

Evaluating the Role of Carbon Pricing in India's Low-Carbon Transition

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1 Abstract

India faces the complex challenge of decarbonizing its fast-growing economy while ensuring social equity and continued development. The introduction of robust carbon pricing mechanisms—centrally the rate-based Carbon Credit Trading Scheme (CCTS)—marks a pivotal advance in climate policy, offering market-driven incentives for emissions reduction. This paper systematically explores the rationale for carbon pricing, traces the evolution of India's regulatory and market architecture from energy efficiency schemes to the formal CCTS regime, and evaluates scenario-based modelling evidence for its economic and environmental impacts. The analysis underscores that a moderate, gradually implemented carbon pricing strategy—anchedored in rigorous monitoring frameworks and revenue recycling to vulnerable populations—can enable India to achieve its climate targets while supporting just, equitable, and sustainable growth.

2 Problem Definition

India faces the urgent challenge of reconciling rapid economic expansion with its long-term climate commitments to reduce the emissions intensity of GDP by 45% by 2030 and reach net-zero by 2070. Despite progress through energy efficiency programs, renewable energy targets, and regulatory frameworks, these measures remain inadequate to drive the scale of decarbonization required. The absence of a uniform carbon pricing mechanism continues to distort market signals, leaving environmental externalities unpriced in economic decisions and weakening incentives for adopting low-carbon technologies across industries.

As India's energy consumption and industrial output surge, the lack of a price on carbon risks locking the economy into carbon-intensive pathways and heightens vulnerability to emerging international mechanisms like the EU's Carbon Border Adjustment. A structured and transparent carbon pricing framework—anchedored in the new Carbon Credit Trading Scheme and supported by robust market infrastructure—offers an opportunity to align economic growth with emissions reduction. Integrating carbon pricing into India's climate strategy is therefore essential to correct market failures, stimulate innovation, and mobilize domestic finance for a fair and sustainable low-carbon transition.

3 Objectives

This paper seeks to:

1. Present the theoretical and policy case for carbon pricing as a cornerstone of India's low-carbon strategy.
2. Synthesize findings from recent empirical modelling—including energy system, CGE, and macroeconomic approaches—to assess the impact of carbon pricing on emissions, growth, equity, and sectoral transition.
3. Examine India's evolving policy landscape, from legacy schemes (PAT, REC, Coal Cess) to newly operational frameworks under the CCTS and related legal amendments.
4. Analyze key implementation challenges—including sectoral readiness, market infrastructure, stakeholder resistance, and equity safeguards—to inform effective and inclusive carbon pricing design.
5. Recommend phased policy rollout, strategic revenue recycling, and global market integration to maximize environmental and socio-economic benefits, positioning India as a regional leader in sustainable climate action.

4 Introduction

The rising urgency of global climate change demands that nations adopt effective strategies to limit greenhouse gas emissions without compromising developmental goals. Carbon pricing—a broad term encompassing carbon taxes, emissions trading schemes (ETS), and carbon credit markets—has emerged as an effective market-based approach globally to incentivize emission reductions by internalizing the social cost of carbon [1]. By assigning a price to greenhouse gas emissions, carbon pricing aligns economic incentives with environmental sustainability and fosters innovation in clean technologies.

For India, the challenge is particularly pronounced. As the world’s third-largest emitter (Figure 1) and a rapidly developing economy with millions still dependent on fossil fuels for energy and livelihoods, policy instruments must balance environmental goals with poverty alleviation and economic growth [2]. India’s Nationally Determined Contributions (NDCs) under the Paris Agreement underscore this balancing act by committing to a substantial emissions intensity reduction and expansion of renewable energy capacity [3], as shown in Figure 2. However, existing policies such as Perform, Achieve, and Trade (PAT) and Renewable Energy Certificates (REC) schemes, while important, do not sufficiently internalize carbon costs or create broad incentives across all sectors [4].

