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Exploring the Linkage between Temperature and Economic Growth in Bangladesh: An ARDL Approach

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Abstract: This study is investigated the nexus between temperature and GDP in Bangladesh and how GDP is affected by carbon emission, rainfall and temperature. The ARDL bound test is employed to examine the cointegration relationship among the variables and findings suggest that variables are cointegrated in both cases of dependent variable temperature and dependent variable of GDP. Results mirror that economic growth affect negatively the temperature and statistically significant for short run and long run. On the other hand, carbon emission and rainfall have statistically significant short run positive impact on GDP growth. The ECM result indicates the equilibrium converges to steady state at 78% annually when dependent variable is temperature and equilibrium also converges to steady state at 0.0891% annually, when dependent variable is GDP. Granger Causality test finds a one-way causal relationship between GDP and carbon emissions in both situation of the different dependent variables. Aftermath, results would say that carbon emission and rainfall have short run salutary impact on economic growth and the economic growth is conducive to reduce temperature in Bangladesh that moves to sustainable development. It might address underlying economic transitions such as shifts to greener industries or government interventions that promote sustainability. It will help researcher and policymakers for further study to identify environmental friendly growth projects that lead to reduce temperature in Bangladesh.

Keywords: GDP, Temperature, Carbon Emission, Rainfall, ARDL Cointegration

Introduction

Bangladesh, a growing up market economy, is a rapidly developing country in the world. Bangladesh's economy is mostly dependent on agriculture. Agriculture has a connection with rainfall, temperature and a lot of environmental condition like natural calamity, global warming, environmental pollution and climate change and so on. Carbon emission, temperature, rainfall was used as proxies to determine the climate change effect on agricultural productivity besides this temperature, rainfall indicating positive impact and carbon emission indicating negative impact on agricultural production in Nigeria (Akomolafe et al. 2018). Just an opposite scenario has been noticed in Egypt that rainfall and temperature have negatively impact and carbon emission have positively impact on cereal crops (Mahrous 2018). Climate change is now a days a burning issue in the world. Carbon emission is exceedingly responsibly for climate change by increasing the world temperature and polluting environment.

In Bangladesh, the large share of contribution in GDP comes from service sector, industrial sector and the agricultural sector. The size of the economy is growing fast particularly by its readymade garments sector and domestic agricultural production. The production of agricultural products is also mostly depending on environmental condition. Precipitation is an important determinant for agricultural production. An increase in the amount of precipitation increases agricultural output while temperature has adverse effect on agricultural production (Dumrul and Kilicarslan 2017). A country's economy is actually built up by its geographical location, environmental condition and available natural and environmental resources. Production of goods and services, specifically agricultural production undoubtedly depend on environmental condition, land, water and so on. Wheat yield in Pakistan is significantly influenced by humidity rate, water usage and the area of cultivated land. Precipitation and temperature also have impact on wheat production (Kiani and Iqbal 2018). Industrial sector has significantly a lot of influence on economy and environment. Industry has two ways impact- one is enhancing the economy and another is deteriorating the environment by emitting carbon di oxide along with increasing temperature. Zhang et al. (2017) studied the relationship between temperature and manufacturing output in China and identified that above 90° F temperature decreased 0.45% manufacturing output in a day. Whatever the firm is capital intensive or labor intensive, both firms disclose sensitivity to high temperature.

Here, the study investigates the relationship among the variables like temperature, carbon emission, rain fall and GDP in Bangladesh. Basically, it is to identify whether temperature and GDP are related or not and how carbon emission, rainfall and temperature affect GDP. Ali et al. (2019) found carbon emission and temperature negatively and rainfall positively stimulates economic growth in Pakistan.

