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THE IMPACT OF INSTITUTIONAL QUALITY ON ENVIRONMENTAL QUALITY: A TIME-SERIES ANALYSIS OF BANGLADESH (1996–2015)

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ABSTRACT

This paper examines the influence of institutional quality on environmental quality in Bangladesh from 1960 to 2015. While institutional quality is the primary explanatory variable, GDP and natural gas electricity consumption are included as moderating variables to control for economic activity and energy-related influences on the environment. The study utilizes the autoregressive distributed lag (ARDL) bounds testing approach and the Toda-Yamamoto (T-Y) Granger causality test to analyze the association. Two measures of institutional quality are developed. One is a composite index constructed from the Worldwide Governance Indicators (WGIs) using principal component analysis (PCA). The other is the average of the six WGIs. Regardless of the index, the findings indicate that higher institutional quality helps reduce CO2 emissions. On the contrary, both GDP and ENG tend to increase CO2 emissions. The ARDL bounds test results confirm the existence of a long-run relationship among the variables in both models. Policymakers need to concentrate on improving institutions to improve environmental quality. Concurrently, they must ensure that economic progress and electricity generation production are sustainable in Bangladesh.

Keywords: *Institutional Quality, CO_2 Emissions, Environmental Quality, Natural Gas Electricity, Bangladesh.*

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Introduction

Strong institutions play a vital role in reducing pollution and improving environmental outcomes. They do so by shaping effective environmental policies, enforcing regulations, and supporting income growth—all of which can contribute to a cleaner environment (Acemoglu et al., 2001; Jiang et al., 2025; Rahman et al., 2025). Institutions that support transparency alongside competition with accountability measures increase overall operational efficiency, thus enabling better pollution reduction. Institutional quality creates economic growth and promotes better environmental sustainability through its positive effects. Effective institutions stop environmental abuse through their ability to detect and prosecute environmental violations fairly (North, 1990). A well-developed institutional structure proves vital for achieving sustainable development in areas that demand extended environmental planning (Fredriksson et al., 2005). The strength of institutions directly enhances both environmental outcomes and important economic measures regarding growth and productivity (Cole et al., 2006; Dasgupta et al., 2002). A better institutional framework must be implemented because it can effectively enforce regulations that prevent economic activities from causing environmental harm, including pollution and resource overuse (Farzin & Bond, 2006). The environmental outcomes from countries depend on institutional quality, enabling better pollution regulation implementation and natural resource sustainable management as well as environmental adaptation capacity (Abbas et al., 2025; Halkos & Tzeremes, 2013; Saba et al., 2025).

Institutions adjust environmental outcomes by three distinct aspects: decentralization systems, legal effectiveness mechanisms, and their capacity to respond to external economic influences. According to the research of Jiang et al. (2025) and Khan & Rahmat (2024), the environmental response of regions improves through local governance accountability. Similarly, Saboori et al. (2024) found that robust judicial enforcement prevents industrial interference in regulation compliance. The way environmental safeguards persist depends on institutional quality and worldwide trade and investment initiatives, as per research by Saba et al. (2025). The strength of institutions determines whether regulatory capture occurs since weak structures permit environmental goals to be undermined. Openness, together with public involvement, is a fundamental requirement in such situations. Environmental institutions today serve as primary actors in sustainable energy transition management, aiming to achieve green policies that serve both environmental sustainability and social equity (Rahbarqazi & Taleihur, 2024).

The institutional quality expressed through governance exceeds enforcement capabilities, including decision-making processes that maintain inclusivity while being transparent and accountable. Bangladesh's environmental outcomes are regularly affected by institutional deficiencies, including corruption, inefficient bureaucracy, and gaps in agency coordination (Karim et al., 2023; Sultana et al., 2022). Environmentally successful policies require effective governance systems that implement anti-corruption reforms and civil society participation, according to research by Rahman & Sultana (2024) and Shibli & Ghosh (2023). Implementing environmental accountability across development planning using decentralization models and performance-based public management and regulatory oversight systems provides effective results in emerging economies, according to Masud et al. (2022) and Siddique (2022). Enhancements made to institutions that serve to increase openness in financial budgets and environmental project execution and improve citizen participation methods will boost both policy trustworthiness and environmental sustainability (Sarker et al., 2017; Sultana et al., 2022).