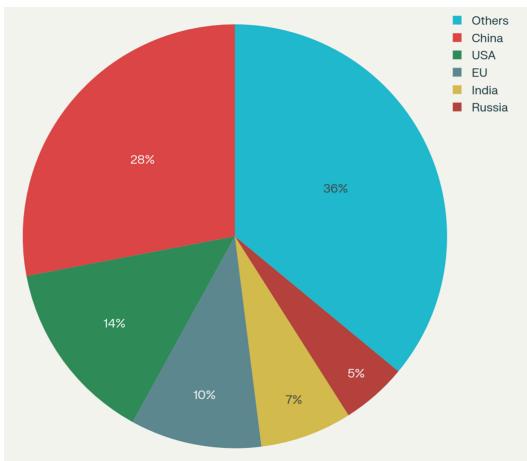


Figure 1: Global Greenhouse Gas Emissions by Country (% Share) for 2023, highlighting India as the third largest emitter [5]

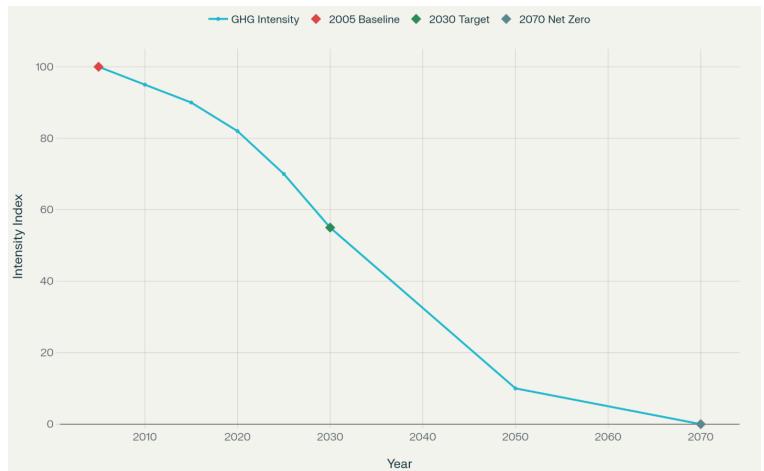


Figure 2: India’s GHG Emissions Intensity Reduction Trajectory (2005-2070), showing the target 45% reduction by 2030 and net-zero by 2070 [6]

This paper argues that instituting a carbon pricing mechanism adapted to India’s socio-economic realities is a critical step. Carbon pricing can complement existing policies by providing transparent price signals that encourage energy efficiency, cleaner fuels, and technological innovation. International examples show that well-designed carbon pricing yields environmental benefits alongside fiscal revenues that can fund social programs and amplify climate investments [7].

The following sections review the conceptual foundations of carbon pricing, analyze India’s policy evolution and regulatory framework, and examine evidence from recent modelling studies that simulate the impacts of carbon pricing on emissions, economic growth, and equity. We then discuss policy design, sectoral coverage, and institutional requirements, concluding with recommendations for a just and effective carbon pricing strategy in India.

5 Taxonomy of Carbon Pricing Frameworks

Carbon pricing is a market-based strategy globally adopted to combat climate change by assigning a monetary value to the carbon dioxide and other greenhouse gas emissions responsible for global warming. The core economic rationale is the “polluter pays” principle, which holds that those who emit greenhouse gases (GHGs) should bear the external cost of climate damage their emissions cause. By

internalizing these costs into production and consumption decisions, carbon pricing creates continuous incentives for actors to reduce their carbon footprint, invest in cleaner technologies, and innovate toward sustainability.

Figure 3 provides a structured taxonomy, highlighting both governmental and corporate frameworks and distinguishing between explicit and implicit carbon pricing instruments.

