Assessing the Role of Green Finance in Reducing Carbon Emissions: Evidence from Bangladesh

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ABSTRACT

Green investment has emerged as a key driver of sustainable economic development globally, and Bangladesh is no exception. This study examines the impact of green finance on carbon emissions in Bangladesh, aiming to determine its contribution to building a greener economy. Using the Autoregressive Distributed Lag (ARDL) bounds testing approach with quarterly data from 2013 to 2023, the findings indicate that green financing has a significant positive impact on air quality by reducing carbon emissions. However, the positive effect of green-oriented foreign direct investment (FDI) on emissions reduction is moderated by overall economic growth, highlighting a tradeoff between growth and sustainability. These results suggest that Bangladesh must strengthen its green financing mechanisms and integrate environmental planning into development policies to ensure a sustainable transition toward a low-carbon economy.

Key words: Green Finance, Foreign Direct Investment, Economic Growth, Carbon Emissions, ARDL

INTRODUCTION

Long-term development cannot exist without ecological integrity, which is closely linked to economic resilience and social well-being, as the productivity of natural resources is crucial for a sustainable future (Bekun et al., 2019). Nevertheless, increased anthropogenic activity, especially fossil fuel burning and deforestation, significantly promotes greenhouse gas (GHG) emissions, of which carbon dioxide (CO_2) proves to be the most detrimental. Cumulatively, CO_2 emissions grew from 22.7 million kilotons in 1990 to more than 36 billion kilotons by 2015 CO_2, causing warming effects on the planet and destabilising climate systems across the world (Raihan et al., 2022).CO_2 contributes to climatic instability by warming the atmosphere, which endangers ecosystems, human health, and socio-economic stability (Sadiq et al., 2023).

In the context of the scientific opinion that emphasizes the urgency of CO_2 mitigation, the problem of balancing environmental sustainability with economic growth always exists. The imbalance between ecological withdrawals and economic investments caused by industrialization, energy-based production, and globalization has intensified since the 1970s (Miller & Mössner, 2020). Developing economies face a twofold pressure: pursuing growth while mitigating environmental degradation. This pressure is particularly acute in South Asia, where rapid industrialization, surging energy demand, and heightened climate vulnerability converge (Mamun et al., 2025).

STATEMENT OF THE PROBLEM

Bangladesh is an example of this developmental paradox. The country is ranked seventh in the Global Climate Risk Index 2021 and experienced climate-induced economic losses of approximately $ 3.72 billion between 2000 and 2019 (Hoque et al., 2019; Islam & Islam, 2021). Although emitting only 0.09 percent of the total global CO_2 emissions, Bangladesh ranks 13th in the Asia-Pacific region in terms of such emissions, which are rapidly increasing on a fuel-based basis. Bangladesh has increased its per capita CO2 emission in the period between 1972 and 2022 by 5.3% on an annual average basis from 0.05 tons per year to 0.6 tons per year. Although 17.17 million tons of CO2 were discharged through the combustion of its fuels, approximately 74 percent of total energy consumption also relies on non-renewable fossil fuels (Mamun et al., 2025).

As Figure 1 shows, the value of carbon intensity had been growing consistently since 2013, until about 2020, when there was a dip due to the pandemic, followed by a sharp reversal. Between 2013 and 2019, Bangladesh experienced steady and robust economic growth, with GDP growth rates consistently exceeding 6% and reaching a peak of above 8% in 2019. These indicate the structural link between economic activity and carbon intensity.

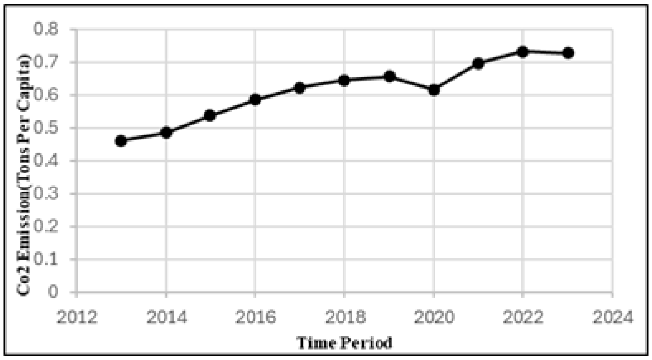

Figure 1: CO_2 Emissions (Tons per Capita) in Bangladesh (2013–2023)
Source: World Development Indicators, World Bank

The Paris Agreement *(UNFCCC, 2015)* and other international frameworks prioritize reducing emissions. Ranging between high and medium, the current responsibility of NATO countries regarding mitigation within the Nationally Determined Contributions (NDC, 2021) is the reduction of CO_2 emissions by 21.8 % until 2030, which applies to Bangladesh. Such commitments entail a shift in financial systems that will reward investments in low-carbon options. The introduction of green finance (GF) to invest in sustainable projects (renewable energy, energy efficiency, waste management, and green infrastructure) has proven to be an essential mechanism (Zhang et al., 2022). Shift towards GF helps in redirecting investments out of harmful industries and establishing other economic impetus to low-carbon transitions (Gu et al., 2021).

