The Climate-Trade–Globalization Nexus: A Panel Analysis of SAARC Economies

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ABSTRACT

Globalization has significantly boosted economic growth and facilitated closer international ties, but it also presents major environmental challenges particularly climate change for transitioning SAARC economies. Recognizing the relationships between climate change, trade, and globalization, this study aims to explore these interrelationships specifically among SAARC countries, covering the post reform period from 1991 to 2023.

Using panel data regression techniques, the study finds that climate change, measured through both CO_2 emissions and temperature rise, significantly influences trade dynamics, while temperature variations also exert a strong positive effect on globalization. These results suggest that climate change is not only an environmental outcome but also a key economic force shaping patterns of trade and global integration in climate-vulnerable SAARC economies which are characterized by high trade dependence and limited adaptive capacity.

Contrary to most previous studies that analyze these dimensions in isolation, this study integrates these dimensions into a unified empirical framework and captures the direct environmental impact more comprehensively by using both CO_2 emissions and temperature rise as indicators of climate change within the context of SAARC economies, an area that remains relatively underexplored. Additionally, the study uniquely treats globalization not only as a causal factor but also as an outcome variable, highlighting how climate change can influence the degree of global integration.

KEYWORDS: *Globalization, climate change, carbon emission, greenhouse gases, Global Warming, global networks, global trade, SAARC economies*

INTRODUCTION

Rising global temperatures and increasing carbon emissions are increasingly reshaping international trade patterns and economic integration. Globalization brings many opportunities, like economic growth and cultural exchange, but it also comes with challenges such as environmental strain. While the surge in global trade and industrial activity boosts economic growth, it also tends to increase carbon emissions and energy consumption which are key drivers of global warming.

Climate change is no longer just an environmental issue. Globalization further amplifies these challenges by linking economies through complex supply chains, meaning that disruptions in one region can quickly spread worldwide (European Central Bank, 2024). This makes climate change a truly global issue. Rising temperatures, extreme weather events and changing environmental conditions are reshaping global trade by disrupting supply chains, damaging critical infrastructure, affecting health of both people and nature (Leslie, J. 2022; FAO, 2022). For example, droughts affecting key trade routes like the Panama Canal and floods disrupting major economies highlight the vulnerability of global trade (Reuters, 2023; World Economic Forum, 2021). While new opportunities, such as emerging Arctic shipping routes, are appearing, they also bring geopolitical and environmental concerns (Gricius, 2021). This complex network of trade makes less resilient economies, particularly the SAARC countries, more vulnerable to global disruptions (Wang, D. 2024).

Thus, increasing global warming contributes to greater fragility in global trade systems. These dynamics have significant economic implications, as climate-induced disruptions to trade and globalization can affect economic growth, undermine stability, and exacerbate global and regional inequalities especially in the developing and less developed economies. So, addressing problems of climate change requires countries to work together, just like they do in trade or global cooperation. Additionally, climate policy tools—like carbon border taxes and green trade agreements—are increasingly merging environmental priorities with trade regulation, affecting tariffs and market entry (Kenney. 2023). Globalization intensifies these dynamics by connecting far-flung economies via intricate supply chains, meaning that environmental shocks in one region can ripple across continents (European Central Bank.2024). The challenge is finding a balance: to enjoy the benefits of globalization and trade while making sure we

protect the environment for future generations.

Majority of the existing studies look at climate change, trade, and globalization separately or focus mainly on developed countries which creates a research gap. Also, there is very limited research that examines how these three factors are connected, especially in SAARC countries, which are highly vulnerable to climate change and heavily dependent on trade. Furthermore, while many studies use CO_2 emissions to measure environmental impact, fewer consider temperature rise as a direct indicator of climate change. Most studies treated globalization as a cause, not as something that can be affected by climate change. This study addresses these gaps by integrating climate change, trade, and globalization into a unified empirical framework, with a specific focus on SAARC economies. It argues that climate change, measured not only through CO_2 emissions but also temperature variation, fundamentally alters trade dynamics and the trajectory of globalization in climate-vulnerable economies

LITERATURE REVIEW

The accelerating pace of climate change, largely driven by CO_2 emissions, has brought into sharp focus the intricate relationship between environmental degradation, international trade, and globalization. Empirical evidence shows that in many middle-income countries, rising energy use and the growth of industrial and service sectors are major contributors to CO_2 emissions (Sohag et al. 2017). Given the inherent transboundary nature of climate change, its consequences ripple beyond environmental concerns to influence global economic systems and trade dynamics. A growing body of literature has explored these connections, highlighting the multidimensional and interdependent nature of climate, trade, and globalization.