Most research on environmental performance in Bangladesh analyzes economic growth, energy usage, and CO2 emissions while ignoring institutional factors. Academic research identifies institutions as essential for influencing environmental performance, but

Bangladesh receives inadequate attention in this study area. A limited number of studies about institutional quality yield counterintuitive results by linking better institutions to deteriorating environmental conditions (Islam et al., 2021; Mehmood et al., 2021). Investigators normally discover opposite results in global research, but this study presents contrary findings. A result that deviates from expectation reveals an important research deficit because researchers need to examine institutional impacts through modern comprehensive analysis. The present study fills this research gap by examining how institutional quality affects environmental performance in Bangladesh.

This research endeavors to re-analyze the relationship between institutional quality and environmental outcomes in Bangladesh by analyzing the institution's impact on the environment while controlling for economic progress and energy structure by employing time-series data from 1996 to 2015 that uses an autoregressive distributed lag modeling approach. To achieve this broad objective, the study sets out three specific objectives: first, to evaluate the long-run and short-run effects of institutional quality on CO_2 emissions in Bangladesh, using distinct composite measures derived from the Worldwide Governance Indicators (WGIs); second, to investigate how economic growth and natural gas-based electricity generation influence environmental quality; and third to provide evidence-based policy recommendations aimed at strengthening institutional frameworks and promoting sustainable environmental outcomes in Bangladesh. These objectives work together to enhance academic research about Bangladesh's subject and policy development.

Following this introduction, Section 2 summarizes important related research. Section 3 states the hypotheses, Section 4 presents the data and methodology, and Section 3 provides an in-depth analysis of the results. Lastly, Section 6 wraps it all up with a conclusion.

Literature Review

Many studies have looked into the ways the quality of the environment can be positively influenced by good institutions (Bernauer & Koubi, 2009; Dal Bó & Rossi, 2007; Dutta et al., 2013; Hoekman et al., 2005; Silajdzic & Mehic, 2015). Most of these studies focused on CO_2 emissions to measure environmental quality. Also, there is inadequate congruity regarding the affiliation between environmental quality and its influencing factors. The rest of the section provides an overview of this topic's current and compatible literature. Table 1 presents a summary of selected recent and relevant time-series studies that are closely aligned with the focus of this research.

The results of Ahmed et al. (2017), based on five South Asian countries, suggest that trade, energy, and population growth increase CO_2 emissions. In contrast, higher earnings tend to reduce emissions. Similarly, Munir and Riaz (2019), using South Asian data, pointed out that greater use of gas, electricity, and coal drives up CO_2 emissions. Moreover, rising energy use and financial development negatively affect environmental quality. Interestingly, foreign direct investment (FDI) helps reduce pollution but makes matters worse regarding trade openness. Strong institutions play a vital role by lowering pollution substantially and thus lessening the deterioration of the environment. In another study, Hunjra *et al.* (2020) discovered a pollution-promoting impact on financial development. However, their research highlighted stronger institutions' role in balancing financial development's detrimental impacts on the green environment. Additionally, there is proof that strong institutions encourage green growth (Ahmed et al., 2022).

Zafar *et al.* (2020) found that industrial activity generated greater CO_2 releases in 46 Asian countries. In a study of 18 Asia-Pacific countries from 1992 to 2015, Danish and Ulucak (2020) determined that strong institutions support environmental protection, renewable energy helps reduce carbon emissions, and non-renewable energy negatively affects the environment. Additionally, it discovered a unidirectional causality between institutions and the environment. Similarly, Ahmed *et al.* (2017) identified consumption of non-renewable energy as the primary determinant of environmental degradation in eight Association of Southeast Asian Nations (ASEAN) nations.

Coal rent regulations positively influenced carbon release in BRICS nations (Adedoyin *et al.*, 2020). Yameogo, Omojolaibi, and Dauda (2021) also emphasized the importance of institution and governance elements for environmental sustainability in Sub-Saharan Africa. Ali et al. (2020) found quality institutions significantly reduced the ecological footprint in 47 OIC states. Christoforidis and Katrakilidis (2021) documented how institutions generate beneficial effects for reducing environmental destruction throughout 29 Organization for Economic Cooperation and Development (OECD) nations. According to Haldar and Sethi (2021), developing nations must utilize good institutions and renewable energy sources to decrease CO_2 emissions. Also, they argue that strong institutions and renewable energy utilization in developing nations serve as essential factors for decreasing CO_2 emissions.

