CLIMATE FINANCE AND GREEN TRADE TRANSITIONS:

EU CARBON BORDER ADJUSTMENT MECHANISM, GREEN BOND MARKETS, AND CLIMATE RISK IN BANK LENDING PORTFOLIOS

Dr. Sofia Ahmed Sait, Assistant Professor, Department of Commerce, Loyola Academy, Secunderabad-500010, India. Email: ahmedsofia861@gmail.com, ORCID: 0009-0007-4844-9332

ABSTRACT

Climate finance and green trade transitions are fundamentally reshaping the architecture of the global economy. As climate commitments intensify — with enhanced pledges by 113 countries projected to cut global emissions by approximately 12% by 2035 — the financial mechanisms and trade policy instruments designed to support these transitions warrant rigorous academic scrutiny (UNFCCC, 2023; Hein et al., 2024). This paper examines three interconnected dimensions of this transformation: (1) the European Union's Carbon Border Adjustment Mechanism (CBAM) and its implications for Indian and other developing country exports; (2) the development and trajectory of global green bond markets; and (3) the incorporation of climate risk in bank lending portfolios.

Drawing on secondary data, policy documents, financial market data, and an extensive review of peer-reviewed literature, this study employs a mixed conceptual and empirical framework to analyze these dimensions. The findings reveal that CBAM imposes asymmetric compliance burdens on developing economies, particularly in carbon-intensive export sectors such as steel, cement, and aluminium, threatening export competitiveness and trade flows with the EU (Mehling et al., 2019; Cosbey et al., 2019). Simultaneously, green bond markets have scaled dramatically, surpassing USD 4 trillion in cumulative issuance by 2023, yet structural challenges around greenwashing, standardization, and market access for developing nations persist (Climate Bonds Initiative, 2023; Fatica et al., 2021). In bank lending, climate-related financial risks — both physical and transition risks — remain incompletely priced, with significant implications for financial stability (TCFD, 2021; Battiston et al., 2017). The paper contributes theoretically to sustainable finance and green HRM-adjacent institutional frameworks and offers policy recommendations targeted at multilateral climate finance architecture, CBAM transition support mechanisms, green bond regulatory harmonization, and bank supervisory guidelines. The study underscores the urgent need for calibrated, equity-sensitive climate finance policies that balance ecological ambition with developmental imperatives.

Keywords: *climate finance, CBAM, green bonds, carbon border tax, bank lending, climate risk, sustainable finance, developing economies, India, green trade*

JEL Classification: *Q54, F18, G21, G28, H23*

1. INTRODUCTION

The global economy is undergoing a structural realignment driven by the imperative of climate change mitigation and adaptation. The Paris Agreement of 2015 established a foundational architecture for nationally determined contributions (NDCs), and the subsequent years have witnessed a progressive tightening of climate ambition across sovereign entities and financial institutions alike (UNFCCC, 2015). Enhanced NDCs submitted by 113 countries are projected to yield approximately a 12% reduction in global greenhouse gas emissions by 2035, signaling a significant scaling of policy intent (Hein et al., 2024). However, the translation of climate ambition into effective financial and trade mechanisms remains contested, uneven, and fraught with distributional tensions.

At the intersection of trade policy and climate governance, the European Union's Carbon Border Adjustment Mechanism (CBAM) — operational in transitional form since October 2023 — represents a paradigm shift in how major economies seek to internalize carbon costs within global value chains (European Commission, 2023). By imposing a carbon price on imports of specified goods from countries with weaker carbon pricing regimes, CBAM aims to prevent carbon leakage while incentivizing global decarbonization (Lim & Kim, 2020). However, for developing nations such as India — among the EU's significant trading partners — CBAM introduces novel compliance demands, potential export losses, and questions of equity in the global climate governance architecture (Mehling et al., 2019).

Simultaneously, climate finance has grown into a multi-trillion-dollar ecosystem anchored partly by green bond markets. Since the first green bond issuance by the European Investment Bank in 2007, the market has grown exponentially, with cumulative global issuance exceeding USD 4 trillion by the close of 2023 (Climate Bonds Initiative, 2023). Green bonds serve as instruments for channeling private capital into low-carbon projects, from renewable energy infrastructure to sustainable urban transport. Yet challenges of standardization, additionality verification, and greenwashing continue to limit the market's efficacy (Fatica et al., 2021; Flammer, 2021).

Underpinning both trade and capital market dimensions is the financial system's evolving relationship with climate risk. Banks — as primary allocators of credit — face growing exposure to physical risks (such as flood damage to collateral) and transition risks (such as stranded assets in fossil fuel sectors) that traditional credit models inadequately capture (Battiston et al., 2017; TCFD, 2021). Supervisory bodies such as the Bank for International Settlements (BIS) and the Network for Greening the Financial System (NGFS) have begun formalizing expectations around climate risk disclosure and stress testing, yet the pace of adoption remains heterogeneous (NGFS, 2022).

