit is overstated.
- **Baseline Uncertainty:** Incorrect baselines can result in excessive credit generation.
- **Measurement and Verification:** Greenhouse-gas emissions can be technically difficult to measure, particularly for complex industrial processes and land-based activities.
- **Double Counting:** The same mitigation outcome should not be counted by multiple entities.

- **Carbon Leakage:** Firms may shift production to regions with weaker environmental regulations.
- **Price Volatility:** Uncertain carbon prices can reduce the willingness of firms to make long-term investments.
- **Market Concentration:** Large firms may have huge capacity to participate in carbon markets than small and medium enterprises.
- **Administrative Complexity:** Effective carbon markets require registries, monitoring systems, verification institutions and regulatory enforcement.
- **Social Justice:** Some carbon projects, particularly land-based projects, may create conflicts concerning land rights, community participation and benefit distribution.

These challenges demonstrate that carbon markets require strong institutional governance.

India's Carbon Market Potential for Mitigating Greenhouse-gas Emission Reduction, Technological Innovation and Low-Carbon Investment

As the world's third-largest greenhouse gas emitter, India plays a pivotal role in global climate action. Under its revised Nationally Determined Contributions (NDCs), India's ambitious climate pledge is to achieve Net Zero greenhouse gas emissions by 2070 and reduce the carbon emission intensity of its GDP by 45% by 2030 (relative to 2005 levels) demands a robust domestic carbon infrastructure. To transition away from fragmented command-and-control regimes, the Government of India introduced the Carbon Credit Trading Scheme under the statutory framework of the amended Energy Conservation Act, 2001. This landmark scheme establishes a national compliance carbon market designed to internalize the cost of carbon emissions, placing a clear financial value on climate action. By shifting the regulatory mechanism from rigid technical compliance to a flexible, asset-based tradeable credit platform, India is building an ecosystem which is capable of scaling climate finance, optimizing cross-sector industrial efficiencies, and attracting significant institutional capital into the green transition. Regarding India's carbon market potential some important points are:

1. **Greenhouse Gas Emission Reduction Potential:** The domestic compliance framework target points precisely at energy-intensive, hard-to-abate sectors to drive systemic decarbonization. The institutional roadmap leverages baseline emission allocation thresholds and rewards improvements over predefined intensity targets across multiple core vectors:

Power and Utility Sector: Generating nearly 40% of the nation's total industrial emissions, the thermal power grid represents the single largest mitigation block. Imposing a market-based cap-and-trade mechanism forces older, less efficient subcritical coal plants into early retirement or deep retrofits, while heavily incentivizing fuel-switching and co-firing. This sectoral correction is projected to achieve a net mitigation volume of 250 to 300 million tonnes of CO2e per annum by 2030.

Heavy Industry and Manufacturing: Industrial domains specifically iron and steel, cement, aluminum, chemicals, and fertilizers have transition targets. The CCTS replaces older energy-efficiency metrics with rigorous carbon intensity baselines. This technical shift acts as an operational driver for the deployment of waste heat recovery systems, energy management software, and high-efficiency material substitutions, yielding an estimated reduction of 100 to 150 million tonnes of CO2e per annum.

Voluntary Offset Alignment: Beyond the compliance mandate, non-obligated sectors such as sustainable agriculture, electric vehicle infrastructure, and nature-based solutions (agroforestry and soil carbon retention) feed high-quality offset credits into the liquidity pool, creating distributed financial incentives for grass-roots carbon sinks.

2. **Catalyst for Technological Innovation:** A sustained and predictable carbon price signal alters corporate financial metrics, transforming low-carbon research and development (R&D) from an ESG line item into a core commercial imperative. This pricing framework drastically enhances the Internal Rate of Return (IRR) for capital-intensive, frontier clean technologies:

Frontier Clean Tech Deployment: Carbon monetization bridge-funds the commercial viability gap for advanced technologies. Commercial entities can directly monetize their avoided emissions, justifying capital allocation into green hydrogen production, green ammonia synthesis, and localized Carbon Capture, Utilization, and Storage (CCUS) infrastructure.

Digital MRV Systems: To ensure environmental integrity and eliminate double-counting, the carbon market accelerates the roll-out of next-generation Digital Monitoring, Reporting, and Verification (DMRV) frameworks. Utilizing internet-of-things (IoT) sensor arrays, satellite imagery, and immutable blockchain ledgers radically lower transaction processing costs, enabling small-scale developers, MSMEs, and rural agricultural projects to seamlessly interface with the national exchange.

Green Hydrogen and Ammonia: Carbon crediting methodologies approved under national missions provide direct economic incentives to replace gray hydrogen with green alternatives in refineries and fertilizer plants.