Dong et al. (2018) studied Chinese data to show that the Environmental Kuznets Curve existed specifically through natural gas and renewable energy source reductions in carbon emissions. Makhdum et al. (2022) demonstrate that Chinese renewable energy deployment, along with strong institutions, results in less environmental harm, yet financial development combined with natural resource usage precipitates more environmental damage. The EKC hypothesis receives support from Sreenu (2022) in India, but Sajeev and Kaur (2020) only detected evidence in the short term. Through a Granger Causality analysis and their primary research, Tiwari et al. (2013) established coal consumption and openness as India's main CO2 emission factors. The study in India by Karedla *et al.* (2021), covering 1971-2016 and using the ARDL method, revealed that while trade helped reduce pollution, manufacturing and GDP growth contributed to increased pollution.

Danish et al. (2017) strongly substantiate the EKC in Pakistan. Renewable energy reduces carbon emissions while their non-renewable counterparts increase them. In a study for Pakistan, Khan et al. (2019) found that the economic upswing, along with all the elements of the set of non-renewable energy consumption, individually negatively affects the environment. Similarly, Hassan et al. (2020) concluded that robust institutions and higher income levels contribute to CO2 reductions with a both-way causality between institutional quality and pollution. Ahmed et al. (2020) also discovered similar findings, underscoring the need for strong institutions to tackle environmental issues.

Turkish data also validated the EKC, where income plays the biggest role in CO_2 emissions (Kılavuz & Doğan, 2021). Evidence from Qatar suggests that energy consumption and FDI negatively impact environmental quality (Salahuddin & Gow, 2019). Findings from Kuwait show that energy consumption is one of the key variables that significantly raise pollution (Salahuddin et al., 2018). EKC's presence has also been vindicated in the case of the United Arab Emirates. Openness and electricity consumption reduced CO_2 emissions, while urbanization increased them (Shahbaz et al., 2014). Malaysian data suggest a long-term association among carbon emissions, institutions, exports, and development. This underscores the need for strong institutions to support sustainable economic growth (Lau et al., 2014).

Table 1: Summary of Selected Time-Series Studies

Author(s)	Country	Period	Methodology	Key Findings
Makhdum et al. (2022)	China	1996-2020	ARDL	Institutional quality and renewable energy reduce environmental damage
Karedla et al. (2021)	India	1971-2016	ARDL, Granger Causality	Trade reduces CO_2 emissions while industry, GDP raise it
Khan et al. (2019)	Pakistan	1971-2016	ARDL	CO_2 emissions positively affected by growth and energy
Ahmed et al. (2020)	Pakistan	1996-2018	ARDL	Institutions and financial development have a significant long-run relationship with environmental quality
Hassan et al. (2020)	Pakistan	1984-2014	ARDL	Institutions and GDP reduce CO_2 emissions
Kılavuz and Doğan (2021)	Turkey	1961-2018	ARDL	Impact of GDP non-linear. Industry's impact on CO emissions is positive
Abulibdeh (2022)	Qatar	1990-2019	ARDL, Granger Causality	Electricity, energy, and crop production affect GHG emissions positively while economic growth affects negatively
Abdel-Gadir (2020)	Oman	1980-2018	ARDL	GDP and energy affect CO_2 emissions positively
Begum et al. (2020)	Malaysia	1990-2016	DOLS	Economic growth affects CO_2 positively.
Baek and Kim (2013)	Korea	1971-2007, 1978-2007	ARDL	Economic growth and nuclear energy affect the environment positively. Electricity from fossil fuels and energy affects the environment negatively
Agboola et al. (2022)	Russia	1970-2020	ARDL	Economic growth and fossil fuel energy harm the environment. Strong institutional quality enhances environmental sustainability.
Ali et al. (2017)	Singapore	1970-2015	ARDL	Urbanization affects CO2 emissions negatively, and economic growth's impact is positive.
Adabeyo and Akinsola (2021)	Thailand	1971-2018	ARDL, Granger causality	Economic growth causes CO2 emissions
Udeagha and Ngepah (2022)	South Africa	1960-2020	ARDL	Institutions affect environmental quality positively. Energy has negative impacts. The impact of GDP supports EKC.
Cherni and Jouini (2017)	Tunisia	1990-2015	ARDL	Long-run relationship among GDP, renewable energy, and CO2 emissions
Ayobamiji and Kalmaz (2020)	Nigeria	1971-2015	ARDL	Energy affects CO_2 emissions positively
Al-Mulali et al. (2016)	Kenya	1980-2012	ARDL	Energy consumption and GDP increase air pollution.
Khan et al. (2021)	USA	1985-2020	ARDL	Institutional quality reduces CO_2 emissions
Banerjee and Rahman (2012)	Bangladesh	1972-2008	ARDL, Granger Causality	Industry and population increase carbon emissions.
Rahman and Kashem (2017)	Bangladesh	1971-2011	ARDL, Granger Causality	Energy and industry impact CO_2 positively.
Murshed et al. (2021)	Bangladesh	1980-2015	ARDL	EKC exists. Natural gas reduces emissions.
Islam et al. (2021)	Bangladesh	1972-2016	ARDL	GDP and energy consumption raise CO_2 emissions. Institutional quality negatively impacts environmental quality.
Mehmood et al. (2020)	Bangladesh, India, Pakistan	1996-2016	ARDL	Institutional quality negatively affects environmental quality in Bangladesh.