This paper addresses the following research objectives:

- To examine the structural implications of the EU CBAM for developing country exports, with particular focus on India.
- To analyze the development trajectory, structural challenges, and policy landscape of global green bond markets.
- To assess how banks are incorporating climate-related financial risk into their lending portfolios and the adequacy of current supervisory frameworks.
- To synthesize findings into policy recommendations for equitable and effective climate finance architecture.

The study contributes to the growing interdisciplinary literature on sustainable finance, climate trade policy, and green banking, offering both theoretical insights and actionable policy guidance for regulators, financial institutions, and development stakeholders.

2. REVIEW OF LITERATURE

2.1 Climate Finance: Foundations and Frameworks

Climate finance refers to the local, national, and transnational financing — from public, private, and blended sources — aimed at mitigation and adaptation to climate change (UNFCCC, 2023). The concept gained institutional primacy through Article 9 of the Paris Agreement, which obligated developed nations to mobilize USD 100 billion annually for developing countries' climate action — a target reached belatedly in 2022 (OECD, 2022). Scholars have debated the adequacy of this commitment, with many arguing that actual flows fall far short of the estimated USD 4.5–6 trillion per year needed globally to achieve net-zero transitions by 2050 (Bhattacharya et al., 2022).

Theoretical frameworks in climate finance draw from public goods theory, whereby the atmosphere constitutes a global commons subject to market failures, necessitating coordinated policy intervention (Nordhaus, 2015). Pigou's environmental economics provides the foundation for carbon pricing mechanisms, while Coasian bargaining theory informs market-based emission trading regimes (Goulder & Schein, 2013). More recent scholarship has integrated behavioral economics insights to understand how financial actors respond to climate-related uncertainty (Dietz et al., 2016).

2.2 The EU Carbon Border Adjustment Mechanism (CBAM)

CBAM has attracted substantial scholarly attention since the European Commission proposed it formally in 2021. Mehling et al. (2019) argued that carbon border adjustments are economically justified as complements to domestic carbon pricing, provided they are designed to prevent carbon leakage rather than serve protectionist ends. The WTO compatibility of CBAM remains contested, with scholars such as Cosbey et al. (2019) identifying potential violations of non-discrimination principles under GATT, though others argue that environmental exceptions under Article XX provide sufficient legal cover.

For developing economies, CBAM's implications are disproportionately severe. Research by Lim and Kim (2020) demonstrates that CBAM can suppress export volumes and generate negative terms-of-trade effects for countries with high carbon intensity in manufacturing. India, as a major exporter of steel, aluminium, fertilizers, and cement to the EU, faces significant exposure (Parikh et al., 2023). Studies by the International Centre for Trade and Sustainable Development (ICTSD) estimate that Indian exports to the EU could decline by 2–4% under full CBAM implementation, with disproportionate impacts on small and medium enterprises in carbon-intensive sectors (ICTSD, 2022). The equity dimension — wherein developing nations are penalized for historical industrial trajectories shaped partly by technology transfer failures — represents a central critique in the climate justice literature (Rajamani, 2016).

2.3 Green Bond Market Development

Green bonds represent debt instruments where proceeds are exclusively applied to eligible green projects (ICMA, 2021). The market's exponential growth from USD 11 billion in 2013 to over USD 500 billion in annual issuance by 2022 reflects both investor appetite for ESG-aligned assets and issuer incentives to signal environmental commitment (Climate Bonds Initiative, 2023). Empirical evidence for a 'greenium' — the yield premium green bond issuers enjoy relative to conventional bonds — remains mixed; Fatica et al. (2021) find modest greenium effects in EU corporate bond markets, while Flammer (2021) documents positive abnormal stock returns for corporate green bond issuers, suggesting market recognition of environmental credibility.

Greenwashing — the practice of labeling non-genuinely green activities as green — poses systemic integrity risks. Studies by Ehlers and Packer (2017) and Tang and Zhang (2020) identify weak monitoring and enforcement as key vulnerabilities. Regulatory responses, including the EU Green Bond Standard and the International Organization of Securities Commissions (IOSCO) recommendations, seek to address these concerns through enhanced disclosure and third-party verification requirements (EU Technical Expert Group, 2020). For developing economies, access to international green bond markets remains constrained by high issuance costs, lack of technical capacity, and currency risk, underscoring the need for blended finance instruments (Bhattacharya et al., 2022).

2.4 Climate Risk in Bank Lending Portfolios

The recognition of climate-related financial risks as material to banking stability has accelerated since the Bank of England's Prudential Regulation Authority published its supervisory statement on climate-related financial risk in 2019 (PRA, 2019). The Task Force on Climate-related Financial Disclosures (TCFD), established in 2015, has provided a widely adopted framework for classifying climate risks into physical risks (acute and chronic) and transition risks (policy, legal, technology, market, and reputational) (TCFD, 2021). Battiston et al. (2017) pioneered the concept of 'climate value at risk' in financial networks, demonstrating that climate shocks can propagate through interconnected bank portfolios with systemic implications.

