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The price of carbon: Exploring the future of carbon pricing mechanisms

MS Apoorva[1], Arti Bhatia[1]*, Ashish Khandelwal[2]

[1]Division of Environmental Sciences, ICAR- IARI, New Delhi- 110012

[2]Marine Biotechnology, Fish Nutrition and Health Division, ICAR-CMFRI, Kochi - 682018

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*Corresponding Author
Arti Bhatia*

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INTRODUCTION

Carbon pricing emerged as an important tool to address the increasing concentration of green house gas(GHG) emissions in the atmosphere by assigning the monetary value to emissions and shifting the cost of environmental damage to the emitters. It helps in internalizing the cost of carbon pollution while incentivizing the low carbon emitters. Various mechanisms such as emission trading system, carbon taxes, hybrid instruments, internal pricing and baseline- credit system provides price certainty and market flexibility. Globally carbon pricing coverage has expanded significantly and currently one- fourth of emissions covered with increasing integration into the climate change related policies and agreements. EU's Carbon border adjustment mechanism (CBAM) is a pioneer initiative in this regard and digital tools like Artificial intelligence (AI) and blockchain technology will further enhance the transparency and flexibility. with some challenges still persists including low price, market volatility and equity concerns, future pricing lies in dynamic pricing models, revenue recycling and sector – specific expansion etc. As countries are now moving towards net- zero targets, carbon pricing becoming strategic asset for global decarbonization, sustainable development and climate resilience.

Key words: *Carbon pricing, Carbon tax, Emission trading, Net zero targets, Carbon border adjustment mechanism (CBAM)*

The price we are paying for increasing carbon dioxide in the atmosphere is huge which is often invisible yet highly noticeable. Changing carbon from pressing issue into an asset is a challenge but not impossible. Carbon pricing is one such thing which helps countries globally to fight against climate change and to become carbon neutral. This helps in not only earning credits but also to achieve sustainability. World bank defines carbon pricing as an approach that is used to reduce greenhouse gas emissions by assigning a cost to the emitting carbon dioxide and other greenhouse gases. By putting the price on carbon, this mechanism shifts the cost of environmental degradation towards protection of the environment. The fundamental principle associated with this is the polluter should pay for the damage caused by their emissions i.e. "Polluter Pay Principle" and providing economic benefits to the one who emits less which ensures equity. According to State and Trends of Carbon Pricing report (World bank 2025), 28% of the global emissions are now covered under direct carbon price compared to 5% in 2005 and 80 emission trading systems and carbon taxes are already implemented globally. The main drawback that the carbon pricing mechanisms facing now is price of carbon is very low but the buyers are more in number. Due to slow implementation, grassroots problems, funding issues and governmental and intergovernmental regulatory issues, carbon pricing mechanisms facing problem in its widescale adaptation. As countries in the world now focusing on meeting their climate targets under international agreements and commitments, carbon pricing is a central strategy to move towards the sustainable path. Carbon Border Adjustment Mechanism introduced by European union (EU) to ensure imported goods will also face the same carbon tax as goods produced within the EU is one of the advanced pricing systems currently operational in the world. The future of carbon pricing lies in integrated, cross-border and technology-driven mechanisms that go beyond simple taxation.

Types of carbon pricing

1. Emission Trading System (ETS)

It is also known as a cap and trade system which caps the total level of greenhouse gas emissions and allows those industries with low emissions to sell their extra allowances to larger emitters. By creating supply and demand for emissions allowances, an ETS establishes a market price for greenhouse gas emissions. The cap on emissions helps to ensure that the required emission reductions will take place to keep the emitters within their pre-allocated carbon budget. This mechanism ensures environmental certainty, cost-effectiveness and creates a carbon market and price signal while, carbon price volatility and complex monitoring and enforcement are the limitations.

2. Carbon tax

It directly sets a price on carbon by defining a tax rate on greenhouse gas emissions or more commonly on the carbon content of fossil fuels. The government sets a price per tonne of CO_2 emitted and companies must pay based on their emissions. Advantages of this pricing mechanism are high price certainty, simple to administer, encourages innovation and fuel switching, helps in generating the government revenue. Accurate emission measurement is the challenge associated with this mechanism because there is no guaranteed quantity of emission reduction. Historically, carbon pricing has mainly focused on the energy and industrial sectors. However, countries like Denmark will be the first to tax GHG emissions directly from the agricultural and livestock sectors by 2030.