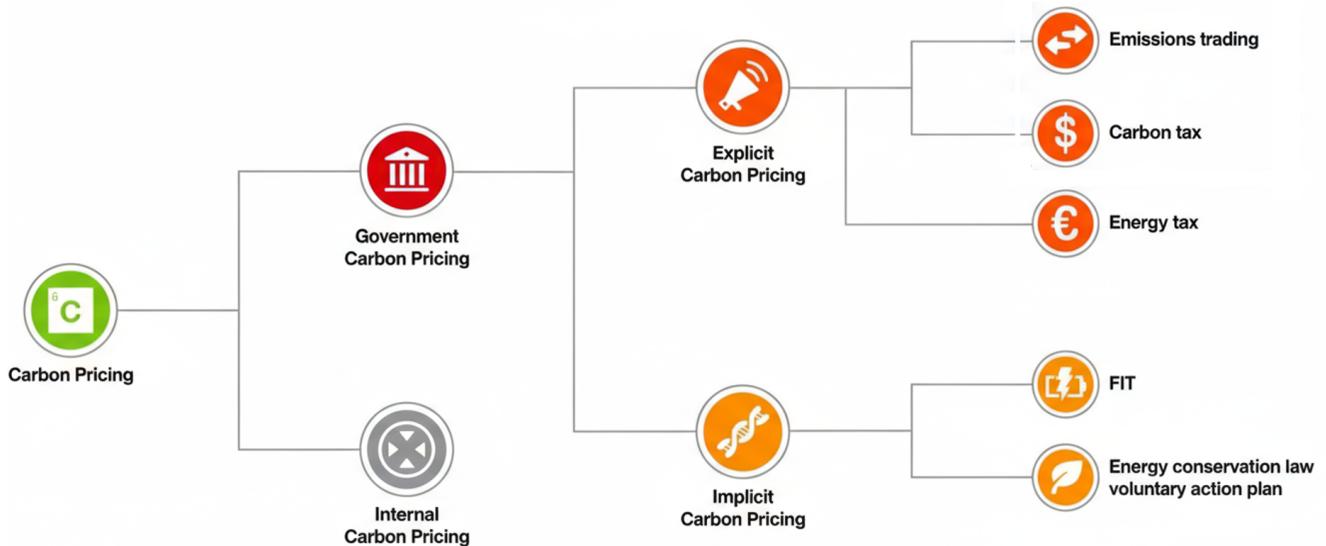


Figure 3: Classification of Carbon Pricing [8]

5.1 Government Carbon Pricing

Government carbon pricing policies are categorized as explicit or implicit, reflecting the directness with which they impose a cost on carbon emissions.

5.1.1 Explicit Carbon Pricing

These are instruments that quantify GHG emissions and directly assign a monetary value:

- **Emissions Trading System (ETS):** A cap-and-trade system in which the government defines an overall emissions ceiling for a group of emitters. Permits are distributed or auctioned, and trading among participants ensures emissions reductions occur wherever it's cheapest. The market sets the price, allowing flexibility and dynamic adjustment—but potentially with price volatility. Widely adopted by regions and countries including the European Union, China, California, Sweden, and Canada, ETS can be economy-wide or sector-specific depending on national circumstances.
- **Carbon Tax:** A fixed charge per tonne of CO₂ (or equivalent) released, applied upstream on fossil fuels or directly on emitters. Predictable and transparent, carbon taxes are praised for administrative simplicity but do not guarantee a specific emissions outcome—emission reductions depend on behavioral and technological responses at the prevailing tax rate.
- **Energy Tax:** This encompasses levies on energy consumption, commonly applied to fossil fuels. While not always termed as “carbon taxes,” these still indirectly put a price on emissions according to the fuel’s carbon content.

5.1.2 Implicit Carbon Pricing

Instruments that do not measure or price emissions directly, but which alter the relative attractiveness of low-carbon alternatives and create effective carbon prices:

- **Feed-In Tariff (FIT):** Governments designate fixed/premium prices for renewable energy generation, incentivizing deployment of clean power sources over carbon-intensive alternatives. FITs, by making renewables more competitive, implicitly penalize emissions in electricity generation.
- **Energy Conservation Law Voluntary Action Plan:** Regulatory frameworks (including energy efficiency standards) and voluntary industrial commitments can induce companies to cut emissions below required or baseline levels. These policies, statistically estimated via marginal abatement cost, generate an implicit price signal even where no formal carbon market exists.