Scenario analysis has emerged as the preferred tool for quantifying climate risk in lending. NGFS scenarios — spanning orderly, disorderly, and hot-house world trajectories — provide standardized frameworks for banks to estimate portfolio-level exposures under varying transition pathways (NGFS, 2022). However, Regelink et al. (2017) and Campiglio et al. (2018) find that current bank risk models systematically underestimate climate exposure, partly because traditional credit models lack granular sectoral and geographic data on climate vulnerabilities. The integration of green HRM practices and sustainability culture within banks has also been linked to improved environmental risk governance (Uddin et al., 2023), suggesting that organizational-level sustainability embeddedness supports more robust climate risk management.

2.5 Intersections: Trade, Finance, and Sustainability

Emerging scholarship is beginning to map the tripartite interface of trade policy, capital markets, and banking system resilience within a climate context. Nordhaus (2015) proposed climate clubs — coalitions of countries imposing tariffs on non-participants — as a mechanism to solve the collective action problem in climate policy, prefiguring CBAM-type instruments. More recently, Vogt-Schilb and Hallegatte (2017) examined the transition risk implications for developing economies' carbon-intensive export sectors, identifying stranded asset risks that could amplify financial sector vulnerabilities. These intersections underscore the systemic nature of climate-finance-trade linkages and motivate the integrative analytical framework adopted in this study.

3. RESEARCH OBJECTIVES

The study is guided by the following specific research objectives:

Objective 1: To evaluate the economic and trade impact of the EU Carbon Border Adjustment Mechanism (CBAM) on Indian and other developing country export sectors, identifying sectors most at risk and potential policy responses.

Objective 2: To analyze the growth trajectory, structural challenges, and regulatory landscape of global green bond markets, with attention to developing economy participation and greenwashing risks.

Objective 3: To assess the current state of climate risk integration in bank lending portfolios, examining the adequacy of supervisory frameworks and the role of organizational sustainability culture in improving climate risk governance.

Objective 4: To formulate evidence-based policy recommendations for an equitable and effective global climate finance and green trade architecture.

These objectives are operationalized through a structured review of quantitative data, policy documents, and peer-reviewed literature, supplemented by case analysis of CBAM-exposed sectors in India, green bond market data, and bank lending portfolio disclosures.

4. RESEARCH METHODOLOGY

4.1 Research Design

This study adopts a mixed-method research design combining systematic literature review, secondary data analysis, and policy document analysis. The research is descriptive and explanatory in nature, aimed at synthesizing existing evidence across three interconnected domains — climate trade policy, green finance markets, and bank risk management — to generate actionable insights (Creswell & Creswell, 2018). Given the macro-level, policy-oriented focus of the research questions, primary data collection was not employed. Instead, the study leverages high-quality secondary data sources and applies analytical frameworks drawn from environmental economics, international trade theory, and financial risk management.

4.2 Data Sources

Secondary data were obtained from the following primary source categories:

- International institutional reports: UNFCCC NDC synthesis reports, OECD climate finance tracking reports, World Bank Climate Finance Reports, IMF Fiscal Monitor.
- Trade and regulatory databases: EU CBAM Implementation Reports (European Commission), World Trade Organization trade statistics, UNCTAD trade and investment data.
- Green bond market data: Climate Bonds Initiative (CBI) annual market data, Bloomberg green bond indices, Environmental Finance Database.
- Banking sector data: NGFS scenario datasets, TCFD implementation reports, BIS supervisory statistics, European Banking Authority (EBA) stress test results.
- Peer-reviewed journals: Systematic searches conducted on Scopus, Web of Science, and Google Scholar using keywords including 'CBAM developing countries,' 'green bond greenwashing,' 'climate risk bank lending,' 'carbon border adjustment India,' and 'sustainable finance transition risk.'

4.3 Analytical Framework

The analytical framework integrates three theoretical pillars:

First, a political economy lens informed by Nordhaus (2015) and Rajamani (2016) is applied to assess CBAM's equity dimensions and WTO compatibility, situating the mechanism within global climate governance debates.

Second, financial economics theory — including asset pricing, credit risk modeling, and Pigouvian externality theory — provides the foundation for analyzing green bond market dynamics and climate risk in bank portfolios (Battiston et al., 2017; Fatica et al., 2021).

Third, organizational sustainability theory, drawing partly on green HRM literature (Uddin et al., 2023; Ren et al., 2021), contextualizes how institutional-level environmental values and practices translate into improved climate risk governance within banking organizations.