Existing studies indicate that climate change disrupts trade both directly and indirectly (Buettner and Kotlovinas 2013). Rising global temperatures and associated climate change not only creates environmental concerns but also disrupts productivity, food security, and export earnings particularly in agriculture-dependent economies by damaging infrastructure, reducing agricultural output, and interrupting supply chains (FAO 2022; Reuters 2023). Furthermore, extreme weather events also interfere with major trade routes and logistics, increasing costs and delays (Yemane et al. 2021). However, much of this research focuses on short-term disruptions, with limited attention to long-term structural adjustments.

Another important issue discussed in the literature is *carbon leakage*, where industries shift production to countries with weaker environmental regulations (Kemet et al. 2004). Changes in temperature influence labor productivity and sectoral performance, trigger long-term structural shifts in global trade by recalibrating the economic viability of different sectors and regions (IPCC, 2023). While carbon leakage is often attributed to stringent environmental policies, it is difficult to isolate its effects from other economic determinants of industrial relocation, such as labor costs, market size, and supply chain efficiency.

Globalization plays a dual role. While globalization creates opportunities by accelerating industrialization and increasing trade volume (Arca's & Elger, 2013), factors like trade openness, population growth, and economic expansion are closely connected and together drive long-term increases in emissions (Kebede 2018). Technology transfer, driven by trade and international cooperation, is seen as a middle-ground strategy to decarbonize economies and foster sustainable development. Therefore, while globalization is a major emanation of greenhouse gases, it could potentially be a route to climate adaptive strategy and conduct if trade agreements are executed to the desires of environmental demands. These findings suggest that economic growth and trade expansion must be supported by integrated planning and sustainability-focused strategies (Rasaq, 2015).

In recent years, there has been a noticeable shift toward regionalization, where global supply chains are increasingly reorganized into regional networks. This shift has been influenced by the COVID-19 pandemic and rising geopolitical uncertainties, but it is also considered as a potential strategy to reduce emissions by shortening supply chains and reducing transport-related carbon footprints. However, the environmental benefits of regionalization are not always straightforward. In some cases, domestic production in carbon-intensive economies may generate higher emissions than importing goods from more efficient producers abroad. This highlights that emissions depend not only on distance but also on production technology and energy sources.

In response to these challenges, global institutions increasingly emphasize the need to integrate climate policies into trade frameworks. Policy instruments such as carbon pricing, climate-resilient infrastructure, and sustainable trade practices are gaining prominence (Brenton and Chemutai, 2021; World Bank, 2025). Mattoo et al. (2009) stress that while climate policy tools such as carbon pricing, border adjustment taxes, and emissions trading aim to internalize the external costs of carbon emissions, they introduce new challenges for international competitiveness especially for developing nations which often rely on energy-intensive exports. In this context, stricter climate policies in developed countries may constrain market

access for developing countries, potentially exacerbating global economic inequalities.

In this context, international cooperation becomes essential. Through global cooperation and trade, countries can share cleaner technologies, adopt sustainable practices, and work together through international agreements (OECD, 2023). Flexible policy mechanisms, such as emissions trading and cross-border permit systems, can improve the overall efficiency of emission reduction efforts (Kemfert et al. 2001). Thus, aligning trade policies with environmental goals is not just necessary, but increasingly unavoidable in a climate-affected global economy.

The SAARC region illustrates these challenges clearly. Despite being highly vulnerable to climate change, regional environmental cooperation remains limited. Strengthening cooperation through climate-aligned trade policies, green logistics corridors, and shared infrastructures such as sustainable regional ports can reduce emissions while promoting economic integration. Overall, while regionalization offers potential environmental benefits, its effectiveness depends on coordinated policy frameworks and stronger regional cooperation.

Therefore, the literature reviewed underscores the interdependency between climate change, CO_2 emissions, and international trade. While international trade can exacerbate environmental pressures through increased industrial activity and emissions, it also offers pathways for mitigation and adaptation through policy innovation, technology transfer, and multilateral cooperation. The future of global trade systems must consider these dual roles and actively work towards embedding sustainability within economic frameworks.