5.2 Internal Carbon Pricing

Many corporations now set their own internal carbon prices to reflect regulatory risks, drive investment in efficiency, and show climate leadership. These self-imposed “shadow prices” range from modest notional values to higher figures used in capital budgeting and scenario analysis. Internal prices anticipate future regulation and can lead to earlier adoption of low-carbon solutions, aligning business strategies with long-term sustainability goals.

5.3 India’s Unique Approach: Carbon Credit Trading Scheme (CCTS)

India has pioneered an intensity-based Carbon Credit Trading Scheme (CCTS) that differs markedly from conventional cap-and-trade systems. Instead of imposing absolute limits, the CCTS assigns permissible emissions per unit of output for regulated facilities. Entities that exceed their efficiency benchmarks create tradable carbon credit certificates (CCCs), while underperformers must buy credits to comply. This system offers several critical advantages:

- **Supports Growth with Decarbonization:** Capping emissions intensity (not total level) allows expanding industries to increase output while staying within compliance by improving efficiency.
- **Accommodates Sectoral Diversity:** The system accounts for different technological, operational, and regional contexts across India’s economy.
- **Market Flexibility:** By enabling trading, CCTS incentivizes cost-effective reductions and rewards innovation, drawing from explicit carbon markets but with a rate-based methodology.

5.4 Global Variability and Lessons

Globally, carbon pricing systems are designed to reflect each country’s policy priorities and economic realities, as shown in Figure 4. Some advanced economies, such as Sweden and Canada, employ economy-wide carbon taxes due to their administrative simplicity and broad coverage, delivering predictable revenue streams and incentivizing emissions reductions across all sectors. The European Union’s Emissions Trading System (EU ETS) stands out for its comprehensive scope—covering power generation, heavy industry, and aviation—and has achieved significant emissions abatement at comparatively low cost by allowing firms flexibility to trade allowances. In contrast, emerging economies like China and Brazil have adopted intensity-based or sector-specific trading schemes, which balance the dual goals of industrial growth and climate action.

These global experiences highlight the need for careful market design, phased implementation strategies, transparent price signals, targeted revenue recycling, and robust monitoring, reporting, and verification (MRV) protocols to ensure both market effectiveness and public trust.

