American Research Journal of Humanities & Social Science (ARJHSS)
E-ISSN: 2378-702X
Volume-07, Issue-09, pp-29-40
www.arjhss.com

Research Paper Open Access

Exploring the impact of Economic Growth on Climate Change: Insights from Bangladesh

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Abstract: Bangladesh is geographically located in climate vulnerable region in the world. The environmental degradation and climate change are mainly caused by emission of greenhouse gases (GHG), specifically CO_2 emissions. This creates serious threats to human life, environmental quality, and sustainable development. In this context, this analysis purposes to identify the nexus of the Climate Change, per-capita GDP earning and sustainable & non-stainable energy consumption in Bangladesh. In estimation process, this research utilizes the annual secondary data from 1990 to September 2023 available from WDI by using FMOLS method. Greenhouse gas discharges (GHS) is the dependent variable in the estimation process GDP per-capita, Renewable energy consumption, Non-Renewable energy consumption and Trade Openness are included as a control variable. A simple the Correlation Matrix is also done to detect the interconnection among the variables. The result of this analysis indicates a statistically significant and reveals that GDP per-capita, Renewable energy consumption, Non-Renewable energy consumption and Trade Openness has impact in the long-run on GHS emissions of Bangladesh, but the statistical sign of the Non-Renewable energy consumption did not show the result as per the theory. This is because, Non-Renewable energy usage in Bangladesh has very low impact on overall CO_2 emissions. Besides, Bangladesh as least develop country its contribution on greenhouse gas emission is not significant that's why the sign of the Non-Renewable energy consumption didn't exhibit the result as per theory. The findings of this study are informative to policymakers or experts for formulating policies as well as providing important insights for the handling the climate changes and also taken policy to take regulatory policy about sustainable development.

Keywords: Co_2 emissions, Renewable energy usages, Fully Modified OLS, Sustainable Development
JEL: K32, Q01, L72, Q54

I. Introduction

Asia and the Pacific hold significant geographic importance in global climate change efforts, and Bangladesh is worse affected country suffered from climatic variation in this region. This region makes approximately fifty percent of all greenhouse gas emissions globally, and most countries are unprotected from the adverse impact of climate change. These countries include coastal, deltaic, and island, and 11 of the 20 countries most affected by extreme weather events in 2000–2019 (Germanwatch e. V. 2021). Bangladesh faces annual losses of $1 billion from tropical cyclones, with up to one-third of agricultural GDP at risk by 2050 due to climate change, threatening half the country's employment. Climate impacts could drive 13.3 million internal migrants over 30 years, and severe flooding might reduce GDP by 9%, with escalating costs from environmental degradation and health issues (World Bank, 2022). Besides, in recent few years, due to COVID-19 pandemic, and the Russia-Ukraine conflict have been putting Bangladesh economy under various external and internal pressures and creating obstacles to achieving sustainable economic growth for this country. However, Bangladesh need to attain all 17 SDGs by 2030. COVID-19 pandemic has caused substantial setbacks and delaying the action of environmental SDGs such as climate change action, encouraging green consumption and production, and protecting life on land and below water, has been prolonged (ADB, 2021). However, Kalkuhl, M., & Wenz, L. (2020) project that if global mean surface temperature will rise around 3.5°C, the global productivity could decline by 7-14 percent in the end of century in 2100, along with severe damage expected in tropical and poor regions.

In addition, the country's ecosystem is under major threat as 60 percent of its land mass is barely 5 meters above sea level. There is a prediction that the country will experience about 40 cm (15 inches) of sea level rise by 2080 (Streatfield, 2008), which will certainly further worsen the situation and wreak havoc on the lives and livelihoods of its people, in particular those who are living across the climate hotspots of the country. The Global Climate Change Risk Index 2021 ranks Bangladesh seventh among the countries most affected by extreme weather events in the last 20 years, since 1999 (Eckstein D. et al., 2021).

Projections from the General Circulation Model (GCM) for Bangladesh suggest a temperature rise of 2.4°C and also a 9.7 percent increase in annual rainfall by 2100. The Bangladesh Delta Plan 2100 indicates that these historical movements are likely to persist, with temperatures continuing to upsurge and rainfall calculated annually expected to surge in the future. A World Bank study highlighted that floods inundate up to two-thirds of Bangladesh every three to five years, causing severe damage to overall infrastructure, agricultural sector, food production and peoples' livelihood. Additionally, lowland coastal areas face heightened risks from cyclones and storm gushes. The Intergovernmental Panel on Climate Change (IPCC) forecasts that Bangladesh could lose around 17% of its low-lying land and 30% of food production due to the negative impact of environmental degradation on agriculture. According to the IPCC's Fifth Assessment Report, Bangladesh is particularly vulnerable to climate change, facing risks from sea-level upsurge and adverse weather events such as salinity, drought, unwanted rainfall, and tidal flows. Despite contributing only 0.35 percent of global emissions, Bangladesh suffers highly due to environmental transformation.