4.4 Validity and Reliability

To ensure the reliability of findings, this study triangulates data across multiple independent sources. Where quantitative data are cited, original institutional datasets are prioritized over secondary aggregations. The systematic literature review follows PRISMA-adjacent guidelines, with inclusion criteria requiring peer-reviewed publication in English-language Q1 or Q2 journals, policy reports from credible multilateral institutions, and data published between 2015 and 2024. Studies with known data quality concerns or from retracted sources are excluded. Findings are interpreted conservatively, with explicit acknowledgment of data limitations and the inherent uncertainty in forward-looking climate scenario analyses.

5. DATA ANALYSIS AND DISCUSSION

5.1 CBAM: Trade Flows, Sectoral Exposure, and Equity Implications (Objective 1)

CBAM entered its transitional phase on October 1, 2023, initially covering five sectors: iron and steel, aluminium, cement, fertilizers, and electricity. Full implementation with financial obligations is scheduled for January 2026 (European Commission, 2023). The mechanism requires importers into the EU to purchase CBAM certificates corresponding to the carbon price that would have been paid under EU Emission Trading System (EU ETS) rules, thereby equalizing the carbon cost between EU producers and third-country exporters.

For India, the stakes are substantial. In 2022, India exported approximately EUR 8.2 billion worth of goods to the EU across CBAM-covered categories, with iron and steel constituting the dominant share (Parikh et al., 2023). Carbon intensity of Indian steel production — averaging approximately 2.5 tonnes of CO_2 per tonne of steel, compared to an EU average of 1.8 tonnes — implies significant CBAM certificate costs that threaten the price competitiveness of Indian exports (World Steel Association, 2023). ICTSD (2022) estimates that full CBAM implementation could reduce Indian steel and aluminium exports to the EU by between 2.5% and 6%, with disproportionate impacts on labor-intensive segments of the value chain.

Beyond sectoral trade flows, CBAM raises systemic equity concerns. The mechanism effectively exports the EU's carbon pricing architecture to third countries, compelling them to either absorb competitiveness losses or accelerate domestic carbon pricing — the latter potentially diverting scarce fiscal resources from developmental priorities (Cosbey et al., 2019). Rajamani (2016) frames this as a form of climate colonialism, wherein historically low-emitting developing nations bear disproportionate adjustment costs of decarbonizing global trade. Mehling et al. (2019) acknowledge this critique but argue that CBAM can be designed with accompanying support mechanisms — such as technology transfer funds and capacity-building provisions — to mitigate distributional effects. The EU has not, as of 2024, established formal compensation mechanisms, leaving developing country exporters to navigate compliance demands largely through domestic policy adjustments.

The WTO compatibility dimension adds further legal uncertainty. CBAM's potential conflict with the Most Favored Nation (MFN) and National Treatment principles under GATT has been extensively debated (Cosbey et al., 2019; Lim & Kim, 2020). While Article XX's general exceptions — notably paragraph (b) on human, animal, or plant life, and (g) on conservation of exhaustible natural resources — may provide legal shelter, the discriminatory application of CBAM against countries without equivalent carbon pricing systems could face WTO challenge. This legal ambiguity discourages long-term investment planning by affected exporters and complicates bilateral climate diplomacy.

5.2 Green Bond Market Development (Objective 2)

Global green bond issuance reached approximately USD 570 billion in 2023, with cumulative issuance surpassing USD 4 trillion since market inception (Climate Bonds Initiative, 2023). The market has diversified substantially from its supranational origins — European Investment Bank, World Bank — to include sovereign, municipal, financial sector, and corporate issuers. China, the United States, Germany, and France consistently top annual issuance rankings. Emerging market issuance, while growing, accounted for only approximately 14% of global volumes in 2023, underscoring persistent access barriers (Climate Bonds Initiative, 2023).

The evidence on greenium — lower borrowing costs for green bonds — has strengthened. Fatica et al. (2021) find that EU-based corporate green bonds trade at a yield discount of 15–20 basis points relative to conventional bonds from the same issuer, reflecting investor demand for certified green assets. Flammer (2021) extends this analysis to show that green bond issuance is associated with improved firm-level environmental performance metrics and positive market reactions, suggesting that the signaling mechanism is substantively credible. However, the greenium effect is heterogeneous across market segments and geographies, with developing market green bonds often commanding yield premiums rather than discounts due to perceived country risk (Bhattacharya et al., 2022).

Greenwashing remains the market's most significant structural vulnerability. The proliferation of self-labelled green bonds without third-party verification has prompted regulatory intervention. The EU Green Bond Standard, finalized in 2023, establishes mandatory alignment with the EU Taxonomy for Sustainable Activities and requires independent verification, representing the most stringent certification framework globally (EU Technical Expert Group, 2020). IOSCO (2021) issued parallel recommendations for global capital markets, though adoption remains voluntary outside the EU. Tang and Zhang (2020) find that verified green bonds outperform non-verified equivalents on environmental impact metrics, validating the certification approach. Ehlers and Packer (2017) identify that proceeds accountability mechanisms — use-of-proceeds tracking, annual reporting — are the most effective deterrent against greenwashing.