In Korea, economic growth and nuclear energy improve environmental quality, while fossil fuel-based electricity and energy consumption reduce it (Baek & Kim, 2013). Findings from Russia suggest that economic growth and fossil fuel energy degrade the environment, while strong institutions enhance it (Agboola et al., 2022). In South Africa, the evidence supports the EKC hypothesis and identifies political institutions as instrumental in dealing with environmental challenges (Sarkodie & Adams, 2018). Adjustments in energy use, economic growth, and political institutions are essential for environmental improvements. Similarly, institutional quality in the USA has been found to lower emissions and ameliorate the environment (Khan et al., 2021).

In Bangladesh, several works investigated the features influencing the environment. Alam et al. (2012) find growth being generated by energy consumption. Furthermore, it reveals a bidirectional connection between these two variables. Banerjee and Rahman (2012) identified that population and industrial growth contribute positively to CO_2 emissions, while FDI has a negative impact. Another study found no impact of trade and growth of the economy on the nation's environmental quality (Zaman, 2012). Following Alam (2014), the GDP shares of services and industries increase CO_2 emissions. Rahman and Kashem (2017) confirm a relationship between industry, energy, and pollution in the long run. Both industry and energy were significantly increasing CO_2 emissions. Additionally, some works discussed factors affecting institutional quality in the country (Toufique, 2024a, 2024b).

However, a majority of the earlier works in Bangladesh failed to examine the impact of institutions on the environment. Two recent studies have addressed this gap. One of them discovered that institutional quality led to a decline in environmental quality by increasing pollutions in both the short and long term (Islam et al., 2021). The other research shows that institutional quality contributed to higher CO_2 emissions based on data from 1996 to 2016 (Mehmood et al., 2021). This study employed one of the six WGIs to measure institutions, while the former study used the political terror scale to measure institutions.

Existing literature underscores the important influence of institutions' quality on the environment. Studies from different countries suggest that strong institutions help lower pollution and improve environmental quality. Research on Bangladesh has paid insufficient attention to the importance of institutions. The few studies suggest a negative influence of institutional quality on environmental quality – a finding opposite to the findings from other countries. This emphasizes the need for further investigation to understand better the role of institutional quality in Bangladesh's environmental outcomes. This research postulates that better institutional quality improves environmental quality in the country. It extensively scrutinizes the relationship by using distinct measures of institutions and constructing two models.

Hypothesis Development

To address the gap identified in the literature review, this paper formulates a model that examines how the environment is affected by institutions in Bangladesh, considering per capita GDP and natural gas's electricity share. Hence, the study formulates the following hypotheses:

H_1: Improved institutional quality reduces CO_2 emissions

H_2: Economic growth increases CO_2 emissions

H_3: Greater reliance on natural gas-based electricity generation reduces CO_2 emissions