In this circumstance, it is crucial to detect the elements that will create economic and environmental strength and resistance against climate vulnerability to protect the environment, the whole economy, and human beings from great disasters. Bangladesh is least developed country and climate exposed, so it is vital to determine the interconnection of climate changes and sustainable economic growth and which factors create threats to environmental degradation or potentialities to achieve sustainable development for governments, policymakers, and experts to initiates effective action and policy reforms for this country.

In the present perspective, this study will explore the dynamics between Climate Change and Sustainable Economic Growth across geographic areas, specifically for Bangladesh, and examine the threatening and safeguarding factors behind Climate Change and Sustainable development because this remains time for a country attempts to achieve the highest economic growth without sacrificing environmental quality. The basic objective of this analysis is to visualize nexus of GDP per-capita, energy consumptions and trade openness the long-run effects CO_2 discharge and the resulting environmental impact on the Bangladesh. For this purpose, this study analyses the secondary data available and adopts the FMOLS and CCR approaches for estimation to find out effects in the long-run by utilizing supply side variables such as GDP per-capita and demand side factors such as environment friendly and fossile fuel energy consumption with an external side variable trade openness. To investigate the casual linkage the pairwise Granger causality test is also implied. Other than this technical analysis, remaining part of this analysis remains arranged according to the following ways; part two reviews the literature, part three exhibits the data and econometric methodology, part four explains the econometric analysis with the interpretation of the experiential results, and part five offers policies, describes conclusion and limitations of this study.

II. Related Literature

Though there is some research on how GDP growth affect CO_2 emission, there is very little study on per capita GDP, energy uses and an external side variable such as trade openness and its impacts on GHS emission on Bangladesh context. In this regard, the work pursued to find out nexus between the per capita GDP, energy uses and an external side variable such as trade openness and its impacts on CO2 emission in Bangladesh and what is Bangladesh's contribution to global climate change? To find out this answer, we are incorporate these previous literatures in this study to explain increase in GDP per capita, utilization of renewable and non-renewable energy and trade openness catalyzing on GHS emission Bangladesh as well as different economy.

In 1896, Svante Arrhenius became the first scientist to make a quantitative forecast of environmental warming due to a doubling of atmospheric greenhouse gas emission. Over the past 125 years, scientists have extensively studied the effects of greenhouse gas emissions and inadequate climate action on the global climate (Auffhammer M., 2019).

The conventional economic hypothesis on the connection between environmental pollution and per-capita income was first introduced by Kuznets in 1955, known as "Environmental Kuznet Curve (EKC)".

Raihan et al. (2022), conducted a study that investigated the relationship between economic growth, energy use, urbanization, agricultural productivity, and CO2 emissions in Bangladesh, using time series data from 1972 to 2018. It found that these factors contribute to increased CO2 emissions, emphasizing the need for strong regulatory policies to achieve sustainable development.

Alam M. J. et al. (2012) observed the potential dynamic causation between energy usages, electric power utilization, GHS emissions, and GDP in Bangladesh. The research found that both energy and electricity consumption meaningfully drive GDP in Bangladesh, with evidence of long-term bidirectional causality. However, the research also revealed that increased energy use results in higher carbon emissions, emphasizing the importance of adopting sustainable energy policies.

Hasan, M. A. et al. (2020). The study assessed Bangladesh's climate change policies, finding limited impact on reducing emissions, particularly in energy decarbonization and demand management. While some policies align with strategic development goals, others, like fossil fuel-based power, do not, highlighting the need for more integrated and effective strategies.

Bhuiyan, M. A., et al. (2022) examined the systematically analyses the relationship between sustainable energy usages and GDP by analyzing 46 SCI/SSCI indexed peer-reviewed journal articles from 2010 to 2021, following PRISMA guidelines. The findings indicate that sustainable energy usages do not obstruct the economic growth in both emerging and advanced nations, though its effect on progress in advanced nations is minimal beyond a certain threshold. The study suggests that policymakers should promote renewable energy as a sustainable growth strategy without fearing negative economic impacts.