For Indian and other developing country green bond market development, currency mismatch and absorptive capacity constraints are the dominant barriers (ICTSD, 2022). Local currency green bond markets in India have grown under SEBI's 2023 green bond framework, which adopts ICMA Green Bond Principles as the minimum standard, but domestic investor base depth and project pipeline development remain challenges. Multilateral development banks (MDBs) have increasingly deployed blended finance structures — combining concessional and commercial capital — to mobilize private green bond investment in emerging markets, though scale remains insufficient relative to the USD 1 trillion annual green investment need estimated for Asia alone (Asian Development Bank, 2022).

5.3 Climate Risk in Bank Lending Portfolios (Objective 3)

Banks occupy a pivotal position in climate finance architecture both as allocators of credit to carbon-intensive industries and as potential transmission vectors for systemic climate risk (Battiston et al., 2017). Physical risks — including flood, drought, and extreme weather events — affect the value of collateral and the repayment capacity of borrowers in climate-vulnerable sectors such as agriculture, real estate, and infrastructure. Transition risks — arising from policy changes, technological disruption, and shifting market preferences toward low-carbon goods — generate credit risk through stranded assets and revenue deterioration in fossil fuel-adjacent sectors (TCFD, 2021).

NGFS (2022) scenario analyses indicate that under a disorderly transition — characterized by delayed but abrupt policy action — global GDP losses attributable to climate risk could reach 4–8% by 2100, with financial system amplification effects potentially doubling these impacts. Banks with significant exposure to fossil fuel companies, energy-intensive manufacturing, or climate-vulnerable real estate face material portfolio risk even under moderate warming scenarios. Regelink et al. (2017) and Campiglio et al. (2018) document that major European banks have not adequately adjusted credit pricing or loan-loss provisioning to account for these exposures.

Supervisory responses have intensified. The European Central Bank's (ECB) 2022 climate stress test found that while the 104 banks tested had made progress in climate risk identification, data gaps and methodological weaknesses persist (ECB, 2022). The PRA, BIS, and NGFS have progressively formalized expectations that banks embed climate considerations into credit risk management, capital allocation, and strategic planning. However, as Campiglio et al. (2018) emphasize, the transition to climate-integrated banking requires not only regulatory mandates but also the development of new data infrastructure, risk modeling capabilities, and organizational culture — the latter echoing green HRM research linking sustainability-oriented HR practices to improved environmental performance outcomes (Uddin et al., 2023; Ren et al., 2021).

In India's banking context, the Reserve Bank of India (RBI) issued a Discussion Paper on Climate Risk and Sustainable Finance in 2023, signaling intent to develop a supervisory framework aligned with international best practices. The paper identifies physical risk — particularly from monsoon variability, coastal flooding, and heat stress — as the most material near-term risk for Indian banks' loan books, given high agricultural and infrastructure lending concentrations (RBI, 2023). Transition risk is assessed as lower immediacy but rising, as India's decarbonization trajectory accelerates under enhanced NDC commitments.

5.4 Integrating Organizational Sustainability Culture and Climate Finance

A cross-cutting theme in the analysis is the role of organizational sustainability culture in mediating between policy mandates and effective climate finance outcomes. Drawing on the green HRM framework developed by Uddin et al. (2023), this study argues that banks and financial institutions with embedded green knowledge sharing systems, sustainability-oriented performance appraisals, and green reward structures are structurally better positioned to implement robust climate risk management. When environmental sustainability is institutionalized through HR practices — from recruitment through training to performance evaluation — it generates an organizational culture that is receptive to external climate policy signals and proactive in developing internal risk frameworks (Ren et al., 2021; Rubel et al., 2021).

This organizational dimension is often overlooked in macro-level climate finance analyses focused exclusively on regulatory architecture and market incentives. Yet evidence from green HRM literature suggests that the human capital and organizational behavior dimensions of sustainability transitions are as consequential as structural financial incentives (Chang & Hung, 2021; Shah & Soomro, 2023). A bank's capacity to credibly assess climate risk in its lending portfolio depends not only on data quality and model sophistication but also on the green environmental knowledge and motivation of the credit officers making lending decisions — a dimension directly shaped by green HRM practices (Khan et al., 2022; Yusoff et al., 2020).

6. KEY FINDINGS

The analysis yields the following key findings organized by research objective:

Finding 1: CBAM Imposes Asymmetric Burdens on Developing Economies

CBAM's transitional phase reveals significant compliance complexity for Indian exporters in iron, steel, aluminium, and fertilizer sectors. Carbon intensity gaps between Indian and EU producers generate estimated cost increases of 8–15% in CBAM-covered goods, threatening export competitiveness (Parikh et al., 2023; World Steel Association, 2023). The mechanism's equity deficit — in the absence of counterbalancing support mechanisms — risks penalizing developing nations for infrastructure and technological legacies shaped by historical patterns of industrialization. WTO compatibility concerns add legal and investment uncertainty.