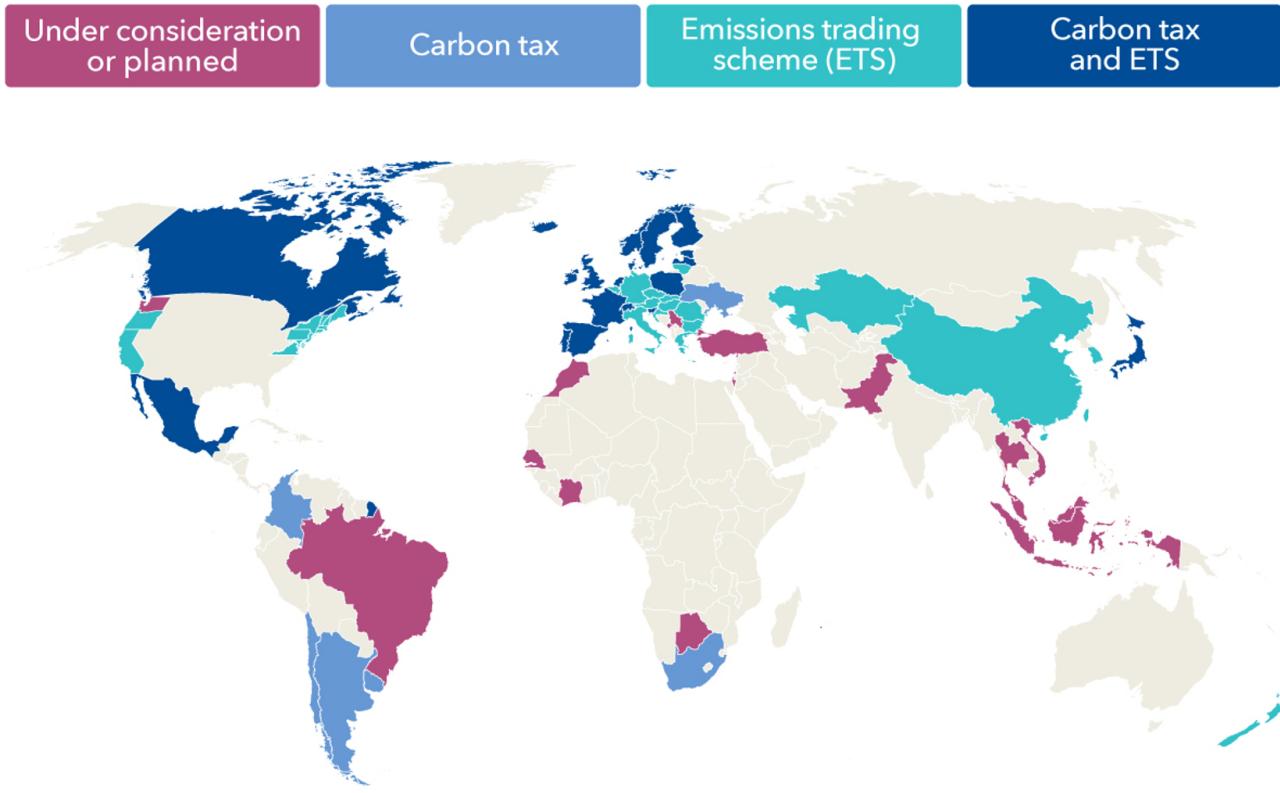


Figure 4: Global Scenario of Carbon Pricing Schemes [9]

6 Evolution of Carbon Pricing Policy in India

India's carbon pricing journey has evolved over the past decade from indirect and fragmented approaches to a structured, regulatory framework aimed at broad-based carbon market development.

The journey began with energy efficiency and renewable energy mandates, notably:

- **Perform, Achieve, and Trade (PAT) Scheme:** Launched in 2012 by the Bureau of Energy Efficiency (BEE) under the National Mission for Enhanced Energy Efficiency (NMEEE), PAT incentivized large industrial consumers to improve energy efficiency beyond mandated targets and allowed trading of excess Energy Saving Certificates (ES Certs) [10]. This market-based efficiency trading was a precursor to broader carbon credit schemes, proving the viability of market incentives in the Indian context.
- **Renewable Energy Certificates (REC):** Complementing PAT, the REC mechanism was designed to incentivize renewable electricity generation, enabling entities to meet renewable purchase obligations through market instruments [11].
- **Coal Cess (2010):** Introduced as India's first economy-wide implicit carbon tax, the coal cess was levied on coal production to fund clean energy and environmental programs [12]. While it successfully raised revenue and delivered a price signal, administrative challenges and its eventual integration into the Goods and Services Tax (GST) system diluted its carbon pricing impact.

A landmark legislative milestone was the passage of the *Energy Conservation (Amendment) Bill*, 2022, which institutionalized carbon markets by authorizing compliance and voluntary carbon credit trading mechanisms [13]. The Bill provides legal backing for carbon pricing, empowering the central government to specify industrial sectors for inclusion and to define emission intensity baselines.

Building on this framework, in July 2024 the Government of India formally adopted the *Carbon Credit Trading Scheme (CCTS)*, which consists of two pillars [14] (Figure 5):

- **Compliance Mechanism:** Mandates emission intensity targets for designated industrial sectors (including power, cement, steel, aluminum, and others). Facilities must hold enough Carbon Credit Certificates (CCCs) to cover their emissions relative to output. Overperforming entities generate credits they can sell; underperformers must buy credits to remain compliant.
- **Voluntary Mechanism:** Enables other entities—including businesses, municipalities, and individuals—to participate by undertaking emission reduction activities and generating tradable carbon credits recognized under the scheme.