Farajzadeh, Z. et al. (2023) explored the consequences of climate change on economic growth in Asia using a macroeconomic-climate model that incorporates temperature-related damage into an augmented Solow growth framework. The study found that environmental climatic variation meaningfully reduces productivity per worker, specifically under severe damage scenarios, with productivity growth being most adversely affected. To mitigate these impacts, the study suggests that policymakers should encourage flexible production technologies, invest in capital-embodied technologies, and reduce reliance on environmental capital.

Musa, M., et al. (2024) evaluated the connection between economic growth, energy utilization, industrialization, and CO_2 emissions in Bangladesh from 1990 to 2020, using dynamic ARDL models and frequency domain causality tests. The findings reveal that economic growth and energy consumption contribute to environmental degradation, while industrialization and FDI also increase CO_2 emissions in the short term. The study suggests that Bangladesh should prioritize policies focused on environmental innovation, renewable energy adoption, and attracting sustainable foreign investments to achieve balanced economic growth and environmental sustainability.

Zeb, R., (2014) examined the short- and long-run causality relationships among power production, CO_2 discharge, environmental resource exhaustion, economic growth, and poverty for SAARC countries from 1975 to 2010 using Granger causality tests and Fully Modified OLS (FMOLS). The findings reveal that energy production reduces carbon emissions but increases GDP and poverty impacts vary across countries. The study suggests that SAARC nations should focus on sustainable energy production to balance economic growth with environmental protection and poverty reduction.

Different works have been done to find out the causal-effect relationship between economic growth and carbon emission and exhibit that there is bidirectional, unidirectional, or neutral causality among variables like economic growth, CO2 emission, financial development, and electricity consumption (Salahuddin et al., 2015; Kofi Adom et al., 2012).

Tariq, G. et al. (2022) researched the impact of green technology, green energy consumption, energy optimization, trade, economic development, and FDI on climate change in South Asian countries. He pointed out that green energy consumption, technology, and energy optimization negatively impact greenhouse gas emissions.

Carbon emissions are the main factor in environmental degradation associated with climate change and global warming, which risks environmental sustainability where eco-friendly energy, technology, and environmental taxes contribute to mitigating carbon emissions (Khan et al., Z. 2021).

Farajzadeh, Z. et al. (2023) reviewed the effect of climate change on economic growth and found that among the three channels of the climate effect, productivity growth reduction showed the most adversative impact on productivity. Another study conducted by Dogan, E., & Seker, F. (2016) for top countries that use renewable energy found that enhances in renewable energy consumption, trade openness, and financial development decrease carbon emissions while increases in non-renewable energy consumption contribute to the level of emissions.

By using the ARDL model Hasan, M. B., et l. (2022), explored the impact of sustainable energy use and conventional energy use on Bangladesh's economic growth and climate change nexus since 1980 toward 2018. The outcomes revealed that REC enhances economic growth and environmental quality, while NREC hampers both. The study suggested that Bangladesh should focus on policies promoting renewable energy, for example providing subsidies, tax credits, and technological advancements, to ensure sustainable economic progress.

Murshed, M., Ahmed, et al. (2021) assessed the environmental impact of macroeconomic factors on Bangladesh's carbon footprint using the data since 1975 to 2016, using climatic footprints as a new measure of ecological welfare. The study found that fossil fuel and natural gas consumption increase carbon footprints, while non-fossil fuels and hydroelectric power reduce them. Additionally, economic growth and international trade contribute to higher climate footprint. This study focused the need for a transition to clean energy to help Bangladesh achieve carbon neutrality and meet its Paris Agreement commitments, advocating for policies that promote renewable energy.

III. Data and model specification and Model of the estimation procedure

Recently, achieving sustainable development and maintaining an environment-friendly economic system has been crucial. Climate change and economic growth are multivariate factors and many direct and indirect components influence these.

This research work is constructed on secondary data, and these data are composed from WDI. However, this study utilized the Annual data of GDP per-capita (constant 2015 US$); Total greenhouse gas emissions (kt of CO_2 comparable), Renewable energy consumption (% of total final energy consumption), Fossil fuel energy consumption (% of total) as proxy of Non-Renewable energy and Trade (% GDP) is proxy as Trade Openness. This study's chosen sample period may be specified from 1990 to 2022 due to different structural changes, data availability, and financial reforms before the stated period.

In this research, our key variable is CO2 emission, since we want to explore connection between the greenhouse gas emissions and GDP per-capita in Bangladesh. So, we examined the greenhouse gas emissions as a dependent variable and other variables respectively GDP per-capita, Renewable energy consumption, Non-Renewable energy and Trade Openness are implied as explanatory variables or independent variables. In this investigation, the estimating process is done by using the FMOLS model. FMOLS is suitable when all the variables attain stationarity after first differencing and at the same time cointegrated (Mehmood & Shahid, 2014). Additionally, a correlation matrix is also illustrated to point out the connection between greenhouse gas emissions (GHS) and other variables respectively GDP per-capita, Renewable energy consumption (REC), Non-Renewable energy consumption (REC)and Trade Openness (TO).