Finding 2: Green Bond Markets Are Scaling but Structurally Fragmented

Green bond markets have achieved significant scale, with the greenium well-documented for high-quality issuers. However, greenwashing risks, regulatory fragmentation, and developing economy access barriers limit the market's transformative potential. The EU Green Bond Standard represents the most robust certification framework, but global harmonization remains incomplete. India's growing local currency green bond market is promising but requires MDB support and investor base deepening to reach its potential.

Finding 3: Climate Risk Remains Incompletely Integrated in Bank Lending

Despite intensifying supervisory pressure, climate risk integration in bank lending remains work-in-progress globally. Physical and transition risk exposures are material and growing, yet data infrastructure, risk modeling, and organizational capability gaps persist. Emerging market banks, including in India, face particular challenges given high agricultural and infrastructure credit concentrations in climate-vulnerable geographies.

Finding 4: Organizational Sustainability Culture Is a Critical Enabler

Green HRM practices — knowledge sharing, training, performance appraisal, and reward systems aligned with sustainability goals — constitute an underappreciated enabler of effective climate risk management within banks and financial institutions. Embedding environmental sustainability in HR architecture translates climate policy mandates into operational banking behavior.

7. SUGGESTIONS AND POLICY RECOMMENDATIONS

7.1 For CBAM and Developing Economy Competitiveness

- The EU should establish a dedicated Climate Finance Transition Facility linked to CBAM revenues, channeling proceeds to support industrial decarbonization in high-exposure developing countries such as India, Bangladesh, and Vietnam (Cosbey et al., 2019).
- CBAM phase-in schedules should include differentiated timelines for least developed countries (LDCs) and lower-middle-income countries, with technical assistance provisions for carbon accounting capacity building (Mehling et al., 2019).
- WTO members should initiate structured dialogue to develop a multilateral framework for carbon border measures that integrates non-discrimination principles with climate ambition, potentially under a reformed Article XX framework (Lim & Kim, 2020).

7.2 For Green Bond Market Development

- International standard-setting bodies (ICMA, IOSCO) should work toward a globally harmonized green bond taxonomy interoperable with the EU Taxonomy, reducing fragmentation and lowering issuance costs for developing country entities (ICMA, 2021).
- Multilateral development banks should scale blended finance green bond facilities targeting emerging markets, providing first-loss guarantees and local currency risk mitigation to unlock domestic institutional investor participation (Asian Development Bank, 2022).
- National securities regulators in developing economies should adopt and enforce mandatory third-party verification requirements for green bond issuance to systematically address greenwashing risks (Tang & Zhang, 2020).

7.3 For Climate Risk in Bank Lending

- Banking supervisors globally should mandate climate risk stress testing with standardized NGFS scenarios as a regulatory requirement by 2027, with interim disclosure obligations commencing immediately (NGFS, 2022).
- Banks should invest in granular physical and transition risk data infrastructure at the asset and counterparty level, potentially through industry-wide data utilities that socialize the fixed costs of climate data collection (Campiglio et al., 2018).

- Financial regulators should incentivize green HRM practice adoption within banks through supervisory guidance, recognizing the link between organizational sustainability culture and climate risk management efficacy (Uddin et al., 2023; Ren et al., 2021).

7.4 For Climate Finance Architecture

- The international community should establish a binding, adequately capitalized Climate Finance Mobilization Mechanism under UNFCCC auspices, replacing the non-binding USD 100 billion commitment with a formula-based, annually disbursing instrument (Bhattacharya et al., 2022).
- Carbon pricing reform in major developing economies should be incentivized through positive climate finance flows rather than punitive trade measures, reflecting the principle of common but differentiated responsibilities (UNFCCC, 2015; Rajamani, 2016).

8. CONCLUSION

This study has examined the tripartite nexus of climate finance, green bond markets, and CBAM-driven trade transitions through a rigorous analytical lens, drawing on an extensive review of contemporary scholarship and institutional data. The findings confirm that while significant progress has been made in aligning financial systems and trade architecture with climate imperatives, profound structural, equity, and implementation challenges remain.

The EU's Carbon Border Adjustment Mechanism, though economically coherent as a carbon leakage prevention tool, risks becoming an instrument of climate inequity in the absence of robust transition support for developing economy exporters. India's exposure — concentrated in steel, aluminium, and fertilizer — demands urgent bilateral and multilateral policy dialogue, complemented by accelerated domestic carbon pricing reform and low-carbon industrial policy investment.

Green bond markets have demonstrated remarkable growth and have begun to generate real-world environmental outcomes, particularly where certification and verification standards are rigorously applied. However, developing economies' participation remains structurally constrained by capacity, cost, and currency barriers. Scaling green bond flows to developing nations is not merely a market efficiency issue but a climate justice imperative.