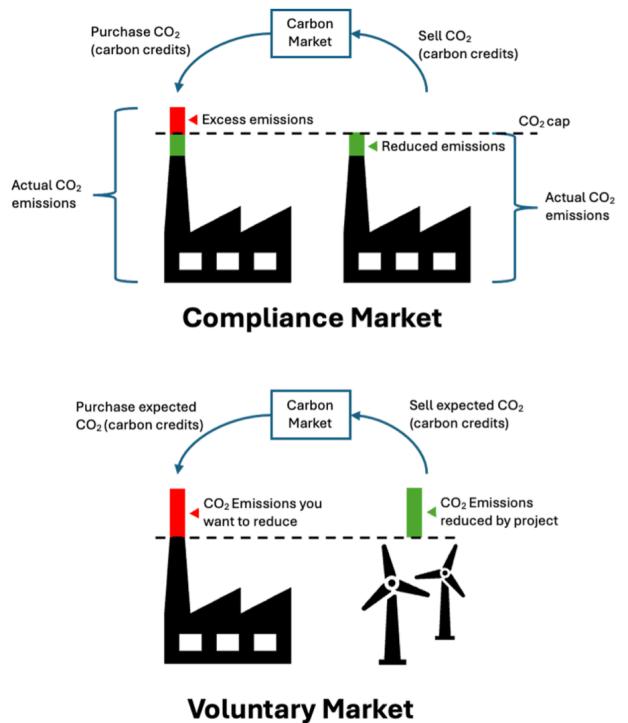


Figure 5: Compliance and Voluntary Schemes in Indian Carbon Market

The regulations provide detailed guidance on monitoring, reporting, and verification (MRV), establishing transparent registries and market oversight to ensure environmental integrity. The Bureau of Energy Efficiency (BEE) plays a central coordinating and regulatory role, supported by the Ministry of Power and other stakeholders.

India's choice of an intensity-based scheme rather than absolute emission caps aligns with its economic development priorities—allowing for output growth while incentivizing efficiency. This rate-based approach provides crucial flexibility for a rapidly industrializing economy, mitigating competitiveness concerns and enabling sector-specific trajectories.

The government plans to phase in coverage, starting with high-emission and energy-intensive sectors, and progressively expand as capability and market maturity increase. The CCTS framework is expected to harmonize with international carbon trading markets and global climate policies, positioning India to meet its NDC commitments and participate in emerging carbon finance landscapes.

7 Arguments for a Carbon Pricing Mechanism

The rationale for implementing a carbon pricing mechanism in India rests on multiple pillars, including economic efficiency, environmental effectiveness, policy flexibility, equity considerations, and international alignment.

- **Economic Efficiency:** Carbon pricing internalizes the negative externality of carbon emissions by assigning a cost to emitting activities. This incentivizes both producers and consumers to reduce emissions where it is cheapest to do so, thus achieving environmental goals at lower social cost than regulatory mandates or subsidies alone. By signaling the true cost of carbon, it shifts investment towards low-carbon technologies, energy efficiency, and cleaner fuels, fostering innovation and long-term structural transition.
- **Environmental Effectiveness:** Unlike fragmented policies that target specific sectors or technologies, carbon pricing covers a broad base and creates continuous incentives for emission reductions. India's emissions intensity-based trading scheme (CCTS) encourages firms to exceed benchmarks

and trade credits, providing flexibility and encouraging efficiency improvements without constraining growth.