In this analysis followed the functional form of natural log form for the greenhouse gas (Co2) emissions and for GDP per-capita except the rate of renewable energy consumption, the rate of non-renewable energy consumption and the rate of trade Openness. The equation is given below:

LNGHS = f (LNGDP, REC, NREC, TO) …………….…. (1);

Where, LNGHS = Log of the Greenhouse Gas (Co2) Emissions;
LNGDP = Log of GDP Per-Capita (constant 2015 US$);
REC = Rate of Renewable Energy Consumption;
NREC = Rate of Non-Renewable Energy Consumption;
TO = Rate of Trade Openness;

This study uses FMOLS model to determine the long-run effect of GHS emission with GDP per capita as well as energy usages. The FMOLS equation of this analysis is:

An empirical Model can be drawn as per the following way:

$$GHS_t = \delta_0 + \delta_1 GDP_t + \delta_2 REC_t + \delta_3 NREC_t + \delta_4 TO_t \text{ ……………… (2);}$$

An econometric model can be drawn from equation (2)

$$GHS_t = \delta_0 + \delta_1 GDP_t + \delta_2 REC_t + \delta_3 NREC_t + \delta_4 TO_t + U_t \text{ ……………… (3);}$$

Logarithmic form of the equation (3) can be rewrite as per the following way;

$$LNGHS_t = \delta_0 + \delta_1 LNGDP_t + \delta_2 REC_t + \delta_3 NREC_t + \delta_4 TO_t + U_t \text{ ……………… (4);}$$

Here, t means time, U symbol of error disturbance term, δ_0 is the intercept and δ_1, δ_2, δ_3 and δ_4 are the coefficient of the exogenous variables.

IV. Estimated Result analysis

1.1. Summary of the statistics

In appendix, table:1 presents the statistical findings of several normalcy tests (skewness, kurtosis, Jarque-Bera, and probability) in addition to the summary measurements across variables. There are 34 samples of Bangladesh time series data for each variable from 1990 to 2023. All of the variables are considered normal when the skewness values are almost zero. In addition, the kurtosis measure was employed to ascertain if the series had a heavy or light tail relative to a normal distribution. The observed sample show that all of the series are platykurtic because their values are less than 3. Additionally, lower values for the Jarque-Bera probability suggest that all of the parameters are normally distributed. We decide to investigate the variables' correlations in light of these findings.

1.2. Correlation Matrix

At first, to examine the magnitude or interlinks among the variables, a correlation matrix will be done. Then, it also tests the basic properties of data series, and in the case of panel data analysis, it is essential to check the cross-section dependence among the variables (Baltagi & Pesaran, 2007). Before proceeding toward the FMOLS approach under cointegration regression analysis, the correlation among the variables has been checked to understand how well the variables are connected.

Table 2: Correlation Matrix					
	LNGHS	LNGDP	REC	NREC	TO
LNGHS	1.000000	0.991670	-0.995073	0.987633	0.536171
LNGDP	0.991670	1.000000	-0.989575	0.982271	0.468998
REC	-0.995073	-0.989575	1.000000	-0.996568	-0.542943
NREC	0.987633	0.982271	-0.996568	1.000000	0.557890
TO	0.536171	0.468998	-0.542943	0.557890	1.000000

Table 1 demonstrates that GDP per capita, non-renewable energy consumption, and trade openness are positively interrelated with greenhouse gas emissions. Conversely, renewable energy consumption is negatively correlated with CO_2 emissions. The correlation between CO_2 emissions, GDP per capita, and energy usage suggests that increases in GDP per capita and energy consumption lead to higher CO_2 emissions. This correlation matrix aligns with theoretical expectations.

1.3. Unit Root Test

Table 3: Unit root test								
	ADF-test				**PP-test**			
Variables	At level		At first difference		At level		At first difference	
	t- statistics	p- value	t- statistics	P* - value	Adj.t-statistics	p-value	Adj.t-statistics	P* - value
LNGHS	0.043962	0.9561	-4.618408	0.0008	0.006587	0.9526	-4.589777	0.0009
LNGDP	5.614438	1.0000	-3.174090	0.0310	4.784400	1.0000	- 3.136667	0.0338
REC	-0.575472	0.8617	-5.147491	0.0002	1.252962	0.9978	-11.07188	0.0000
NREC	-1.443253	0.5474	-6.473924	0.0000	-0.737368	0.8233	-6.448224	0.0000
TO	-1.876085	0.3390	-5.047878	0.0003	-1.876085	0.3390	-5.052582	0.0003
Null hypothesis is no unit root presence and * is for statistically significance.								