3. **Mobilization of Low-Carbon Investment Capital:** The carbon market transforms environmental compliance into an investable asset class, projecting a multi-billion-dollar opportunity by 2030. It unlocks domestic and global climate finance through three channels:

International Climate Finance and Article 6 Integration: Alignment with Article-6 of the Paris Agreement establishes a rigorous mechanism for cross-border carbon transfers. By assuring high credit integrity, India's market is positioned to attract an estimated USD 50 to 100 billion in foreign direct investment (FDI) by 2035 from international funds seeking robust offsets.

Domestic Financial Architecture: Carbon tracking integrates with the Reserve Bank of India's (RBI) green finance framework. Tradeable carbon credits serve as secondary financial collateral, enhancing the credit profiles of green bonds and lowering the borrowing costs for sustainable infrastructure ventures.

Global Trade Protection: As international markets impose carbon cross-border penalties—such as the European Union and United Kingdom's Carbon Border Adjustment Mechanism (CBAM)—a domestic compliance market ensures that carbon revenues are retained within India's economy rather than paid as border taxes, preserving the export competitiveness of heavy Indian manufacturers.

India's domestic carbon market represents a critical pivot from passive environmental compliance to proactive, market-driven climate economics. By unifying greenhouse gas mitigation targets, frontier technological innovation, and scalable financial infrastructure under the CCTS, India is uniquely positioned to transition its rapidly growing industrial base. The operational execution and regulatory refinement of this market over the next five years will determine whether India successfully positions itself as a dominant global supplier of high-integrity carbon instruments or remains subject to external economic border penalties. India's carbon market represents a paradigm shift toward sustainable growth. By establishing a credible price on carbon, India will successfully decouple industrial growth from emissions, positioning itself as a premier global hub for green technology and low-carbon capital.

Carbon Trading and Sustainable Development

Climate policy should not be evaluated only in perspectives of emission reduction. A successful carbon-market project can potentially create additional benefits such as employment, improved energy access,

technological development, cleaner air and rural economic opportunities. For example, renewable-energy projects can reduce greenhouse-gas emissions while also improving energy infrastructure. Similarly, improved waste-management systems can reduce methane emissions while improving local environmental conditions. However, carbon-market projects can also create social risks if local communities. Therefore, carbon-market projects should follow appropriate environmental and social safeguards. Carbon mitigation process improves environmental protection which, in turn, increase sustainable development path.

Conclusion and Policy Perspectives

Climate change is fundamentally an environmental-economic problem arising from the difference between private and social costs of greenhouse-gas emissions. Carbon market (Carbon credits and carbon trading) attempts to address this problem by creating an economic value for emission reductions. Carbon trading can potentially improve the cost-effectiveness of climate mitigation. By allowing firms with lower marginal control costs to undertake greater reductions and trade eligible units, the total cost of achieving an emission target may be reduced.

Carbon-market effectiveness depends on three interconnected conditions: Economic efficiency; Environmental integrity; and Institutional credibility. If the carbon price is too low, economic incentives may be insufficient. If environmental standards are weak, credits may not represent genuine reductions. If institutions are weak, monitoring and enforcement may fail.

Carbon markets can also encourage renewable energy, energy efficiency, technological innovation and private investment in mitigation activities. Nevertheless, carbon trading is not a complete solution regarding issues of climate change. Carbon-market effectiveness depends upon the environmental quality of carbon credits. Additionality, credible baselines, permanence, monitoring, reporting, verification and avoidance of double counting are essential.

India's Carbon Credit Trading Scheme represents an important step towards establishing a domestic carbon market. It has the potential to encourage emission-intensity improvements in industrial sectors and create incentives for investment in low-carbon technologies. A market can generate large volumes of trading without producing equivalent climate benefits if credits lack additionality or if baselines are poorly designed.

The success of carbon trading should not be measured by the number of carbon credits created or traded. It should be evaluated on the basis of the genuine additional emission reductions achieved at an economically reasonable cost.

Carbon credits and carbon trading can therefore become valuable instruments of climate-change mitigation, but only when markets are supported by credible science, strong institutions, transparent accounting and effective environmental regulation. Carbon trading should ultimately serve the broader objective of transforming economic production towards a low-carbon, resource-efficient and sustainable development pathway.

The following policy measures are important in this regard like- Strengthen measurement, Reporting and verification systems to ensure credible emission accounting, Genuine additionality, Prevent double counting, Development of the credible emission-intensity targets, Encouragement of low-carbon technological innovation, Safeguards for local communities in land-based and nature-related carbon projects, and Strengthen international cooperation while maintaining environmental integrity in international carbon transactions can boost-up our economy. In this regard, the better coordination between policy measures will be helpful to our society.

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