- **Policy Flexibility:** Carbon pricing offers market-driven flexibility, allowing entities to determine cost-effective abatement levels based on their capabilities. This adapts well to India's diverse industrial landscape and varying energy mixes across states. Price signals can be adjusted over time to reflect technological progress, social cost updates, and international obligations.
- **Equity and Just Transition:** Carbon pricing, if poorly designed, can exacerbate inequities by raising energy prices and disproportionately affecting low-income households. However, India's extensive direct benefit transfer (DBT) infrastructure can channel revenues from carbon pricing to vulnerable groups, cushioning impacts and supporting job creation in emerging clean sectors. Thus, carbon pricing need not conflict with developmental equity but can actively promote a just transition.
- **International Integration:** As global climate policies tighten, companies face increasing exposure to carbon border adjustment mechanisms (CBAM) and international carbon markets. Implementing a domestic carbon pricing scheme prepares Indian industries for this global environment, enhances competitiveness, and opens opportunities for international carbon credit trading and investment.

Overall, carbon pricing sits at the intersection of economic rationality, environmental necessity, equity concerns, and international climate diplomacy, making it a compelling strategy for India's climate policy framework.

8 Modelling Evidence and Scenario Analysis

Quantitative models provide critical evidence on the potential impacts and efficacy of carbon pricing in India. Diverse methodologies, including integrated energy system simulation, macroeconomic input-output modelling, and computable general equilibrium (CGE) analysis, illuminate sectoral transitions, economic trade-offs, and policy design imperatives. The following table summarizes key findings, methodologies, and policy takeaways from prominent studies.

Table 1: Empirical Modelling Evidence on Economic and Environmental Implications of Carbon Pricing in India

Model Type	Study / Source	Key Findings	Policy Implications
Power Sector Modelling	Benitez et al. (2023) [15]	Moderate carbon prices ($\text{Rs. } 1500\text{--Rs. } 3000/\text{tCO}_2$) shift generation from coal to renewables and gas. Emission reductions are substantial, but grid reliability requires complementary policies (storage, demand management).	Supportive measures needed for managing renewable variability. Moderate carbon pricing effective for clean energy transition.

Table 1 (continued from previous page)

Model Type	Study / Source	Key Findings	Policy Implications
Macroeconomic Modelling	CSEP ESAM (2025) [16]	Carbon tax at Rs.2150/tCO ₂ reduces emissions intensity by 1% with minimal GDP impact (-0.22% to -0.33%). Revenue recycling via direct benefit transfers neutralizes regressive effects.	Revenue recycling essential for equity and social acceptance. Carbon tax feasible without large economic disruptions.
Computable General Equilibrium (CGE)	IEG (2022) [17]	Emission reductions of 5–7% achievable; energy-intensive sectors contract modestly while service and renewable sectors grow. Employment losses manageable with social policies.	Complement carbon pricing with active labor market policies to ensure a just transition.
Policy Insights	Synthesis	Sectoral phased approach, robust MRV and market governance	Phased implementation starting with high-emission sectors recommended. Transparent governance critical for market credibility. Institutional capacity and gradual sectoral expansion key for long-term success.

The table underscores that carbon pricing in India is not a one-size-fits-all instrument; its effectiveness is amplified when combined with complementary policies and robust governance. Phased sectoral implementation, transparent MRV systems, and institutional capacity are critical to ensure compliance, maintain market credibility, and foster public trust. The modelling consistently highlights that revenue recycling is essential—not only to mitigate regressive impacts but also to support investments in clean technologies and enable a just transition for affected workers.

Collectively, these insights emphasize that careful calibration of carbon price levels, thoughtful sequencing of sectoral coverage, and integration with existing energy and environmental policies can make carbon pricing a cost-effective, socially inclusive, and environmentally impactful tool. By adopting a flexible and adaptive approach, India can drive meaningful emission reductions while maintaining economic growth and strengthening the resilience of its low-carbon transition.

9 Challenges and Opportunities

India's transition to an effective carbon pricing regime presents a complex interplay of opportunities alongside significant challenges that must be strategically navigated to achieve long-term climate and development goals.