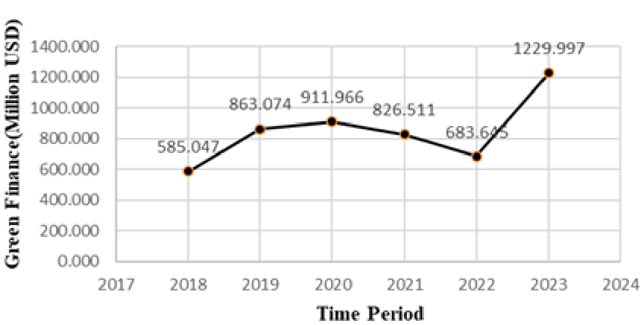

Figure 2: Green Finance in Bangladesh from 2018 to 2023 (Million USD)
Source: Sustainable Finance Department, Bangladesh Bank

Figure 2 shows GF investment in Bangladesh, indicating that it has grown by approximately US$580 million over the last five years and is expected to exceed US$1.2 billion by 2023, driven by its responsiveness to economic and policy trends.

Foreign direct investment (FDI) is another important external source of capital that supplements domestic GF flows as it influences the industrial composition and the environmental performance. Given the strengthening effect of Export Processing Zones (EPZs) and Special Economic Zones (SEZs), FDI inflows reached USD 3.61 billion in 2018, with a focus on energy-intensive power generation and export-oriented industries (UNCTAD, 2019). There is a dispute regarding the environmental impact of FDI. Technology transfers and industrial upgrading can facilitate climate-friendly implementation, but emissions usually increase when capital flows to carbon-intensive industries (Banerjee & Rahman, 2012).

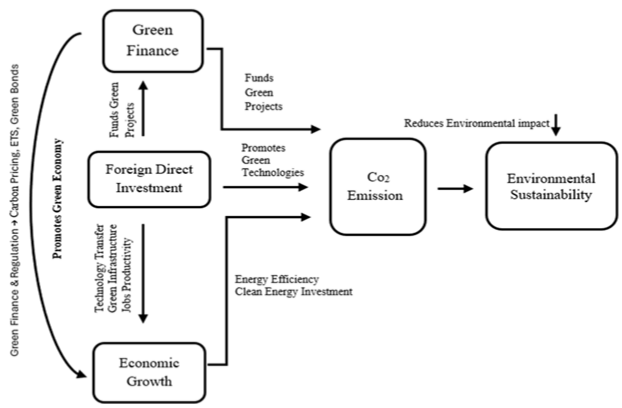

Figure 3: Conceptual Framework for the Impact of Green Finance, FDI, and Economic Growth on CO_2 Emissions in Bangladesh

The interactions among green finance, FDI, GDP growth, and CO_2 emissions are synthesized in **Figure 3**, which depicts GF as a potential mitigator, FDI as context-dependent, and GDP growth as traditionally emissions-intensive but potentially reconcilable with sustainability under effective policies. Mediating factors, such as regulatory strength, the diffusion of green technology, and environmental taxation, further shape these dynamics. Understanding these pathways is essential to align Bangladesh's development trajectory with its climate commitments.

The recent surge in literature on the economic–environmental nexus focuses much on the extent of GF in Bangladesh; a few of the studies address its mitigating role on environmental degradation. However, empirical investigation of the impact of GF on the environment, particularly in terms of checking CO_2 emissions, is a largely overlooked issue. This study empirically examines the impact of green finance, foreign direct investment, and economic growth on CO_2 emissions in Bangladesh. It will assess the trends and structural impacts of green finance and FDI in Bangladesh (2013–2023), along with estimating the short- and long-run sensitivities of CO_2 emissions to green finance and FDI flows.

The balance of the study is structured as follows. Section 2 reviews the existing literature on CO_2 emissions, green finance, foreign direct investment, and economic growth. Section 3 details the models, theoretical framework, econometric methodology, variable description, and sources. Section 4 presents empirical results and interpretations. The study concludes in Section 5 with a policy recommendation and a summary of the findings.

LITERATURE REVIEW

Green financing plays a crucial role in reducing carbon emissions by channeling funds toward sustainable projects and clean technologies. Several theories explain this relationship. The Environmental Kuznets Curve (EKC) suggests that green finance accelerates the transition to lower emissions as economies grow. The Porter Hypothesis emphasizes that financial support for environmental compliance drives innovation and efficiency. The Green Growth Theory emphasizes the balance between economic development and sustainability, while Institutional and Stakeholder theories focus on regulatory and societal pressures for greener practices. The Resource-Based View and Innovation Diffusion Theory demonstrate how firms can gain competitive advantages through green investments. Overall, green financing aligns financial flows with climate goals, supporting global commitments such as the Paris Agreement (UNFCCC, 2015).

Empirical literature on the impact of green or sustainable financing on environmental quality is noteworthy. A study published in Panel Robust Fixed (2025) found that green finance indeed brings a significant reduction in CO_2, especially when combined with environmental protection expenditure. The results of the current study are like those obtained by Bai et al. (2022), Li et al. (2024), and Raihan & Tuspekova (2022), showing that a specific fiscal treatment, as well as public and private partnerships, enlarge the environmental returns of green finance. Wei et al. (2025) established that green finance is crucial for achieving carbon neutrality goals worldwide. Its effectiveness is also represented through country-specific evidence. Zhu et al. (2023) employed a Spatial Durbin Model (SDM) in China. They concluded that green finance promotes low-carbon development at the regional scale, as it enhances capital allocation, industrial restructuring, and innovation, resulting in quantifiable effects of spatial spillover beyond the initial geographies. By applying threshold regressions, Wu et al. (2025) found a characteristic U-shaped relationship between bond and digital economic maturity, indicating that the effectiveness of green finance is enhanced in more digitally advanced contexts. These studies show green finance significantly reduces CO_2 emissions, with effectiveness enhanced by fiscal policies, partnerships, digital maturity, and regional spillover effects.