These hypotheses are developed by tracing the relationships observed in earlier studies. Environmental quality, typically measured by CO2 emissions, is influenced by institutional quality, GDP growth, and the structure of energy sources. Through better governance, regulatory effectiveness, and public accountability, strong institutional frameworks are generally linked to lower pollution levels (Abbas et al., 2025; Acemoglu et al., 2001; Halkos & Tzeremes, 2013). Nevertheless, empirical evidence from Bangladesh indicates a different trend, where stronger institutions have coincided with worsening environmental outcomes (Islam et al., 2021; Mehmood et al., 2021), highlighting the need for a more nuanced re-examination. Economic growth is often associated with environmental deterioration in the primary phases of development, as suggested by the EKC before improvements occur at higher income levels (Danish et al., 2017; Sreenu, 2022). In Bangladesh's case, studies suggest that rising GDP continues to exacerbate CO_2 emissions (Alam et al., 2012; Zaman, 2012). Natural gas generates less carbon pollution than coal or oil but still produces CO2 emissions. The 60% contribution of natural gas to electricity generation in Bangladesh requires additional environmental assessments (Dong et al., 2018; Islam et al., 2020). The study employs the ARDL modeling approach to empirically verify these hypotheses while describing its implementation in subsequent sections.

Data Sources and Research Methods

Different measurement approaches exist for institutional quality assessment, but the WGIs are the most widely utilized among academic researchers (Kaufmann et al., 2010). The WGIs evaluate six distinct dimensions, which include voice and accountability (VA), political stability and absence of violence (PS) together with government effectiveness (GE), regulatory quality (RQ), rule of law (RL), and control of corruption (CC). Studies commonly evaluate institutional quality using single or multiple indicators from the WGIs framework, according to experts Almatarneh and Emeagwali (2019). In their research Alonso & Garcimartín (2013) propose that combining the average values from six WGIs generates a trustworthy quantitative measure for institutional analysis because it evaluates the entire institutional framework. The findings of Alonso & Garcimartín were validated through alternative indices that included the institutional component of the Global Competitiveness Index along with Objective Governance Indicators, Corruption Perceptions Index and Doing Business Indicators.

In line with this literature, the current study employs two proxies for institutional quality. The construct of the first proxy uses principal component analysis to create an aggregated index. PCA provides substantial benefits because it extracts statistical variance among six WGIs while reducing data complexity and producing a condensed governance quality measurement (AlShiab et al., 2020). The constructed index obtains essential common governance patterns through this approach, which selects the most important elements from multiple dimensions. The PCA-based index appears as INQ in the document.

A second proxy utilizes the simple arithmetic mean from the six WGIs according to the methodology described by Alonso & Garcimartín (2013). Using average values simplifies institutional quality measurement and retains consistency with earlier empirical studies. This index is denoted by AvgINQ.

The research uses CO_2 emissions per capita, expressed in metric tons, to measure environmental quality. Other measures used in the relevant literature are greenhouse gas (GHG) emissions, PM2.5 concentration, and ecological footprint (Sapkota & Bastola, 2017). However, as Tabash et al. (2024) point out, CO_2 emissions per capita serve as an effective direct, quantifiable indicator of countrywide environmental impact, especially in evaluating energy-use and economic development relationships and their environmental consequences. GDP per capita in constant 2015 U.S. dollars is used to capture economic development. While alternatives like gross national income (GNI) per capita exist, GDP per capita is a standard and widely accepted indicator that better captures the domestic economic activities relevant to environmental outcomes (Shahbaz et al., 2015). ENG represents the percentage of natural gas usage in electricity generation relative to entire electricity output in Bangladesh. Natural gas production in Bangladesh stands at 60% of the country's total electricity output, which directly affects economic progress and CO_2 emissions levels (Chen et al., 2023). This implies that natural gas is a key covariate. To ensure consistency and reliability, all variables have been retrieved from the reliable World Development Indicators (WDI) database. All variables undergo natural logarithmic transformation to maintain consistency and enhance interpretability while aligning with prior studies. The examined timeframe stretches from 1996 through 2015 because the WGI and electricity data are available during this period.