To start the estimation of the analysis, at first, we examined the stationary test of the variables because a random time series is assumed to be stationary if its mean and variance are time invariant (Gujarti, 1995). At first, to determine whether the variables are stationary, we have done ADF test. ADF is the simple and convenient approach to determine stationarity. Philips-Perrron (PP) unit root tests (Philips-Perrron, 1988) have also been used to test stationarity among the variables. However, all variables are stationary in the first difference at the 5% significance level. The results of the unit root test are depicted in Table-3.
After stationary test, we found co-integrating equation among the variables. If there exist at least one co-integrating equation, then we can proceed to run the FMOLS model; otherwise, we have to carry on ARDL model.

1.4. Co-integration test

In our analysis (Table 3), we used the most convenient co-integration method, the Johansen co-integration test, and we found three co-integrating equation. Besides, the trace test indicates 3 co-integrating equation at the 0.05 level, and the Maximum–eigen value test also showed 3 co-integrating equation at the 0.05 level. The results of the Johansen co-integration test indicate the long-run relationship among the variables.

Table 4: Johansen co-integration test				
Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.787784	102.7415	69.81889	0.0000
At most 1 *	0.501822	53.13665	47.85613	0.0147
At most 2 *	0.445042	30.83910	29.79707	0.0378
At most 3	0.304236	11.99551	15.49471	0.1571
At most 4	0.012042	0.387671	3.841465	0.5335
Trace test indicates 3 cointegrating equation(s) at the 0.05 level *** denotes rejection of the hypothesis at the 0.05 level** ****MacKinnon-Haug-Michelis (1999) p-values**				

In addition, the result of Engle-Granger cointegration test is also showed this series is cointegrated.

Table 5: Cointegration Test - Engle-Granger		
Null hypothesis: Series are not cointegrated		
	Value	Prob.*
Engle-Granger tau-statistic	-1.635050	0.9790

Engle-Granger z-statistic	-7.891904	0.9420
*MacKinnon (1996) p-values.		
Intermediate Results:		
Rho - 1	-0.239149	
Rho S.E.	0.146264	
Residual variance	0.000262	
Long-run residual variance	0.000262	
Number of observations	33	
Number of stochastic trends**	5	
**Number of stochastic trends in asymptotic distribution.		

As per p-value, null hypothesis is rejected and this applied series in cointegrated.

1.5. Fully Modified Least Squares (FMOLS) Method:

FMOLS approach generally helps to illustrated the long-run affects among the variables and the following table presented the findings of FMOLS estimate:

Table 6: FMOLS model

(Dependent Variable is as LNGHS = Log of the Greenhouse Gas (Co2) Emissions)				
Variables	**Co-efficient Value**	**t-Statistic**	**Std. Error**	**Prob.**
LNGDP	0.220911***	0.089575	2.466224	0.0200
REC	-0.021825***	0.004926	-4.430772	0.0001
NREC	-0.013795***	0.005364	-2.571978	0.0157
TO	0.001987***	0.000769	2.583243	0.0153
C	12.23149***	0.999060	12.24299	0.0000
R^2 is 0.993938 **Adjusted R^2 is 0.993072**				

On the basis of FMOLS estimation, the equation can be illustrated as following ways:

$$LNGHS_t = 12.23149 + 0.220911LNGDP_t - 0.021825REC_t - 0.013795\ NREC_t + 0.001987TO_t + U_t \quad \ldots\ldots\ldots\ldots\ldots\ldots (5);$$

The FMOLS is appropriate in this study to show the long-term effects. This result of FMOLS indicates that percentage changes in supply side variables and demand side variables influence the Greenhouse Gas (Co2) Emissions. This estimation reveals, a 1 percent increase in Per-Capita GDP might contributes nearly 22 percent in total the Greenhouse Gas (Co2) Emissions, which is coherent with the real scenario. This is actually representing the supply side behavior of economic activities. When economic activities increased by exploiting the environmental resources at the same time it may immediately boost Co2 Emissions up. Besides, this result is also statistically significant. Besides, the coefficients of Renewable Energy Consumption and Non- renewable Energy Consumption showed negative sign which meaning that for Bangladesh both energy consumption influenced negatively the greenhouse gas (CO2) emission. Actually, this is because Bangladesh is not major emitter of harmful greenhouse (CO2) gas and maximum and maximum developed countries like: china, India, USA etc. Bangladesh have very low contribution in Emitting Greenhouse Gas in the World so it is very normal that the rate of fossil fuel utilization for Bangladesh negatively influenced the total greenhouse gas emission. Moreover, a 1 percent surge in renewable energy consumption decreased CO2 emission at 0.2 percent which coherent with theory. Additionally, the external variable trade openness has very minor impact but statistically significant result to increase CO2 discharge. The statistical results for R^2 and Adjusted R^2 indicate the model's strong goodness of fit, showing that the independent variables explain 99% of the variation in the dependent variable.