Other research highlights the focus on the focal nature of green bonds. According to the works of Zaid et al. (2018), Tang et al. (2023), Zheng et al. (2023), Chen et al. (2023), and Mamun et al. (2025), the negative relationships between green bond issuance, as measured with the environmental degradation metric, have demonstrated robust relationships. Jiang et al. (2020) conducted their research on S&P 500 companies, utilizing quantile-on-quantile regressions to establish a correlation between capital markets and environmental output. In the meantime, Saeed Meo and Karim (2022) reported negative solid relationships between green finance and emissions across the top 10 economies of green finance. Nevertheless, not all the findings are positive. Using the CS-ARDL model on emerging Asian economies, Chan et al. (2024) established that the impacts of green finance were also insignificant under weak institutional capacity and regulatory enforcement. Such differences suggest that the robustness of green finance is significantly influenced by the level of economic development, government regulation, and supporting policies.

To conclude, the ability of green finance to decrease CO_2 emissions has been supported by a large volume of evidence; however, the effectiveness of green finance varies depending on institutional quality, technological preparedness, and the location of digital infrastructure. The environmental impacts of FDI are contentious and have been captured under two contrasting concepts: the Pollution Haven Hypothesis (PHH) and the Pollution Halo Hypothesis. These concepts postulate that stringent environmental regulations prompt polluting industries to relocate, whereas tighter environmental regulations lead to the movement of cleaner technologies and better environmental performance by international firms. Hence, research highlights both positive and mixed impacts of green finance. While green bonds and capital market dynamics often reduce emissions, weak institutions and poor regulation undermine effectiveness. Key determinants include institutional quality, government policies, technological readiness, and digital infrastructure. Additionally, the environmental effects of FDI remain contested under the Pollution Haven and Halo Hypotheses.

Other developing economies, such as Bangladesh, are not unanimous in their support of this line of evidence. (Sarker et al., 2016) Islam et al. (2021) also associated the result with increasing CO_2 emissions in Bangladesh and attributed them to energy-intensive industrial growth linked to FDI inflows. Building on this, Khan et al. (2021a, 2021b) have reported that the connection between FDI and emissions in MENA countries is of an N shape, which means that the inflow of FDI in the countries initially increases emissions, but later the emissions decrease due to the adoption of cleaner technology. However, using the ARDL and Granger causality methodology, Khalid et al. (2024) determined that technological innovation and openness to trade contribute to the ability of FDI to reduce emissions. The study by Amin et al. (2018) also revealed that infrastructure-oriented FDI served to alleviate the intensity of energy in Bangladesh. The presence of cross-national research adds another twist to the story. According to Mert & Bölük (2016), the combination of increased FDI and the use of renewable energy enhanced environmental quality in countries that were signatories to the Kyoto Protocol. The Pollution Halo Hypothesis has been confirmed by Zhou et al. (2013), who utilized dynamic panel models in China. In contrast, studies by Liu et al. (2017), Pao et al. (2011), and Perkins & Neumayer (2009) found no statistically significant relationship between FDI emissions. There is no evidence related to Bangladesh in this regard. Using the Fourier ARDL on the 1990-2022 period (Qamruzzaman, 2024), the study concluded that the impact of FDI on emissions is inconclusive and is further moderated by renewable energy uptake and openness to trade. This is in line with Letchumanan (2000), who concluded that, in most developing economies, there is no regular association between FDI and pollution. On balance, the environmental effects of FDI appear somewhat dependent on the quality of the regulatory environment in the host country, its absorptive technological capabilities, and industrial structure, which suggests the need for case-sensitive research.

Such economic impacts also revolve around the economic effects of CO_2 emissions, which are usually studied under the framework of the Environmental Kuznets Curve (EKC). This framework postulates a so-called inverted U-shape relation between the level of income and environmental degradation. Whereas the studies by Dinda (2004) and Selden & Song (1994) confirm the EKC, others, such as Friedl & Getzner (2003), detect an N-shaped curve, and Agras & Chapman (1999) fail to corroborate a systematic relationship. There is a strong case to support the notion that in developing economies, such as Bangladesh, the negative correlation between GDP and emissions is at its lowest. Raihan et al. (2024) employed DOLS and ARDL bounds tests to determine whether economic growth, financial development, and energy consumption are the primary drivers of emissions. (Paul et al., 2025) further noted that the growth of GDP and energy consumption increases emissions, whereas financial development has a U-shaped impact on emissions. Datta (2024) accentuated the moderate effect of renewable energy, further stating its modulating impact. In contrast, Oh & Bhuyan (2018) did not find trade openness to be significant, although growth was still recognized as the primary determinant of emissions.

This tendency is also observed in studies from around the world, including Nigeria (Adebayo & Odugbesan, 2021), Malaysia (Begum et al., n.d.), Kazakhstan (Akbota & Baek, 2018), and ASEAN countries (Vo et al., 2019). Teng et al. (2020) demonstrated that economic growth is a significant contributor to emissions in OECD countries, a finding also reported by Islam (2021) and Basri & Kongcharoen (2021) for Bangladesh. Studies of EKC in Bangladesh are still subtle. The Dynamic ARDL approach of Islam et al. (2024) led to the determination that, although FDI can reduce emissions, they are still facilitated by GDP growth. By using IPAT and Johansen cointegration from 1972 to 2015, Kashem & Rahman (2019) obtained long-term cointegration and short-term causality, further supporting structural connections between emissions and growth. Hence, Green finance and FDI show mixed impacts on CO_2 emissions, with effectiveness shaped by institutional quality, technological readiness, and growth dynamics, underscoring the need for country-specific, case-sensitive research.