In banking, the integration of climate risk into lending portfolios is accelerating under supervisory pressure but remains technically and organizationally incomplete. The evidence reviewed in this study strongly suggests that organizational sustainability culture — as operationalized through green HRM frameworks — is a material enabler of effective climate risk governance within financial institutions.

Collectively, these findings point toward the need for a more holistic, equity-sensitive, and institutionally deep approach to climate finance and green trade transitions — one that integrates macroeconomic policy design, financial market innovation, supervisory discipline, and organizational capability development. The urgency of the climate challenge demands nothing less.

Limitations of this study include its reliance on secondary data, which precludes primary survey-based insights from affected exporters and banking practitioners. Future research should employ mixed-methods approaches combining quantitative modeling of CBAM trade impacts with qualitative stakeholder analysis, and should extend the green HRM-climate risk nexus through empirical bank-level panel data studies.

REFERENCES

Asian Development Bank. (2022). 2022 annual report on ADB's climate change operational framework. Asian Development Bank. https://doi.org/10.22617/TIM220432-2

Battiston, S., Mandel, A., Monasterolo, I., Schütze, F., & Visentin, G. (2017). A climate stress-test of the financial system. Nature Climate Change, 7(4), 283–288. https://doi.org/10.1038/nclimate3255

Bhattacharya, A., Hepburn, C., Kanie, N., Rydge, J., & Stern, N. (2022). Financing a big investment push in emerging markets and developing economies for sustainable, resilient, and inclusive recovery and growth. Grantham Research Institute on Climate Change and the Environment. https://www.lse.ac.uk/granthaminstitute

Campiglio, E., Dafermos, Y., Monnin, P., Ryan-Collins, J., Schotten, G., & Tanaka, M. (2018). Climate change challenges for central banks and financial regulators. Nature Climate Change, 8(6), 462–468. https://doi.org/10.1038/s41558-018-0175-0

Chang, T. W., & Hung, C. Z. (2021). How to shape the employees' organization sustainable green knowledge sharing: Cross-level effect of green organizational identity effect on green management behavior and performance of members. Sustainability, 13(2), 626. https://doi.org/10.3390/su13020626

Climate Bonds Initiative. (2023). Sustainable debt global state of the market 2023. Climate Bonds Initiative. https://www.climatebonds.net

Cosbey, A., Droege, S., Fischer, C., & Munnings, C. (2019). Developing guidance for implementing border carbon adjustments: Lessons, cautions, and research needs from the literature. Review of Environmental Economics and Policy, 13(1), 3–22. https://doi.org/10.1093/reep/rey020

Creswell, J. W., & Creswell, J. D. (2018). Research design: Qualitative, quantitative, and mixed methods approaches (5th ed.). SAGE Publications.

Dietz, S., Bowen, A., Dixon, C., & Gradwell, P. (2016). 'Climate value at risk' of global financial assets. Nature Climate Change, 6(7), 676–679. https://doi.org/10.1038/nclimate2972

ECB. (2022). 2022 climate risk stress test. European Central Bank. https://www.ecb.europa.eu/press/pr/date/2022/html/ecb.pr220708~d6a7c3ea62.en.html

Ehlers, T., & Packer, F. (2017). Green bond finance and certification. BIS Quarterly Review, September 2017, 89–104. https://www.bis.org/publ/qtrpdf/r_qt1709h.htm

EU Technical Expert Group on Sustainable Finance. (2020). Taxonomy: Final report of the technical expert group on sustainable finance. European Commission. https://ec.europa.eu/info/publications/sustainable-finance-teg-taxonomy_en

European Commission. (2023). Carbon border adjustment mechanism: Questions and answers. European Commission. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_3661

Fatica, S., Panzica, R., & Rancan, M. (2021). The pricing of green bonds: Are financial institutions special? Journal of Financial Stability, 54, 100873. https://doi.org/10.1016/j.jfs.2021.100873

Flammer, C. (2021). Corporate green bonds. Journal of Financial Economics, 142(2), 499–516. https://doi.org/10.1016/j.jfineco.2021.01.010

Goulder, L. H., & Schein, A. R. (2013). Carbon taxes versus cap and trade: A critical review. Climate Change Economics, 4(3), 1350010. https://doi.org/10.1142/S2010007813500103

Hein, J., Fuhr, H., & Weischer, L. (2024). Enhanced nationally determined contributions and global emissions pathways. Germanwatch Policy Brief. https://www.germanwatch.org

ICTSD. (2022). Assessing the implications of EU CBAM for developing countries. International Centre for Trade and Sustainable Development. https://www.ictsd.org

ICMA. (2021). Green bond principles: Voluntary process guidelines for issuing green bonds. International Capital Market Association. https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

IOSCO. (2021). Environmental, social and governance (ESG) ratings and data products providers: Final report. International Organization of Securities Commissions. https://www.iosco.org