Overall, the literature highlights a complex and bidirectional relationship between climate change, trade, and globalization. While several studies analyzed the disruptive effects of climate change on trade, limited consensus exists on the magnitude and direction of these effects, particularly in developing SAARC economies. While trade expansion contributes to environmental degradation, it also provides avenues for mitigation through technological diffusion and policy coordination. However, the lack of integrated empirical analyses particularly for climate-vulnerable regions such as SAARC limits a comprehensive understanding of this nexus, thereby justifying the present study.

Theoretical Framework

This study is grounded in the view that climate change and economic globalization are interlinked through

trade, production patterns, and environmental externalities. The theoretical foundation integrates the Environmental Kuznets Curve (EKC), Pollution Haven Hypothesis, and globalization–environment nexus to explain how climate variables influence trade and globalization in SAARC economies. Environmental Kuznets Curve (EKC) explains relationship between economic growth and environmental degradation, suggesting an inverted U-shaped trajectory in which emissions rise during early stages of development but decline after a certain income threshold. In the context of SAARC economies, which largely lie on the upward-sloping segment of the EKC, trade expansion and industrialization continue to exert upward pressure on CO_2 emissions, although globalization also offers pathways for technological upgrading and eventual decarbonization. The Pollution Haven Hypothesis explains how differences in environmental regulations influence global trade patterns and emissions distribution. According to this hypothesis, pollution-intensive industries tend to relocate from countries with strict environmental policies to those with more lenient regulations, often developing economies. For regions like SAARC, this implies that increased trade openness may attract environmentally harmful industries and intensify local environmental degradation while allowing developed countries to maintain lower domestic emissions levels.

Based on these hypotheses, the study assumes that environmental degradation, measured through CO_2 emissions and global temperature rise, affects economic integration and trade performance. This relationship is captured through two econometric models:

Model 1: Trade Equation

$$Trade_{it} = \alpha_1 + \beta_1 CO2_{it} + \beta_2 GlobalTemperature_{it} + \epsilon_{it}$$

This model is theoretically supported by the EKC and Heckscher–Ohlin framework, which suggest that a) Rising economic activity increases energy use and emissions in early development stages, b)Trade expansion in labor- and energy-intensive sectors raises environmental pressure and c) climate shocks (temperature rise) affect production efficiency, supply chains, and trade flows. Thus, trade is expected to respond to changes in environmental conditions, either through production shifts, supply disruptions, or adaptive demand changes.

Model 2: Globalization Equation

$$Globalization_{it} = \alpha_2 + \mu_1 CO2_{it} + \mu_2 GlobalTemperature_{it} + \nu_{it}$$

This model is based on globalization theory and the climate–economy feedback framework, which explain that a) CO_2 emissions reflect industrialization levels associated with global integration. b) Temperature rise influences economic openness through trade disruptions, policy coordination, and adaptive globalization responses and c) Globalization may both respond to and reinforce environmental changes through technology transfer and international cooperation

Combining both equations, the study proposes a two-channel relationship. First the direct climate effect which shows how CO_2 emissions and temperature rise directly influence trade and globalization outcomes. Secondly, structural economic channel which shows that climate change alters production efficiency, comparative advantages, and supply chain stability, which in turn reshapes trade intensity and global integration. At the same time, globalization and trade expansion may indirectly reinforce environmental pressures, creating a feedback loop between economic integration and climate change.

This framework implies that in SAARC economies

- Climate change is not only an environmental outcome but also an economic determinant.
- Trade and globalization are both dependent variables influenced by climate conditions
- The relationship is dynamic, interdependent, and reinforced through economic activity and environmental feedback effects

Objective of the Paper

The primary objective of this study is to examine the dynamic relationship between climate change (CO_2 emissions), international trade, and globalization, with a specific focus on understanding how The results show environmental risks influence trade performance and economic integration in SAARC economies. Based on the theoretical framework, the following hypotheses are proposed:

- **H1:** CO_2 emissions and temperature rise have a significant direct association with trade in SAARC economies.
- **H2:** Temperature rise has a positive association with globalization in SAARC economies.
- **H3:** CO_2 emissions have a significant effect on globalization in SAARC economies.