Overall, economic development in Bangladesh continues to increase emissions, underscoring the need for cleaner production technologies and more effective environmental governance to make development sustainable.

Model, Method, and Data Sources

Models

The study aims to examine the impact of GF on CO_2 emissions. It also considers the influence of FDI and economic growth on CO_2 emissions. Therefore, the theoretical model can be stated as follows.

$$= f\left(GF_t , FDI_t , g_t\right) \qquad (1)$$

The empirical model to examine the sensitivity of CO2 emissions to the explanatory variables can be delineated as follows:

$$CoE_t = a + bGF_t + clnFDI_t + dg_t + u_t \qquad (2)$$

Where, CoE_t CO_2 Emission; GF_t Green Finance (% of GDP); $lnFDI_t$ = Natural logarithm of FDI; g_t Economic growth, t stands for time.

Green finance is defined quantitatively as the amount of money (in millions of USD) released by both bank and non-bank financial institutions for environmentally friendly projects. FDI is the net yearly inflows (USD million), using World Bank data and transformed on a log scale to reduce heteroscedasticity. Macroeconomic growth is indicated by changes in the GDP growth rate, based on the interpolation of quarterly figures.

From the earlier discussion, theoretically, it is anticipated that there will be a negative relationship between GF and CO_2 emissions, which a negative coefficient of GF can indicate, that is, $b < 0$, as the FDI is assumed to affect CO_2 emissions negatively under the assumption of green-compliant investment flows, $c<0$. Greater economic growth is associated with the rising trend of the CO_2 output; hence, the Environmental Kuznets Curve (EKC) model (Dinda, 2004) foresees a nonlinear relation; however, since the overall trend in this research stands at the average stage of correlation, it is assumed that the relation is positive, $d>0$.

Methodology

The ARDL bound testing is an analysis developed by Pesaran & Shin (1995) and extended by Pesaran et al. (2001) to examine the long-run and short-run dynamics between the variables in question. The appropriateness of ARDL is especially because it is flexible in combining variables that have been integrated at level I(0) or I(1), and it performs so well in small samples. It can easily estimate the simultaneous dynamics of short-run behavior and long-run behavior.

To verify the order of integration, unit root tests were conducted using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. This ensured that no variable was integrated beyond I(1), preserving the validity of the ARDL bounds testing.

The general ARDL specification for the long-run model is:

$$CoE_t = a + bGF_t + clnFDI_t + dg_t + u_t \quad (3)$$

This model identifies the long-run relationship between CO_2 emissions (COE) and green finance (*GF),* Foreign Direct Investment *(lnFDI)*, and economic growth (g). a and u represent the intercept and error term, respectively. In addition, $b, c, and\ d$ denote the coefficients of the independent variables.

If a long-run relationship is confirmed through the bounds F-test, the associated **Error Correction Model (ECM)** is estimated to capture short-run dynamics:

$$\Delta \boldsymbol{CoE_t} = \boldsymbol{a_t} + \sum_{i=1}^{q_1} \boldsymbol{\gamma_1}\, \Delta \boldsymbol{CoE_{t-i}} + \sum_{i=1}^{q_2} \boldsymbol{\gamma_2}\, \Delta \boldsymbol{GF_{t-i}} + \sum_{i=1}^{q_3} \boldsymbol{\gamma_3}\, \Delta \boldsymbol{lnFDI_{t-i}} + \sum_{i=1}^{q_4} \boldsymbol{\gamma_4}\, \Delta\, \boldsymbol{g_{t-i}} + \boldsymbol{\theta ECT_{t-1}} + \boldsymbol{u_t} \quad (\mathbf{4})$$

In the ARDL error correction model, Δ represents the first difference operator, and the parameters q_1, q_2, q_3, $and\ q_4$ denote the optimal lag lengths for the differenced variables, selected to capture short-run dynamics appropriately. The summation terms (e.g., $\sum_{i-1}^{q_1} \boldsymbol{\gamma_1}\, \Delta \boldsymbol{CoE_{t-i}}$) represent the cumulative short-run effects across those lags. The coefficients $\boldsymbol{\gamma_1}, \boldsymbol{\gamma_2}, \boldsymbol{\gamma 3}, \boldsymbol{and}\ \boldsymbol{\gamma_4}$ quantify the immediate and lagged short-run impacts of the respective independent variables on the dependent variable $\boldsymbol{\Delta CoE_t}$. Finally, the error correction term coefficient θ reflects the speed at which short-run disequilibrium adjusts back to the long-run equilibrium path. A statistically significant negative θ confirms the existence of a stable long-run relationship among the variables. A limitation is that the data are converted from yearly to quarterly using Denton's method. Several procedures exist for converting annual data into higher-frequency series, including Chow–Lin, Fernandez, and Litterman methods. These approaches often rely on auxiliary high-frequency indicators and impose assumptions about the distribution of residuals, which can complicate estimation and may not always be feasible in data-constrained contexts. Against this background, the Denton (1971) proportional benchmarking procedure provides a more practical and flexible solution. It ensures consistency with annual benchmarks while preserving the short-term dynamics of related high-frequency indicators, thereby avoiding distortions in growth patterns. This makes it particularly well-suited for ARDL analysis, where both short-run and long-run dynamics are central. Although Denton's method may introduce some artificial smoothness since interpolated values are still estimates, this limitation is relatively minor compared to the advantages of benchmark consistency, simplicity, and robustness in the present research context.