3. Other types

a. Hybrid Instruments

Combines features of a carbon tax and ETS. These instruments may include an ETS with a price floor and ceiling or a carbon tax periodically adjusted to meet the emission targets. These approaches reduce the uncertainty for investors while maintaining environmental integrity. These are more complex to design and implement.

b. Baseline-and-credit:

This is also called as intensity-based carbon pricing system. In this approach, emissions are measured relative to an output-based benchmark like emissions per unit of production whether in terms of product or in terms of yield in case of agricultural products. Firms that perform better than the baseline earn tradable credits, while those that exceeds it must purchase credits. This

mechanism especially helpful for developing economy because it improves the emission efficiency allowing economic growth to continue.

c. Internal carbon pricing

It is a voluntary mechanism of incorporating the cost of carbon into investment planning, risk management and strategic decision making by firms. Firms uses a shadow price as an internal carbon fee or internal emissions trading to guide capital allocation toward low-carbon technologies. It will not directly reduce the national emissions due to its voluntary nature, but it plays an important supporting role by preparing businesses for future regulations.

Current status of carbon pricing in the world

The global reach of carbon pricing instruments has expanded considerably since the publication of the first *State and Trends of Carbon Pricing* report in 2013. At that time, carbon taxes and emissions trading systems covered only about 7% of GHG emissions (World Bank, 2013). This coverage had increased to approximately 23% of global emissions through 73 operational carbon pricing instruments worldwide by 2023 (World Bank, 2023). According to the World Bank's *State and Trends of Carbon Pricing 2024* report, carbon pricing has also become an important tool with revenues reaching a record of USD 104 billion (World Bank, 2024). India has played a significant role in mitigation efforts via carbon trade by registering the second highest number of Clean Development Mechanism (CDM) projects globally while, the Perform, Achieve and Trade (PAT) scheme has enabled the cumulative savings of more than 106 million tonnes of CO_2 emissions from 2015-2024 (Bureau of Energy Efficiency, 2024). China operates the world's largest ETS, although carbon prices were initially low, they have increased steadily since the launch of the national mandatory ETS since July 2021 now exceeding 100 yuan per tonne of CO_2 for the first time in 2024 (World Economic Forum, 2024). Finland was the first country globally to introduce a carbon tax and Uruguay recorded the highest carbon tax rate worldwide in April 2024 i.e. USD 167 per tonne of CO_2 equivalent, despite the tax covering only about 5% of national GHG emissions (Tiseo et al., 2024). However, significant policy imbalances still persists, as the International Monetary Fund (IMF) estimates that explicit fossil fuel subsidies amounted to around USD 1.3 trillion in 2022 which is far exceeding the revenues generated through carbon taxes and ETS (IMF, 2023). As of now, Carbon pricing is still at infant stage in India, although CCTS (Carbon Credit Trading Scheme) was notified in 2023 not yet fully operationalized and carbon credit market is largely private sector driven in India through voluntary carbon markets.

International Organizations and funds related to carbon pricing

Sl. no.	Organization	Role
1	World Bank	Through the Carbon Pricing Leadership Coalition (CPLC), the World Bank promotes the adoption of carbon pricing worldwide, sharing best practices and policy guidance.
2	International Emissions Trading Association (IETA)	A non-profit association focused on establishing the effective carbon markets and trading systems globally.
3	United Nations Framework Convention on Climate Change (UNFCCC)	Facilitates international climate agreements, including mechanisms under the Paris Agreement that support carbon pricing.
4	European Union (EU)	Operates the EU ETS which is world's largest carbon market, covering sectors like power, industry, and aviation.
5	Environmental Défense Fund (EDF)	Advocates for market-based climate solutions, including strong carbon pricing policies.
6	Carbon Disclosure Project	Works with companies and governments to disclose environmental impacts, including the use of internal carbon pricing strategies.