Table 2: Descriptive Statistics

Variable	Mean	Median	Std. Dev.	Minimum	Maximum
$\ln CO_2$	-1.236	-1.251	0.464	-1.963	-0.534
lnINQ	4.059	4.337	0.914	0.00	4.615
lnAvgINQ	3.741	4.017	1.028	0.00	4.615
lnGDP	6.859	6.831	0.357	6.354	7.487
lnENG	4.470	4.479	0.040	4.390	4.529

Table 2 displays summary information about the variables used in the study. The table reports five fundamental statistical measures for each variable: mean, median, standard deviation, minimum, and maximum. The variable lnGDP demonstrates a mean at 6.859 and a median at 6.831 with standard deviation reaching 0.357, while all recorded values exist between 6.354 and 7.487. Analysis of summary statistics from Table 2 requires the same interpretation method for each variable. To verify stationarity, the study implements three different unit root tests, including the Augmented Dickey-Fuller (ADF), Phillips-Perron (P-P), and modified Dickey-Fuller (DF-GLS). The ARDL model is suitable as an analytical tool as it can handle variables with different integration levels (Pesaran et al., 2001). The method delivers reliable results even in small samples and endogeneity (Muhammad & Abdullahi, 2020; Pesaran et al., 2001; Salahuddin et al., 2018).

The ARDL equations are presented below,

$$\ln CO_{2t} = \beta_0 + \sum_{i=1}^{p} \beta_i \ln CO_{2t-i} + \sum_{i=0}^{k} \gamma_i \ln INQ_{t-i} + \sum_{i=0}^{k} \delta_i \ln GDP_{t-i} + \sum_{i=0}^{k} \rho_i ENG_{t-i} + \varepsilon_t \quad (1)$$

$$\ln CO_{2t} = \beta_0 + \sum_{i-1}^{p} \beta_i \ln CO_{2t-i} + \sum_{i=0}^{k} \gamma_i \ln AvgINQ_{t-i} + \sum_{i=0}^{k} \delta_i \ln GDP_{t-i} + \sum_{i=0}^{k} \rho_i \ln ENG_{t-i} + \varepsilon_t \quad (2)$$

The dependent variable has p lags, and k is the highest lag of the independent variable. The equations given below provides specifications for the ARDL bounds test for Model 1 and Model 2, respectively:

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta \ln CO_{2t-i} + \sum_{i=0}^{k} \gamma_i \Delta \ln INQ_{t-i} + \sum_{i=0}^{k} \delta_i \Delta \ln GDP_{t-i} + \sum_{i=0}^{k} \rho_i \Delta \ln ENG_{t-i} + \lambda_1 \Delta \ln CO_{2t-1} + \lambda_2 \ln INQ_{t-1} + \lambda_3 \ln GDP_{t-1} + \lambda_4 \ln ENG_{t-1} + \varepsilon_t \quad (3)$$

$$\Delta \ln CO_{2t} = \beta_0 + \sum_{i=1}^{p} \beta_i \Delta \ln CO_{2t-i} + \sum_{i=0}^{k} \gamma_i \Delta \ln AvgINQ_{t-i} + \sum_{i=0}^{k} \delta \Delta \ln GDP_{t-i} + \sum_{i=0}^{k} \rho_i \Delta \ln ENG_{t-i} + \lambda_1 \ln CO_{2t-1} + \lambda_2 \ln AvgINQ_{t-1} + \lambda_3 \ln GDP_{t-1} + \lambda_4 \ln ENG_{t-1} + \varepsilon_t \quad (4)$$

Δ represents the first difference, t is for the time index, i shows lag, and ε is the error term. The null hypothesis posits the absence of cointegration, whereas the alternative hypothesis suggests the existence of cointegration.

$$H_0 : \lambda_1 = \lambda_2 = \lambda_3 = \lambda_4 = 0 \quad (5)$$

$$H_1 : \lambda_1 \neq 0, \lambda_2 \neq 0, \lambda_3 \neq 0, \lambda_4 \neq 0 \quad (6)$$

Following the methods of Toda & Yamamoto (1995), Zapata & Rambaldi (1997), Mavrotas & Kelly (2001) and Wolde-Rufael (2010), the Toda-Yamamoto procedure is employed to estimate Granger causality in an augmented VAR model.

Results and Discussion

Table 3 concisely reports the outcomes of the three unit root tests. Based on these findings, all variables are either I(0) or I(1), with none exhibiting integration of a higher order. Hence, the ARDL estimation technique can be used.