1.6. Canonical Cointegrating Regression (CCR) Method:

CCR estimation yields results similar to those of the FMOLS model, indicating the robustness and consistency of the FMOLS model in the estimation process in appendix on Table:7. The CCR model also confirms that coefficients for per capita GDP and trade openness positively influence GHS discharge, while energy usage has a negative impact on GHS discharge. Additionally, the statistical results for all explanatory variables in the CCR estimation process are significant.

1.7. **Pairwise Granger Causality (PGC) Tests:**

Table 8: Granger Causality Tests

Ho (Null Hypothesis)	Obs	Prob.	Causality Direction
LNGDP does not Granger Cause LNGHS	32	0.9926	Bidirectional
LNGHS does not Granger Cause LNGDP		0.1178	
REC does not Granger Cause LNGHS	32	0.7054	Bidirectional
LNGHS does not Granger Cause REC		0.3345	
NREC does not Granger Cause LNGHS	32	0.5405	Unidirectional
LNGHS does not Granger Cause NREC		0.0620	
TO does not Granger Cause LNGHS	32	0.1032	Bidirectional
LNGHS does not Granger Cause TO		0.9515	
REC does not Granger Cause LNGDP	32	0.1783	Bidirectional
LNGDP does not Granger Cause REC		0.1305	
NREC does not Granger Cause LNGDP	32	0.3051	Unidirectional
LNGDP does not Granger Cause NREC		0.0402	
TO does not Granger Cause LNGDP	32	0.5948	Bidirectional
LNGDP does not Granger Cause TO		0.9391	
NREC does not Granger Cause REC	32	0.5165	Bidirectional
REC does not Granger Cause NREC		0.3657	
TO does not Granger Cause REC	32	0.6569	Bidirectional
REC does not Granger Cause TO		0.7464	
TO does not Granger Cause NREC	32	0.9695	Bidirectional
NREC does not Granger Cause TO		0.3177	

The probability values in the table indicate pairwise Granger causality (PGC) and the direction of causality between variables. Results show bidirectional causality between LNGHS and LNGDP, REC and LNGHS, and TO and LNGHS, as the statistical significance leads to the rejection of the null hypothesis. This clearly suggests that the supply side variable GDP drives GHS expulsion, renewable energy usages is also connected with GHS expulsion, and trade openness causes GHS expulsion in Bangladesh. Additionally, the PGC test present unidirectional causality from NREC to LNGHS and from NREC to LNGDP.

1.8. Impulse response Function:

To illustrate the deep scenario about environmental degradation and macroeconomic variables, in this analysis has also incorporate the impulse response functions. The IRF's outcomes, as shown in the appendix in Figure-1, reveal that CO_2 reacts positively and significantly to the any shocks in GDP. Nevertheless, a mixed response and shock are observed in the case of other explanatory variables depending on the different time horizon.

1.9. Diagnostic Test:

In the appendix in figure-2 the result of Jarque-Bera and p-Value reflect the normalcy exists in the residual in the employed model. Besides, the tables-9 and 10 exhibited the applied model is free from serial correlation and Heteroskedasticity at 1 percent level of significance. The model's stability was assessed by using the cumulative sum of recursive residuals (CUSUM) test, with Figure 3 displaying that the utilized model is stable at a 5 percent significance level.

V. Conclusion and Policy Recommendation

In today's world, national wellbeing isn't only depending on economic development or growth. As whole world's economy demands sustainable economic development and we cannot think of our existence on Earth without climate resilience and adaptation. Taking this into consideration, we have designed our study and where we want to analyze the most key factors and potentiality of climate change for Bangladesh by utilizing the Annual data for the sample period 1990 to 2023. In our empirical analysis, we analyzed the impact of GDP per capita, Renewable power uses, fossil fuel utilization which is main determinant of non-renewable power utilization and Trade Openness on greenhouse gas emission and examine whether the per-capita GDP and energy consumption have environmental effects.