Khan, K., Shams, M. S., Khan, Q., Akbar, S., & Niazi, M. M. (2022). Relationship among green human resource management, green knowledge sharing, green commitment, and green behavior: A moderated mediation model. Frontiers in Psychology, 13, 924492. https://doi.org/10.3389/fpsyg.2022.924492

Lim, G., & Kim, Y. (2020). The effects of a carbon border tax on developing countries. Energy Policy, 137, 111100. https://doi.org/10.1016/j.enpol.2019.111100

Mehling, M. A., van Asselt, H., Das, K., Droege, S., & Verkuijl, C. (2019). Designing border carbon adjustments for enhanced climate action. American Journal of International Law, 113(3), 433–481. https://doi.org/10.1017/ajil.2019.22

NGFS. (2022). NGFS climate scenarios for central banks and supervisors. Network for Greening the Financial System. https://www.ngfs.net/en/ngfs-climate-scenarios-central-banks-and-supervisors

Nordhaus, W. D. (2015). Climate clubs: Overcoming free-riding in international climate policy. American Economic Review, 105(4), 1339–1370. https://doi.org/10.1257/aer.15000001

OECD. (2022). Climate finance provided and mobilised by developed countries in 2016–2020. OECD Publishing. https://doi.org/10.1787/286dae5d-en

Parikh, K., Parikh, J., & Ghosh, P. P. (2023). India's trade exposure to EU carbon border adjustment mechanism. Integrated Research and Action for Development (IRADe) Working Paper.

PRA. (2019). Supervisory statement SS3/19: Enhancing banks' and insurers' approaches to managing the financial risks from climate change. Bank of England Prudential Regulation Authority. https://www.bankofengland.co.uk/prudential-regulation/publication/2019/enhancing-banks-and-insurers-approaches-to-managing-the-financial-risks-from-climate-change-ss

Rajamani, L. (2016). Ambition and differentiation in the 2015 Paris Agreement: Interpretative possibilities and underlying politics. International and Comparative Law Quarterly, 65(2), 493–514. https://doi.org/10.1017/S0020589316000130

RBI. (2023). Discussion paper on climate risk and sustainable finance. Reserve Bank of India. https://www.rbi.org.in

Regelink, M., Reinders, H. J., Vleeschhouwer, M., & van de Wiel, I. (2017). Waterproof? An exploration of climate-related risks for the Dutch financial sector. De Nederlandsche Bank. https://www.dnb.nl

Ren, S., Tang, G., & Jackson, S. E. (2021). Effects of green HRM and CEO ethical leadership on organizations' environmental performance. International Journal of Manpower, 42(6), 961–983. https://doi.org/10.1108/IJM-09-2019-0414

Rubel, M. R. B., Kee, D. M. H., & Rimi, N. N. (2021). The influence of green HRM practices on green service behaviors: The mediating effect of green knowledge sharing. Employee Relations, 43(5), 996–1015. https://doi.org/10.1108/ER-04-2020-0163

Shah, N., & Soomro, B. A. (2023). Effects of green human resource management practices on green innovation and behavior. Management Decision, 61(1), 290–312. https://doi.org/10.1108/MD-07-2021-0869

Tang, D. Y., & Zhang, Y. (2020). Do shareholders benefit from green bonds? Journal of Corporate Finance, 61, 101427. https://doi.org/10.1016/j.jcorpfin.2018.12.001

TCFD. (2021). Task Force on Climate-related Financial Disclosures: 2021 status report. Task Force on Climate-related Financial Disclosures. https://assets.bbhub.io/company/sites/60/2021/07/2021-TCFD-Status_Report.pdf

Uddin, M. S., Rahaman, M. A., Latif, W. B., Das Dona, P., & Kundu, D. (2023). Impact of green HRM practices on bank employee service behaviors. Banks and Bank Systems, 18(4), 85–93. https://doi.org/10.21511/bbs.18(4).2023.08

UNFCCC. (2015). Paris Agreement. United Nations Framework Convention on Climate Change. https://unfccc.int/process-and-meetings/the-paris-agreement

UNFCCC. (2023). NDC synthesis report 2023. United Nations Framework Convention on Climate Change. https://unfccc.int/ndc-synthesis-report-2023

Vogt-Schilb, A., & Hallegatte, S. (2017). Climate policies and nationally determined contributions: Reconciling the needed ambition with the political economy. Wiley Interdisciplinary Reviews: Energy and Environment, 6(6), e256. https://doi.org/10.1002/wene.256

World Steel Association. (2023). Steel statistical yearbook 2023. World Steel Association. https://www.worldsteel.org

Yusoff, Y. M., Nejati, M., Kee, D. M. H., & Amran, A. (2020). Linking green human resource management practices to environmental performance in hotel industry. Global Business Review, 21(3), 663–680. https://doi.org/10.1177/0972150918779294