Table 3: Unit Root Tests

	ADF		P-P		DF-GLS		I(?)
	Level	**First Diff.**	**Level**	**First Diff.**	**Level**	**First Diff.**	
CO_2	-5.068***		-4.665***			-3.373***	I(0), I(1)
INQ		-2.673**		-5.995***	-16.521***		I(0), I(1)
AvgINQ		-2.128**		-3.967***	-8.961***		I(0), I(1)
GDP		-3.995***		-3.987***		-4.156***	I(1)
ENG	-3.619***			-3.636***		-2.734***	I(0), I(1)

***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

Based on the Akaike Information Criterion, Model 1 is classified as an ARDL (1, 1, 1, 1) model, while Model 2 follows an ARDL (1, 2, 1, 1) structure. In both models, environmental quality—indicated by CO2 emissions—is shaped by institutional quality, GDP per capita, and electricity generated from natural gas. For Model 1, institutional quality is denoted by INQ, whereas in Model 2, it is represented by AvgINQ. Table 4 provides the ARDL results.

Institutions, GDP, and natural gas electricity significantly impact environmental quality, as shown in Model 1. The coefficient of -0.019 suggests that better institutions reduce carbon emissions. Higher income raises carbon emissions and CO_2 emission is income elastic as the associated coefficient, 1.654, is positive and greater than 1. As the coefficient of 0.794 indicates, more reliance on natural gas for electricity production degrades the environment. In the short term, GDP and electricity produce significant and negative impacts, while institutional quality does not have any important impact. The error correction term (ECT) of -0.957 suggests that around 95.7% of deviations from the long-run equilibrium are adjusted in each period. This coefficient is highly significant at the 1% level. Additionally, the results from the bounds test indicate that the null hypothesis, which assumes no long-run relationship, is rejected at the 5% level. This confirms that a long-term relationship exists between the variables in Model 1.

Table 4: ARDL Estimation with Index Created from the WGIs

Y= CO_2	Model 1 (1 1 1 1)	Model 2 (1 2 1 1)
Variable	**Long run**	
INQ	-.019**(-2.19)	
AvgINQ		-.033***(.009)
GDP	1.654***(.053)	1.686***(.048)
ENG	.794***(.252)	.611**(.215)
	Short run	
Δ INQ	.009 (.009)	
Δ AvgINQ		.023*(.011)
Δ AvgINQ(-1)		.018(.010)
Δ GDP	-3.40**(1.24)	-5.939***(1.66)
Δ ENG	-1.323***(.364)	-1.48***(.382)
Constant	-15.129***(2.852)	-16.29***(2.71)
ECT(-1)	-.957***(.196)	-1.080***(.197)
ARDL bounds Test H_0: no level relationship	Reject H_0 at 5%	Reject H_0 at 5%

Standard errors are presented in parentheses. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

The diagnostic tests relevant to Model 1 are shown in Table 5. The model accounts for 74.61% of the variation in pollution, with the adjusted value being 58.46% after accounting for degrees of freedom. Results from both the Breusch-Pagan and White's tests confirm the errors exhibiting homoskedasticity. No relevant variables have been omitted from the model. Additionally, the residuals are normally distributed, and the model is free from autocorrelation. Following the cumulative sum (CUSUM) tests, the parameters are stable.

Table 5: ARDL Diagnostics

Test	Model 1	Model 2
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity	χ^2 = 1.22 (0.269)	χ^2 = 0.60 (0.438)
White's test	χ^2 = 19.00 (0.391)	χ^2 = 18.00 (0.388)
Ramsey RESET test	F = 1.47 (0.293)	F = 2.43 (0.163)
Breusch-Godfrey LM test	χ^2 = 0.442 (0.506)	χ^2 = 5.454 (0.019)
Durbin's alternative test for autocorrelation	χ^2 = 0.238 (0.625)	χ^2 = 3.478 (0.062)
Jarque-Bera test	χ^2 = 1.833 (0.3998)	χ^2 =4.535 (0.1036)
Cumulative sum test for parameter stability	0.3145 (recursive), 0.4604 (OLS)	0.451 (recursive), 0.305(OLS)

p-values are reported in parentheses. For decisions, the 5% level of significance is considered.

As shown in Table 4, Model 2 demonstrates that institutions, GDP, and electricity generated from natural gas have significant long-term impacts on carbon releases. Their respective coefficients of -0.033, 1.686, and 0.611 show that institutional quality has a negative effect; GDP and natural gas-based power generation have favorable effects. The short-term dynamics reveal that GDP and ENG have significant negative effects, while institutional quality has a positive impact, which is significant only at the 10% level. Following the ECT of -1.080, equilibrium is restored with a gradual oscillation. The outcome of the bounds test confirms long-term variables among the variables. Diagnostic tests, presented in Table 5, reveal that the model shows no signs of heteroskedasticity or omitted variable bias. The residuals follow a normal distribution. Although the B-G LM test points to serial correlation, Durbin's alternative test does not find that at 5%. Finally, the stability of the parameters is validated by CUSUM tests.