Timely implementation of policies is crucial for addressing climate change, considering both the economic supply-side and demand-side channels. Effective management requires robust governmental measures along with careful long-term and short-term planning for sustainable economic development. The following policy proposals should be considered:

- At first combine effort of government, fiscal authorities and monetary authorities, these institutional elements can play as a vital factor to achieve sustainable development.
- Government can introduce climate subsidies and taxes for those communities who are directly affected by climatic imbalances adversely.
- The responsible authorities need to focus on invest in more ecofriendly energy usages.
- As a developing nation, Bangladesh needs more financial resources. Therefore, it is challenging to mobilize more resources from domestic and international sources and allocate them towards the creation of sustainable initiatives. Enterprises and people need to be fully aware of the advantages of sustainable finance in Bangladesh. Raise support for environmentally friendly endeavors and green initiatives takes work.
- Maximize Bangladesh's success in securing and effectively managing grants from the Green Climate Fund (GCF). For this purpose, enhance the skills and expertise of relevant government agencies and stakeholders through targeted training programs. This will ensure that Bangladesh can successfully apply for, manage, and implement GCF-funded projects with a high level of professionalism and accountability.
- Pollutions creates industries need to regulate more comprehensive way, if necessary, need to impose more progressive taxes to discourage these production as like cigarettes industry.
- Developing more financing instruments to mobilize additional resources. Green financing products like green bond, green savings account etc. should be introduced and more focus can be given to venture capital to finance green projects.
- Providing adequate incentives for positive externalities of green projects and penalties for negative externalities of green projects;
- Incorporating SMEs, agent banking and micro finance into green banking;
- A quantitative approach is needed for a more justified Environmental Risk Rating (EnvRR), which is now based on the Environmental Due Diligence (EDD) checklist under subjective criterion.
- Coordinated efforts of MoF and other line ministries, BB and commercial banks are required to move the green economy;
- Data related to green financing should be handled and kept sophisticatedly. Establishing a climate change portal with publicly disclosed data; and
- Strengthening regional cooperation to mitigate adverse impact of climate change and developing a joint regional investment plan in this regard.

In the real case, Bangladesh is not major carbon emitting country but its economy endangers more by climatic degradations. Besides, Bangladesh Delta Plan 2100 (BDP 2100) and 8th Five Year Plan (2021-2025) lay emphasis on the vulnerabilities arising from climate change and put emphasis on several financing options.

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Appendix

Table 1: Summary of Statistics

	LNGHS	LNGDP	REC	NREC	TO
Mean	11.85770	6.774112	47.03816	65.87160	32.09239
Median	11.82578	6.713535	47.90000	65.87400	30.49135
Maximum	12.30347	7.533247	73.10000	84.73198	48.11092
Minimum	11.42782	6.201051	20.06099	44.67104	18.88983
Std. Dev.	0.297295	0.415317	16.25452	11.69716	8.092425
Skewness	0.093212	0.320432	-0.002941	-0.134491	0.408691
Kurtosis	1.582981	1.806395	1.772262	1.960665	2.327755
Jarque-Bera	2.893819	2.600149	2.135449	1.632806	1.586705
Probability	0.235296	0.272512	0.343790	0.442019	0.452326
Sum	403.1619	230.3198	1599.297	2239.634	1091.141
Sum Sq. Dev.	2.916685	5.692124	8718.913	4515.174	2161.082
Observations	34	34	34	34	34

Table 2: Canonical Cointegrating Regression (CCR)

Dependent Variable: Log of Greenhouse gas emission

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNGDP	0.212629	0.092741	2.292710	0.0296***
REC	-0.021870	0.004827	-4.530383	0.0001***
NREC	-0.013640	0.004979	-2.739453	0.0106***
TO	0.001952	0.000747	2.613532	0.0143***
C	12.27925	1.003213	12.23992	0.0000***
R2	0.993760	Mean dependent var		11.87073
Adjusted R^2	0.992869	S.D. dependent var		0.291884
S.E. of regression	0.024649	Sum squared resid		0.017012
Long-run variance	0.000607			