To ensure model reliability, a suite of diagnostic tests is performed, namely- Breusch–Godfrey LM test for testing serial correlation, Breusch–Pagan–Godfrey test for testing Heteroscedasticity; CUSUM and CUSUMSQ tests for structural stability.

Table 1: Description of Variables

Variable's short form	Name of the variables	Source
CoE	CO_2 Emission	World Development Indicators (World Bank, 2025)
GF	Green Finance	Bangladesh Bank
FDI	Foreign Direct Investment	World Development Indicators (World Bank, 2025)
g	Economic Growth	World Development Indicators (World Bank, 2025)

Data description & Sources

The study considers quarterly data, comprising 44 observations from Q1 2013 to Q4 2023, to examine the impact of GF on CO_2 emissions, along with FDI and economic growth. This study utilizes secondary econometric data from the same study period (2013-2023) to empirically analyze the dynamic relationship between green finance, foreign direct investment (FDI), and economic growth in relation to environmental sustainability in Bangladesh, with carbon emissions serving as the primary environmental indicator. The dependent variable is the emission of carbon dioxide CO_2) in metric tons per capita. The numbers were obtained using the World Development Indicators (WDI) of the World Bank. A suitable proxy for green finance is the quarterly disbursement of banks and non-bank financial institutions toward environmentally related projects, such as renewable energy, energy efficiency, and pollution control infrastructure, as reported by the Sustainable Finance Department of the Bangladesh Bank. The data, covering the period from 2013 to 2023, are expressed in millions of U.S. dollars. It is expressed as a percentage of GDP to ensure econometric consistency. The measurement of FDI is driven by yearly net inflows (in millions of USD) in green and technology-driven domains, using WDI data. The GDP growth rate of Bangladesh is used to measure economic growth, and this rate can also be extracted from the WDI dataset (World Bank, 2025).

Empirical Results and Analysis

Descriptive Statistics

To provide a contextual background of the research, a preliminary descriptive analysis of 44 quarterly observations (2013Q1 to 2023Q4) will reveal pertinent distribution conclusions regarding the primary variables: the level of CO_2 emissions per capita (CoE) and green finance (GF), foreign direct investment (lnFDI), and economic growth (g). CO_2 emissions are almost normally distributed (JB = 2.74, p = 0.253), have moderate dispersion (SD = 0.089), and are slightly skewed to the left. There is volatility (SD = 0.220) and skewness (right skewed) in green finance, as it does not exhibit stable growth. The FDI is not highly skewed and has small dispersion. Its trend follows a leptokurtic, left-skewed distribution, characterized by choking up due to external shocks and unusual deviations in trend. The above descriptive features help in selecting appropriate econometric models.

Table 2: Descriptive Study

Statistic Name	CO_2 Emission (CoE)	GF	FDI	g
Mean	0.605238	0.272436	7.615227	6.461262
Median	0.62718	0.119274	7.63	6.64155
Maximum	0.73252	0.666691	7.95	7.881915
Minimum	0.45296	0.046628	7.23	3.448018
Std. Dev.	0.08908	0.220145	0.208789	0.863729
Skewness	-0.318104	0.366963	-0.047942	-1.362325
Kurtosis	1.954738	1.395261	1.672042	5.609443
Jarque-Bera	2.745112	5.708697	3.249888	26.09367
Probability	0.253458	0.057593	0.196923	0.000002
Sum	26.63049	11.9872	335.07	284.2955
Sum Sq. Dev.	0.341219	2.083943	1.874498	32.07921
Observations	44	44	44	44

Sources: *Authors' calculation using EViews*

Unit Root and Stationarity Tests

ADF and PP tests (*Table 3)* confirm a mixed integration order CoE and g are *I(1)*; GF and lnFDI exhibit stationarity at *I(0),* I(1), and borderline trend stationarity at the level. These outcomes validate the adoption of the ARDL framework, which accommodates I(0)/I(1) variables without requiring uniform integration.

Table 3: Unit Root Test

Variable	Test in	Includes	ADF		PP	
			t-statistic	*p*-value	*t*-statistic	*p*-value
CoE	I(1)	Intercept	-2.45	0.135	-2.65	0.091***
GF	I(1)	Intercept	-10.49277	0.000*	-10.49024	0.000*
		Trend & Intercept	-10.35934	0.000*	-10.35899	0.000*
lnFDI	I(0)	Trend & Intercept	-4.182	0.012**	-3.724	0.031**
	I(1)	Intercept	-3.178	0.03**	-3.259	0.023**
g	I(1)	Intercept	-1.404	0.569	-3.119	0.033**

Note: *, **, *** indicates 1%, 5%, 10% level of significance respectively
Sources: Authors' calculation using EViews

Model Selection

To optimize the dynamic lag structure, the Akaike Information Criterion (AIC) was employed through automatic lag selection, with a maximum of nine lags for the dependent variable and seven lags for each regressor. Among 4,608 evaluated models, the *ARDL (9, 7, 7, 6)* specification yielded the lowest AIC, indicating an optimal tradeoff between model complexity and explanatory power (*Figure 4*).

ARDL Bounds Test

The F-statistic from the bounds test (*F = 25.5918*) significantly exceeds the upper critical threshold at the 1% level *I(1) = 4.66*, confirming the existence of a long-run cointegrating relationship among the variables (*Table 4*).