Data and Methodology

This study uses an exploratory research design to investigate the intricate relationship between climate change and globalization, particularly focusing on trade. The study is based on 8 Asian countries who are part of SAARC association namely Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka. The time frame considered is the post reform period from 1991-2023. The study is based on secondary data taken from World Bank database, academic Journals and Government (RBI) Reports. The study analyses data for globalization measured using globalization index, CO_2 emission (measured in kt), Global temperature (represented by average temperature), and trade as (% of GDP) for justifying the objective. Since the data is both time series and cross sectional, hence panel data regression is done using STATA software. The regression considered two different Alternate hypothesis and Null hypothesis, keeping in view the Fixed and Random effect analysis.

Null Hypothesis H_0: Random Effect Model is appropriate

H_1: Fixed effect model is appropriate

HAUSMAN TEST is conducted to analyze the appropriateness of the selected model. If the value of the test is less than 0.05 then Null hypothesis is rejected and Fixed effect model is selected. Multicollinearity is checked using VIF analysis. The results show absence of multicollinearity (Mean VIF=1.01). To address potential autocorrelation and heteroskedasticity, robust standard errors clustered at the country level were used.

Empirical Analysis

Table 1 shows the panel regression results of equation 1. The results show the impact of CO_2 emission and Global temperature on Trade at 5% level of significance. The Hausman Analysis result shows that Prob>chi2 =0.0040. Hence the NULL hypothesis is rejected and FEM is accepted. The relatively low within R^2 suggests that while climate variables are significant, a large portion of trade variation is driven by other economic factors not included in the model. The high value of rho (0.945) indicates strong heterogeneity exists across SAARC countries, justifying the use of fixed-effects estimation.

Table 1: Panel Regression of Trade on Emissions

No of obs=72 **Groups: 8**	**Fixed-effects (within) regression** F(2,61) = 6.97 Prob =0.0019 > F = 0.0000 rho = 0.945		**Random-effects GLS regression** Wald chi2(2) = 9.96 Prob > chi2 = 0.0069 rho= 0.904	
R^2	within = 0.1861 between = 0.2085 overall = 0.0973		within = 0.1837 between = 0.2218 overall = 0.0955	
Trade	**coefficient**	**P value**	**Coefficient**	**P-value**
CO_2	.305387	**0.022***	.2785954	0.043
Global temperature	729.0547	**0.008***	480.8944	0.060
_cons	43.1731	0.000	55.52279	0.000

Source: Author's calculation

The results of the fixed-effects model indicate that both CO_2 emissions and global temperature have a positive and statistically significant association with trade. The coefficient for CO_2 emissions (0.305, $p < 0.05$) suggests that higher CO_2 emission levels are associated with increased trade activity. This reflects the close linkage between industrialization, energy consumption, and export-oriented production in SAARC economies. As production expands, particularly in energy-intensive sectors, both trade volumes and carbon emissions tend to rise simultaneously. Similarly, the coefficient for global temperature is positive and highly significant ($p < 0.01$), indicating that rising temperatures are associated with increased trade. However, this association shows that rather than indicating purely beneficial trade expansion, it may reflect adaptive economic responses to climate-related disruptions. For instance, extreme weather events can reduce domestic production capacity, leading to increased reliance on imports. Additionally, post-disaster reconstruction activities may further increase demand for traded goods such as machinery and raw materials. Thus, collectively these findings highlight the dual role of trade in SAARC economies. On one hand, trade expansion contributes to environmental degradation through increased emissions, consistent with the Pollution Haven Hypothesis. On the other hand, trade also serves as an adaptive mechanism in response to climate stress, reflecting increased dependence on global markets under conditions of environmental vulnerability.

Table 2 shows the panel regression results of equation 2. The results show the impact of CO_2 emission and Global temperature on Globalization at a significance level of 5%. The Hausman test result shows that Prob>chi2 = 0.0275 is less than 0.05. Hence, NULL hypothesis is rejected and FEM is accepted.