*** indicates the 1% level of statistical significance

Figure 1-Impulse Response Function

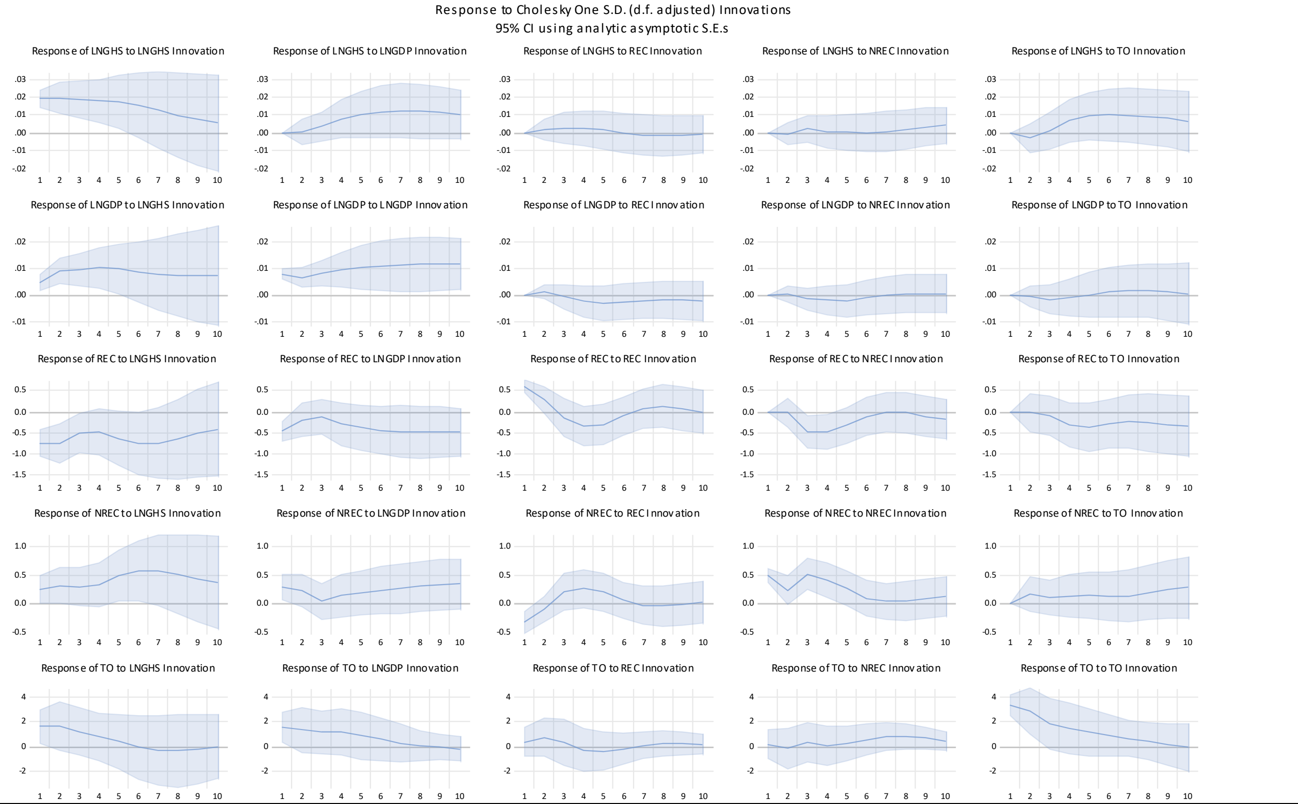

Figure 2: Result of Normality Test

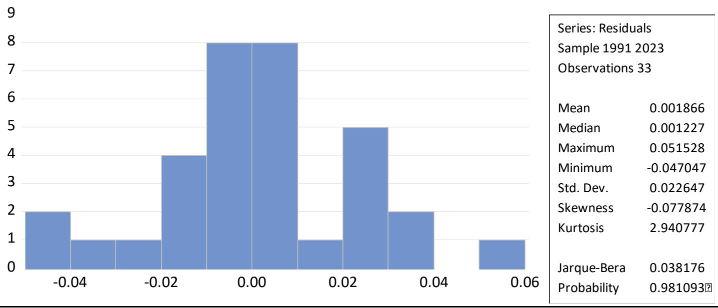

Table 9: Breusch-Godfrey Serial Correlation LM Test			
Null hypothesis: No serial correlation at up to 2 lags			
F-statistic	13.47450	Prob. F(2,27)	0.0001
Obs*R^2	16.98393	Prob. Chi-Square(2)	0.0002
***From the above table, it is clear that there is no Autocorrelation in the estimated model.			

Table 10: Breusch-Pagan-Godfrey Heteroskedasticity Test			
Null hypothesis: Homoskedasticity			
F-statistic	5.176736	Prob. F(4,29)	0.0028

Obs* R^2	14.16374	Prob. Chi-Square(4)	0.0068
Scaled explained SS	16.61248	Prob. Chi-Square(4)	0.0023
***From the above table, it is clear that there is Homoskedasticity in the estimated model.			

Figure 3: Stability Test (CUSUM)