Benefits of carbon pricing

Carbon pricing incentivizes the emission reduction pathways that helps to limit the increase in global average temperature to well below 2°C above pre-industrial levels, while striving to restrict warming to 1.5°C in line with Paris agreement. By raising the cost of carbon-intensive technologies, it encourages the

businesses and individuals to seek more cost-efficient pathways to reduce the emissions there by stimulating the investment and innovation in clean and low carbon technologies. Carbon pricing also helps in achieving the Sustainable Development Goals (SDG) by directing the financial resources towards the sustainable development initiatives. In addition, it generates public revenue that can be reinvested in the green economy through government support for research and development (R&D), climate adaptation measures for vulnerable communities and policies that ease the socio-economic transition to a low carbon economy. Beyond emission reductions, carbon pricing delivers multiple benefits including improved public health from reduced air pollution, it enables the economic diversification and the creation of green jobs.

The Evolution of Pricing Instruments

1. Carbon Taxes and Emissions Trading Systems (ETS)

- **Carbon Taxes** sets a fixed price per ton of CO_2 or CO_2 equivalents emitted. This provides high certainty in price for businesses which allows them to calculate exactly how much their emissions will cost and plan investments for long-term accordingly. However, it comes with uncertainty about the quantity. If the tax is set too low, emissions may not decrease to the desired or intended level.
- **Emissions Trading Systems** sets a hard limit or cap on the total amount of emissions in terms of CO_2 equivalents allowed in a sector. The market will determine the price of permits. This provides certainty in quantity which ensures the cap or limit is met. However, the price of carbon can be highly volatile due to fluctuations in the economic growth, weather or any policy changes.

2. Hybrid Mechanisms

To address the weaknesses of both the systems, modern carbon markets are now adopting Hybrid Mechanisms that introduced the price controls into the trading systems.

- **Price Floor** is the minimum price for carbon. If market demand for permits decrease during the circumstances like economic recession, the price floor ensures that the cost of polluting doesn't fall too low and maintains a constant drive for green innovation.
- **Price Ceilings** are introduced to protect the industries from sudden and extreme price spikes because it sets a maximum price. If the market price hits this level, the regulator releases additional permits to increase supply and drive the price back down. By adding these features, an ETS behaves more like a tax during periods of less demand and more like a cap during high demand which prevents the market volatility that discourages the investment.

3. Revenue Recycling and Carbon Dividends

Primary barrier to the future of carbon pricing is high carbon prices which often faces public resistance due to the increased energy costs.

- **Revenue Recycling:** The money collected from the carbon prices is recycled back into the economy rather than just disappearing into the general government budget.
- **Carbon Dividends:** Money collected from the carbon pricing will be directly paid to the citizens usually as payments to offset any increase in energy or commodity prices due to the imposition of carbon tax.
- **Ensuring Social Equity:** Lower income households spend a larger percentage of their income on energy though they contribute smaller to the total carbon footprint than wealthy individuals hence a flat dividend to them results in a net financial gain for the bottom 60-70% of earners which ensures the equity.
- **Political Viability:** By turning tax into dividend, governments can maintain high carbon prices to reduce the carbon footprint while building a lasting popular move for the climate action, as the public sees it as a direct tangible benefit in their bank accounts.

4. Digital Integration

Blockchain and artificial intelligence (AI) are further boosting the implementation through tracking and real time data management. Digital integration is redefining the carbon markets by

integrating the immutability of blockchain with the analytical power of AI to create a transparent and high integrity ecosystem. Blockchain serves as a decentralized system and real time ledger that assigns a unique digital identity to every carbon credit, effectively eliminating the risk of double-counting and frauds while using "smart contracts" for automatic transactions and bypass the costly intermediaries. In complementary to this, AI optimizes the market by processing huge datasets such as satellite images and Internet of things (IoT) sensor feeds to verify emission reductions with speed and accuracy in order to reduce the verification times from months to hours. Together, these technologies democratize the access for smaller participants and provide the real-time data-driven accountability which is essential for scaling global climate finance towards the Net Zero targets and climate neutrality.