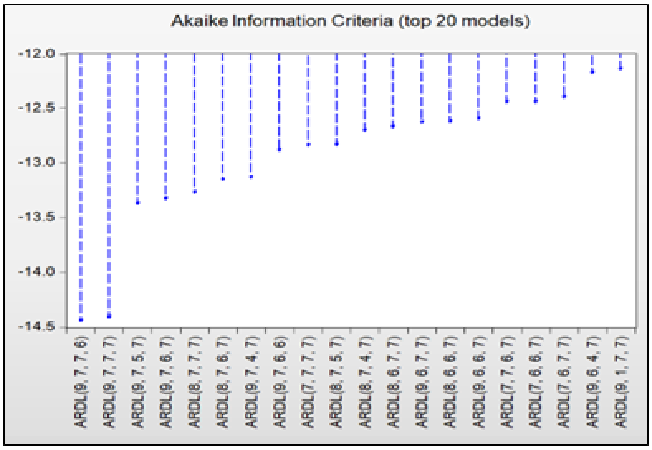

Figure 4: Model Selection Graph

Table 4: ARDL Bound Test

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	25.5918	10%	2.37	3.2
k	3	5%	2.79	3.67
		2.50%	3.15	4.08
		1%	3.65	4.66

Sources: Authors' calculation using EViews

Long-Run Estimation and Interpretation

Long-run estimates (Table 5) yield strong empirical confirmation of structural interactions between macro-financial variables and environmental quality.

Table 5: Long Run Cointegration Test

Variables	Coefficient	S.E	*t*-Statistic	*p*-value
GF	-0.0793	0.0155	-5.1222	0.0361
lnFDI	-0.2888	0.0100	-29.0071	0.0012
g	0.0222	0.0040	5.4785	0.0317
C	2.6713	0.0856	31.2025	0.0010

Sources: Authors' calculation using EViews

Green finance has a statistically significant negative impact on emissions (b = -0.0793, p = 0.0361), implying that the long-term growth of climate-compatible capital has a material effect on decarbonization. A 1% rise in green finance implies a 0.0793% decrease in CO_2 emissions, making green finance a clear-cut trend in climate mitigation. The discovery lends credence to the argument that institutionalized sustainable finance, in terms of green refinancing and sectoral prioritization, mitigates carbon by utilizing technological and resource channels to reallocate it. From a Bangladesh perspective, this result is particularly relevant because green finance has begun supporting renewable energy projects, such as solar mini-grids and clean cookstove programs, as well as energy-efficient manufacturing in textiles, the country's largest export sector. Such sectoral targeting demonstrates how green capital mobilization can gradually shift investment patterns away from fossil-intensive industries.

The impact of FDI is also negative and significant (c = 0.2888, p = 0.0012), which indicates a possible use of a pollution halo in Bangladesh. When FDI increases by one percent, CO_2 emissions decrease by 0.2888 percent, indicating that foreign capital is associated with cleaner production technology and output that follows environmental compliance. This relationship can be explained by the dominance of export-oriented manufacturing (RMG and pharmaceuticals), where multinational firms are subject to stricter global buyer standards on energy efficiency and environmental management. Technology transfer, such as modern dyeing processes, wastewater treatment, and energy-efficient machinery, enables local firms to upgrade their production while reducing emissions. Thus, FDI not only supplements domestic capital but also serves as a channel for importing green technology, skill development, and compliance mechanisms that reinforce low-carbon industrial upgrading.

Economic growth (g), on the other hand, has a positive elasticity (d = 0.0222, p = 0.0317), befitting the middle stage of the EKC. In this case, a 1% growth in GDP has been coupled with a 0.0222% growth in CO_2 emissions, indicating that scale effects are trumping structural transformation. For Bangladesh, this suggests that growth is still heavily driven by fossil-intensive activities, such as brick kilns, transport, and energy-inefficient manufacturing, which offset gains from technological improvements. Without structural reforms—such as accelerating the adoption of renewable energy, greening transportation, and diversifying away from carbon-intensive exports—the growth-emission link will remain positive.

Short-Run Dynamics and Adjustment

Short-run coefficients (Table 6) demonstrate high persistence in CO_2 emissions, with positive and significant autoregressive terms from lag 2 to lag 7. However, lag 8 exhibits a negative adjustment *(−0.2110)*, indicating that emissions eventually become self-correct after a prolonged lag. *ΔGF* initially shows a positive effect *(0.0162, p = 0.0054)*, likely due to transitional emissions from green infrastructure development. From lag three onwards, coefficients become negative and significant, suggesting the long-term mitigation effect dominates. *ΔlnFDI* demonstrates a consistent adverse effect in the current period (−0.0343, p = 0.0261), although lagged values reveal mixed impacts consistent with sectoral variation in environmental intensity. *Δg* is positively associated with CO_2 emissions across all significant lags *(e.g., 0.0113, p < 0.01)*, corroborating the hypothesis that economic activity intensifies emissions in the short term.

The 'Error Correction Term' *CointEq(−1)* is −0.444 (p < 0.01), indicating a moderate speed of adjustment: approximately 44.4% of short-run disequilibrium is corrected in each quarter.