Table 2: Panel Regression of Globalization on Emissions

No of obs=80 **Groups: 8**	**Fixed-effects (within) regression** F(2,70) = 13.05 p = 0.0001 : Prob > F = 0.0000 rho = .790		**Random-effects GLS regression** Wald chi2(2) = 20.01 Prob > chi2 = 0.0000 rho= 0.534	
R^2	within = 0.2713 between = 0.2519 overall = 0.2008		within = 0.2642 between = 0.2600 overall = 0.2076	
Globalization	**coefficient**	**P value**	**Coefficient**	**P-value**
CO_2	-.054895	0.388	-.0685193	0.294
Global temperature	801.5786	0.000	492.175	0.000
_cons	33.64287	0.000	55.52279	0.000

Source: Author's Calculation

Hausman Analysis Prob>chi2 = 0.0275

The results of the fixed-effects model indicate that global temperature has a positive and highly statistically significant association with globalization while CO_2 emissions do not exhibit a statistically significant relationship ($p > 0.05$). This implies that while CO_2 emissions reflect the level of industrial activity, they do not independently influence globalization outcomes such as trade openness, capital flows, or international connectivity.

In contrast, global temperature demonstrates a strong positive and statistically significant association on globalization ($p < 0.01$). The finding suggests that rising temperatures are associated with higher levels of global integration, likely reflecting adaptive economic and institutional responses rather than a direct causal effect. Climate change may not directly promote globalization but may increase dependence on international markets for essential goods, thereby necessitating greater international cooperation, including participation in global climate agreements, technology transfer, and climate finance initiatives. Increased cross-border mobility, including climate-induced migration and capital reallocation, may further contribute to higher levels of globalization. The model explains 27.1% of within-country variation in

globalization, while the high value of rho (0.79) confirms substantial country-specific heterogeneity across SAARC economies. Overall, the results suggest that globalization in the region is more responsive to physical climate shocks than to emissions-based industrial activity.

Discussions and Conclusion

Thus, the findings show that the increasing CO_2 emission and rising Global temperature affect trade, while globalization is only affected by rising global temperature with reference to the SAARC economies. These results suggest that globalization in SAARC economies is influenced more by the physical impacts of climate change (temperature rise) than by emissions levels alone. The results indicate that while emissions-driven industrialization does not directly shape globalization in SAARC economies, climate-induced stress captured through rising temperature plays a significant role in deepening global economic integration, particularly through adaptive and cooperative responses. To mitigate transboundary climate impacts, the SAARC economies need to formulate mutually beneficial climate-adaptive trade strategies and policies by adopting sustainable infrastructural planning and investing in climate-resilient and low-emission trade infrastructure. Promotion of climate discussions related to clean technology transfer, climate finance, and global mobility linked to climate adaptation in global forums will help align environmental and trade objectives and lead to strengthening climate diplomacy among these nations.

This study has certain limitations that should be acknowledged while interpreting the results. First, the study is parsimonious relying on secondary data, which is not only limited but also may contain cross-country differences in reporting accuracy and measurement standards. Second, the study uses CO_2 emissions and average temperature as proxies for climate change, which do not fully capture its broader dimensions such as extreme weather events, rainfall variability, or sea-level rise. Third, although panel regression helps control country-specific effects, the SAARC region is highly diverse in terms of economic structure, governance, and climate vulnerability, which may not be fully captured in the model. Fourth, the results mainly indicate statistical associations rather than definitive causal relationships, as issues like reverse causality, endogeneity and dynamic feedback effects may still exist and can be a part of future studies. Finally, important factors such as technological innovation, renewable energy adoption, and environmental policy strength are not explicitly included, which may influence the observed relationships.

Future research can build on this study in several important ways. First, advanced econometric techniques such as dynamic panel models (GMM) and causality testing can be used to address endogeneity and better identify causal relationships between climate change, trade, and globalization. Also, incorporating additional control variables in future studies would provide a more holistic understanding of the climate–economy nexus. Future studies may also extend the analysis by comparing SAARC with other regional blocks such as ASEAN or the European Union to identify regional differences. Finally, future research can explore the impact of emerging global trends such as carbon border adjustment mechanisms, green trade policies, and climate finance initiatives on developing economies.

Thus in conclusion, the study demonstrates that climate change is not merely an environmental externality but a structural force influencing trade dependence and global economic integration in developing regions.

Ethical Considerations

Ethical standards were strictly followed, with all secondary data sources properly cited to acknowledge original authors and avoid plagiarism. All authors declare that they have no conflicts of interest.

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