Future of carbon pricing mechanisms

1. Global Expansion and Harmonization

Efforts are needed to link carbon markets across borders. Carbon Border Adjustment Mechanisms (CBAM) are critical components as they represent transition from domestic carbon pricing to international trade linked climate policy. For example, CBAM of European Union will tax imports based on their carbon content, pushing global trading partners to adopt their own carbon pricing to stay motivated to reduce the emissions and also the EU ETS could connect with other regional markets which will create a more unified global carbon price. CBAM encourages non- EU countries to implement their own carbon pricing systems so that they can keep their tax revenue domestically rather than watching it collected at the border of EU countries through CBAM. Preventing the Carbon Leakage is very important to prevent industries from moving their production to the countries with lesser environmental regulations i.e. pollution havens. Leveling the playing field ensures that domestic manufacturers who pays a carbon price via tax or ETS or any other form, are not at the disadvantage against foreign producers who do not. Many developing nations view CBAMs as a trade barrier which is potentially contributing to the disputes within the World Trade Organization (WTO) but it's a model for future carbon pricing across borders. The future of CBAM depends on standardized Global Carbon Accounting (GCA). Although it is very difficult to accurately verify or to calculate the "embedded emissions" of complex manufactured goods like cars or electronics as opposed to raw materials like steel, there is a huge space for developing the methods to enhance the accuracy of the current methodologies as well as finding the new ways of accounting.

2. Rising Carbon Prices

To meet ambitious climate goals, carbon prices will increase. Experts suggest that prices may need to reach $100–$150 per ton of CO_2 by 2030 to drive deep decarbonization. This will create more space for earning credits which further pushes towards the sustainability.

3. Market Volatility

As carbon markets grows, there might be price fluctuations influenced by policy changes, economic conditions and technology breakthroughs, especially in volatile sectors like renewable energy. A mechanism is needed to ensure the stability of carbon market.

4. Integration with Corporate Strategies

Many companies are adopting their own "shadow carbon prices" to prepare for regulatory risks and sustainable investments. Carbon pricing will increasingly tie to corporate ESG (Environmental, Social, Governance) goals, influencing supply chains, investment decisions, and stakeholder reporting. This will help to tackle the emissions at entity/ business level.

5. Sector-Specific Pricing

Hard-to-abate sectors like aviation, shipping, agriculture, and construction are now gradually being included in carbon pricing schemes. In India, where agriculture is predominantly practiced, is the area where more carbon credits can be earned by the farmers which is win- win strategy economically.

6. Dynamic Pricing Models

Future mechanisms should adjust prices in real-time based on factors like energy demand, emission levels or technological shifts. Different sectors demand different pricing models so dynamic pricing models could help in better way to tackle price volatility.

7. Technological and Digital Innovations

Technologies like blockchain will improve the Monitoring, Reporting, and Verification (MRV) of emissions which will make carbon markets more transparent and efficient. AI tools could optimize trading strategies, forecast price trends and identify cost-effective decarbonization pathways for businesses.

8. Equity and Just Transition

As carbon prices rise, concerns about affordability especially for vulnerable communities, will grow. Future carbon pricing systems will likely include revenue recycling strategies such as carbon dividends or targeted subsidies. Developing countries may demand more support through carbon finance mechanisms to balance economic growth with climate action.

CONCLUSION

Carbon pricing has emerged as one of the most powerful economic instruments for addressing the climate change. It helps in shifting the burden of environmental degradation to polluters while rewarding low emitters ensures the principle of equity and drives behavioural change across governments, industries and agriculture. Although challenges such as low carbon prices, market volatility, regulatory complexity and uneven global adoption limit its full potential, the growing coverage of emissions under carbon pricing mechanisms signals strong shift in the momentum towards sustainability. Higher and more harmonized carbon prices, integration with corporate strategies, sector-specific approaches and advances in digital technologies will strengthen the effectiveness of carbon markets. If designed and implemented carefully, carbon pricing can move beyond being a policy tool to become a cornerstone of global climate action transforming carbon from an environmental liability into an economic driver for a sustainable and low-carbon future. The future of carbon pricing lies in integrated, cross-border, and technology-driven carbon pricing mechanisms that go beyond simple taxation and ensuring equity.

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