Table 6: Short Run Cointegration Test

Variable	Coefficient	S.E	*t*-Statistic	*p*-value
ΔCoE_{t-2}	0.6046	0.0289	20.8869	0.0023
ΔCoE_{t-3}	0.6521	0.0556	11.7387	0.0072
ΔCoE_{t-4}	0.6728	0.0359	18.7405	0.0028
ΔCoE_{t-5}	0.7071	0.0521	13.5625	0.0054
ΔCoE_{t-6}	0.4649	0.0331	14.0376	0.0050
ΔCoE_{t-7}	0.1484	0.0121	12.2500	0.0066
ΔCoE_{t-8}	-0.2110	0.0113	-18.6651	0.0029
ΔGF_{t}	0.0162	0.0012	13.4917	0.0054
ΔGF_{t-1}	0.0587	0.0030	19.4800	0.0026
ΔGF_{t-2}	0.0222	0.0017	12.7346	0.0061
ΔGF_{t-3}	-0.0156	0.0010	-15.3368	0.0042
ΔGF_{t-4}	-0.0170	0.0008	-21.7782	0.0021
ΔGF_{t-5}	-0.0197	0.0012	-16.1870	0.0038
ΔGF_{t-6}	-0.0151	0.0010	-15.4282	0.0042
$\Delta lnFDI_{t}$	-0.0343	0.0057	-5.9825	0.0268
$\Delta lnFDI_{t-1}$	0.1199	0.0087	13.7062	0.0053
$\Delta lnFDI_{t-3}$	-0.0288	0.0041	-7.0008	0.0198
$\Delta lnFDI_{t-4}$	0.0552	0.0047	11.6568	0.0073
$\Delta lnFDI_{t-5}$	0.0804	0.0033	24.3385	0.0017
Δg_{t}	0.0113	0.0003	42.1654	0.0006
Δg_{t-1}	-0.0090	0.0004	-22.4800	0.0020
Δg_{t-2}	-0.0083	0.0004	-21.4932	0.0022
Δg_{t-3}	-0.0061	0.0006	-9.5572	0.0108
Δg_{t-4}	-0.0135	0.0007	-18.6069	0.0029
Δg_{t-5}	-0.0141	0.0009	-16.5017	0.0037
Δg_{t-6}	-0.0064	0.0005	-12.7761	0.0061
*CointEq(-1)**	-0.444	0.023	-19.593	0.003
EC = COP - (- 0.0793*GF - 0.2888*lnFDI + 0.0222*g + 2.6713)				

Sources: Authors' calculation using EViews

Diagnostic Tests

The diagnostic test results are summarized in the appendix, from Table 7 to Table 8, and in Figures 4-6. The Breusch-Godfrey LM test (Table 7) reports an F-statistic p-value of 0.1459 (>0.05), suggesting no evidence of serial correlation.

Table 7: Breusch-Godfrey Serial Correlation LM Test

F-statistic	18.38394	Prob. F(1,1)	0.1459
Obs*R-squared	33.19438	Prob. Chi-Square (1)	**0**

Table 8: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	0.201476	Prob. F(32,2)	0.9867
Obs*R-squared	26.71325	Prob. Chi-Square (32)	0.7312
Scaled explained SS	0.078917	Prob. Chi-Square (32)	1

The Breusch-Pagan-Godfrey test (Table 8) yields an F-statistic of 0.201 (p = 0.9867), and Obs*R^2 = 26.71 (p = 0.7312), indicating no heteroskedasticity. Thus, the constant variance assumption of classical linear models holds, and the standard errors are efficient. Figure 5 and 6 present the CUSUM and CUSUMSQ plots, respectively. In both cases, the test statistics remain within the 5% significance bands throughout the sample period, confirming that the estimated ARDL model is stable over time and free from structural breaks.

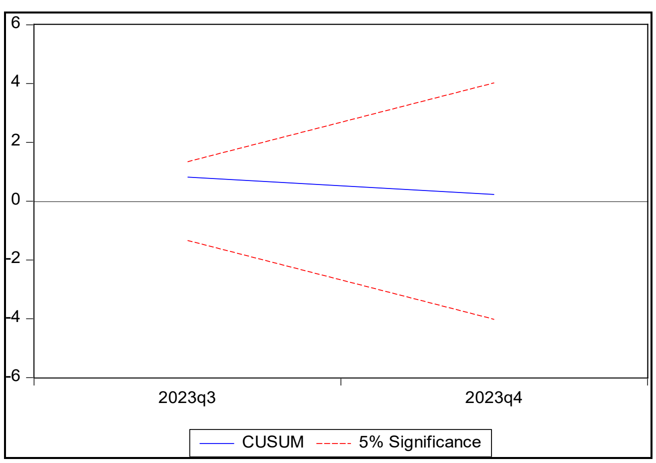

Figure 5: Cusum Test

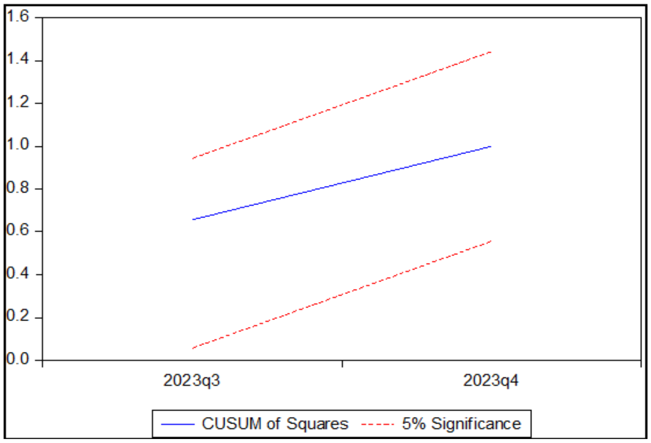

Figure 6: Cusum Square Test

Policy Implications and Conclusion

The results confirm a strong negative long-run relationship between green financing and CO_2 emissions. Specifically, a 1% increase in green finance leads to a 0.079% reduction in emissions, supporting the theoretical argument that sustainable financial instruments enhance environmental outcomes. These findings align with existing literature, which highlights the measurable role of green bonds, ESG lending, and concessional loans in emissions abatement (Zhu et al., 2023; Muchiri et al., 2025). Although short-run effects of green finance may initially appear neutral or slightly positive, its long-run impact is consistently negative, underscoring its value as a climate mitigation tool.