9.1 Sectoral Readiness and Market Infrastructure

Diverse industrial sectors in India exhibit varying levels of readiness to participate in carbon markets. Establishing robust Monitoring, Reporting, and Verification (MRV) systems is paramount to ensure accurate emissions tracking, prevent credit misuse, and maintain market integrity. The development of

essential infrastructure—such as transparent emission registries, efficient trading platforms, and effective dispute resolution frameworks—requires substantial scaling to foster investor confidence and broad-based participation. Current limitations in institutional capacity and technical expertise pose significant hurdles that policymakers need to address proactively.

9.2 Political Economy and Stakeholder Resistance

Resistance from fossil fuel-dependent industries and workers fearing economic dislocation and job losses remains a critical barrier. The political economy surrounding carbon pricing necessitates transparent stakeholder engagement and phased policy implementation to balance environmental ambitions with social acceptability. Targeted support mechanisms, including reskilling programs, social safety nets, and transitional financial assistance, will be vital to ease the burdens on vulnerable sectors and maintain momentum in policy adoption.

9.3 Equity Considerations

Ensuring the equitable distribution of carbon pricing’s socio-economic impacts is a cornerstone of India’s inclusive climate strategy. Carbon pricing can disproportionately affect poor and marginalized communities if left unmitigated. Implementing Direct Benefit Transfers (DBTs) [18], investing in clean energy job creation, skills training, and expanding access to affordable energy services are crucial strategies to safeguard social equity and enhance public buy-in. Failure to prioritize equity risks undermining political support and slowing the pace of climate action.

9.4 Innovation and Long-Term Economic Growth

Carbon pricing acts as a powerful catalyst for technological innovation and capital reallocation toward low-carbon solutions. By providing clear financial incentives, it stimulates private investment in clean energy, energy efficiency, and emerging technologies. This dynamic not only accelerates India’s decarbonization pathway but also creates new green industries and employment opportunities, positioning India as a global leader in sustainable development. Carbon pricing revenues further enhance fiscal space for expanded research and development, infrastructure modernization, and sustainable urbanization.

9.5 International Coordination

India’s engagement in global carbon markets and alignment with emerging mechanisms such as the European Union’s Carbon Border Adjustment Mechanism (CBAM) [19] strengthen the country’s export competitiveness in carbon-sensitive sectors like steel and cement. International cooperation facilitates technology transfer, capital inflows, and harmonization of measurement standards, enabling India to fulfill its Nationally Determined Contributions (NDCs) [6] effectively. However, integrating domestic markets with global systems also presents challenges involving regulatory compatibility, carbon leakage prevention, and diplomatic negotiation.

By proactively addressing these multifaceted challenges with strategic investments and inclusive policies, India can unlock the full transformational potential of carbon pricing. This will not only drive meaningful emission reductions but also support sustainable economic growth, social inclusion, and climate resilience in one of the world’s fastest-growing economies.

10 Conclusion

India stands at a pivotal moment in its climate journey, balancing ambitious development goals with the urgent need to reduce greenhouse gas emissions. This paper has demonstrated that carbon pric-

ing—implemented through carefully designed market-based mechanisms such as the Carbon Credit Trading Scheme (CCTS)—offers a powerful policy tool to align economic growth with environmental sustainability. Empirical and modelling evidence consistently indicate that moderate, carefully phased carbon pricing can deliver substantial emissions reductions across key sectors while maintaining stable economic growth and social equity.

However, realizing the full potential of carbon pricing requires overcoming significant challenges, including building robust institutional frameworks, ensuring stakeholder buy-in, addressing equity concerns, and investing in complementary infrastructures and governance systems. By proactively managing these complexities and seamlessly integrating carbon pricing within India’s broader climate, energy, and industrial policies, the country can promote innovation, attract sustainable investments, and enhance its global competitiveness. Ultimately, carbon pricing will be indispensable in enabling India’s transition to a resilient, low-carbon economy while fulfilling its international climate commitments and ensuring a just and inclusive development pathway.

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