The long-term coefficients in both models exhibit similar signs and significance levels; the short-term coefficients in both follow the same pattern. The ECTs are also quite close in value. Long-term links between variables shown by both models highlight the robustness of the results. The diagnostic tests produce comparable results for both models except for serial correlation. However, Durbin's alternative test provides consistent conclusions across the models at the 5% significance level.

The long-term results show that institutional quality influences CO_2 emissions negatively, supporting Hypothesis H_1. This implies that stronger institutions contribute to better environmental outcomes in Bangladesh, consistent with findings from global studies (Abbas et al., 2025; Halkos & Tzeremes, 2013) but differing from earlier results in the Bangladeshi context (Islam et al., 2021; Mehmood et al., 2021). GDP is positively and significantly associated with CO_2 emissions, validating Hypothesis H_2. This outcome follows the EKC theory at the initial phases of development (Danish et al., 2017) and reflects Bangladesh's ongoing industrial expansion (Alam et al., 2012; Zaman, 2012). Contrary to Hypothesis H_3, natural gas electricity is positively related to CO_2 emissions. Although cleaner than other fossil fuels, the extensive use of natural gas without substantial efficiency gains can contribute to environmental deterioration, supporting apprehensions of some previous studies (Dong et al., 2018; Makhdum et al., 2022). The research findings on CO_2 emissions from Bangladesh are consistent with Islam et al. (2021) and Mehmood et al. (2021) because GDP and natural gas electricity sources demonstrate positive and significant relationships with CO_2 emissions. This study differs because it establishes institutional quality as an emission mitigation factor while employing broader indicators to measure institutional quality.

The results stress the need for an extensive institutional overhaul in Bangladesh to step up governance workings, elevate legislative enforcement competence, and encourage environmentally responsible mechanisms.

Conclusion and Policy Implications

In this study, two distinct institutional quality measures derived from WGIs reassess the institution-environment nexus in Bangladesh. The research estimates two ARDL models to analyze the annual dataset from 1996 through 2015. The results of unit root tests show that applying the ARDL model is appropriate, while diagnostic tests prove both the stability and robustness of the estimated modeling system.

Stronger institutional frameworks lead to lower CO_2 emissions based on the long-run findings and support the hypothesis that institutional and environmental improvements are positively related. On the contrary, natural gas power generation and economic growth increase emissions. The extensive utilization of natural gas as an energy source causes environmental damage because it leads to pollution, even though it ranks higher than traditional fossil fuels in terms of environmental friendliness. GDP growth, together with natural gas electricity usage, produces negative results in the short term, while institutions remain less important in that time frame. The models present a clear long-term connection between all variables and reveal no major problems concerning stability or model fit.

The present study counters findings regarding Bangladesh by Islam et al. (2021) and Mehmood et al. (2021) by finding that enhanced institutional performance reduces environmental harm. The present research uses comprehensive and distinct measures of institutional quality, which differ from previous studies and can be responsible for this result.

Bangladeshi policymakers must enhance their focus on institutional quality building to achieve sustainable environmental benefits. The essential path forward requires enhancing transparency, greater accountability, and the enforcement capacity of governing structures. Environmental regulations should receive strict enforcement while institutions get authorized power to implement effective resource management and control industrial emissions. Energy sector development depending heavily on investments that promote cleaner technologies and enhance operational efficiency especially regarding natural gas-powered electricity plants will be critical. Economic growth requires environmental stewardship through environmental factors incorporated into national development strategies. Institutional capacity strengthening will permit Bangladesh to achieve development that incorporates both inclusion and sustainability.

Future studies could explore additional environmental indicators and broader comparative analyses further to enrich the understanding of institutional impacts on sustainability.

Declaration

Conflict of Interests

None to disclose.

Data Availability Statement

Data were sourced from the World Bank's publicly available data repositories

Authors' Contribution

The conception, design, data collection, analysis and interpretation of results and writing the manuscript were the sole responsibility of the author. All aspects of the research were carried out independently by the author.

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