FDI is also found to significantly reduce CO_2 emissions, with a 1% increase in FDI associated with a 0.288% decline. This supports the Pollution Halo Hypothesis, which explains how foreign investment can have a positive impact on the environment through the transfer of sophisticated technologies and improved practices. Such short-term effects, however, are not consistent, as they vary depending on the sector in question and the effectiveness of the regulations themselves. This fact serves as a reminder of the importance of institutional arrangements in influencing FDI in green business environments.

Economic growth has a positive and significant relationship with emissions in both short- and long-term estimates. A 1% growth in GDP is found to result in a 0.022% increase in emissions. This suggests that Bangladesh may be experiencing the ascending leg of the Environmental Kuznets Curve (EKC) at present, as the consumption of fossil fuels and industrial development are increasing rapidly, outpacing environmental regulations and technological advancements. These findings confirm the importance of incorporating environmental policies into national development plans to prevent long-term environmental degradation. The minus sign and high value (-0.444) of the significant coefficient of error correction indicate that approximately 44.4 percent of deviations slow down towards the long-run equilibrium every four quarters, confirming stability. This model leads to long-run convergence. This once again justifies the usage of the ARDL model.

The study's results have several practical implications. The study suggests that strengthening the green financing framework of Bangladesh through incentives for green bonds, ESG lending, and FDI in clean technologies can curb emissions while sustaining growth. Policymakers must integrate environmental planning into development policies to strike a balance between economic expansion and long-term, low-carbon sustainability.

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APPENDIX

Period		CoE (Tons Per Capita)	GF (% of GDP)	GF (USD Million)	G (GDP Growth Rate, %)	FDI (USD Million)
2013	Q1	0.45296	0.348797209	576.67689	6.394495	1,839.04
	Q2	0.45543	0.424455785	712.160406	6.267532	2,093.68
	Q3	0.4579	0.418349423	712.160406	6.140569	2,348.32
	Q4	0.46037	0.503224237	868.967612	6.013606	2,602.96
2014	Q1	0.46657	0.368114118	645.289324	6.025469	2,587.02
	Q2	0.47276	0.518838404	923.08097	6.037333	2,571.08

	Q3	0.47896	0.501267691	904.93355	6.049196	2,555.13
	Q4	0.48515	0.666690768	1221.017474	6.061059	2,539.19
2015	Q1	0.49787	0.382637886	712.26512	6.183954	2,612.18
	Q2	0.51058	0.519209662	982.064308	6.30685	2,685.17
	Q3	0.52329	0.444825056	854.713552	6.429745	2,758.16
	Q4	0.53601	0.543447209	1060.520924	6.55264	2,831.15
2016	Q1	0.5481	0.522035441	1036.851132	6.692849	2,706.55
	Q2	0.5602	0.581100821	1174.329216	6.833059	2,581.94
	Q3	0.57229	0.448052423	921.0076	6.973269	2,457.33
	Q4	0.58439	0.552464428	1154.805344	7.113478	2,332.72
2017	Q1	0.59401	0.523395975	1112.069896	6.982671	2,202.14
	Q2	0.60364	0.607074503	1310.770984	6.851864	2,071.56
	Q3	0.61327	0.521378175	1143.695164	6.721057	1,940.98
	Q4	0.62289	0.639653917	1425.174514	6.59025	1,810.40
2018	Q1	0.62844	0.087075462	197.55768	6.772541	1,963.20
	Q2	0.63399	0.093155271	215.14955	6.954831	2,116.01
	Q3	0.63953	0.091539366	215.14955	7.137122	2,268.82
	Q4	0.64508	0.081346399	194.509002	7.319413	2,421.63
2019	Q1	0.64764	0.102552918	250.047602	7.460038	2,293.23
	Q2	0.65021	0.083205181	206.793996	7.600664	2,164.84
	Q3	0.65278	0.065568236	166.04959	7.74129	2,036.44
	Q4	0.65535	0.111657236	288.028772	7.881915	1,908.05
2020	Q1	0.64554	0.096162556	250.197662	6.773440751	1,812.36
	Q2	0.63573	0.079304687	208.100256	5.664966351	1,716.68
	Q3	0.62592	0.074464511	197.054692	4.556491951	1,621.00
	Q4	0.61611	0.119889351	319.92833	3.448017551	1,525.31
2021	Q1	0.63607	0.060003877	162.899724	4.320682944	1,574.95
	Q2	0.65603	0.053103294	146.624036	5.193348338	1,624.58
	Q3	0.67599	0.046627898	130.90316	6.066013731	1,674.22
	Q4	0.69594	0.056563532	161.414786	6.938679124	1,723.86
2022	Q1	0.70509	0.059250177	172.082658	6.978966537	1,701.61
	Q2	0.71423	0.074119704	219.022984	7.01925395	1,679.37
	Q3	0.72338	0.075813387	227.86775	7.059541363	1,657.13
	Q4	0.73252	0.125510172	383.596738	7.099828776	1,634.89
2023	Q1	0.73134	0.055503015	172.082658	6.768649675	1,572.45
	Q2	0.73016	0.069651614	219.022984	6.437470573	1,510.02
	Q3	0.72898	0.071461691	227.86775	6.106291472	1,447.59
	Q4	0.7278	0.118657739	383.596738	5.77511237	1,385.16

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