Bangladesh is one of the South Asian nations that are mostly in at risk of the effects of climate change. As it is being a riverine country with having largest sea coastal area, devastating flood, cyclone and other environmental disaster are common phenomena in this country that have very close link to its economic growth and development. Environmental disaster can change the scenario of economic condition of a country. Some of these environmental calamities have direct cohesion to carbon emission, excessive rainfall, and ambient temperature. The aim of this is to identify whether economic growth go on with or without increasing the temperature in Bangladesh. Besides, the paper investigates how GDP is affected by carbon emission, rainfall and temperature. Economic growth should be sustainable through which environment remains unaffected. Economic growth is achievable without deteriorating the environmental quality in Bangladesh (Amin et al. 2012). Environmental factors have noticeable influence on economic growth. An increase in

1°C temperature across all countries led the world GDP goes down by 3.8% (Horowitz 2009). Temperature and economic growth are identified as they are closely related to each other. Per capita GDP growth and temperature are evidenced to have short run and long run relationship in Africa (Lanzafame 2012). Evidences showed that income and temperature adversely related in 12 American countries (Dell et al. 2009).

Bangladesh is actually an agricultural country where rice and jute are the main crops. The main source of employment in Bangladesh is agriculture. In 2017, estimation showed that 42.7 percent of the workforce populations were involved in agriculture and contributed to making up 14.2 percent of GDP in Bangladesh (As of 18 July 2021, Wikipedia). The contribution of agriculture in economic growth cannot be ignored. And the influence of environmental circumstances on agricultural productivity cannot be eliminated. The production of rice not only depend on area of land cultivated, or use of fertilizer but also depend on some environmental factors like rainfall carbon emission, temperature etc. Carbon emission, average temperature affects rice production positively in Pakistan (Chandio et al. 2020). Therefore, environmental factors must be studied in development literature to achieve sustainable development.

Research studies have no bounds to study in any fields. Salim et al (2019) have studied on some factors like research and development, annual rainfall and temperature and literacy rate that affect agricultural productivity in Bangladesh. Forestation and agriculture play a vital role by supplying oxygen and receiving carbon di oxide from environment as well as reducing temperature. Agricultural productivity has the impact on carbon emission. Study revealed that 1% increase in the production of barley and sorghum lead to diminish carbon dioxide emission respectively by 3 percent and 4 percent in Pakistan (Ali et al. 2019). On the other hand, carbon emissions also have impact on GDP growth. Bouznit and Pablo-Romero (2016) showed links between carbon emissions and economic expansion and the study supported the EKC theory in Algeria. A lot of studies have been conducted on environment and economic relationships. Dell et al. (2012) examined the affinity between economic expansion and temperature change. Here has taken the average annual temperature as the environmental degradation indicator. GDP data (current USD) carry the weight of economic growth scenario. Carbon dioxide and rain fall both are the environmental factor as well as economic variables.

Mahrous (2018) have studied to determine the relationship between Egypt's climate change and cereal production. An ARDL technique was applied to calculate the long- and short-term effects of rainfall, temperature, population density, and carbon dioxide emissions on grain production in Egypt. Findings from an analysis of the data from 1961 to 2013 indicated that rainfall and temperature had a short-term detrimental impact on cereal yield. In the long-run, the increase of CO2 in the atmosphere would have positive impact to some cereal crops. On the other hand, carbon emission and cereal yield were negatively linked in Ghana (Amponsah et al. 2015).

Bangladesh, a subtropical monsoon weathering country, distinguished by several seasonal variation with moderate rainfall, high temperature and winter along with less significant autumn late autumn and spring. Chowdhury (2016) have studied on the climate change variables such as temperature, rainfall, carbon emission, humidity, day length etc. and claimed that high temperature and more rainfall in summer lead to raise agricultural productivity in Bangladesh. Generally, the warmest month in Bangladesh is April and the maximum temperature lies in between 30°C and 40°C in summer. The coldest month is January with average temperature is 10°C in most of the country. Rainfall is an important element of environment. Bangladesh is characterized with heavy rainfall country. Most of the area in Bangladesh experienced at least 2000 mm of rain fall annually. The largest average precipitation is occasionally above 4000 mm per year due to Bangladesh's geographic position in the southern Himalayas (Weather Online Bangladesh, 2020).

The term "GDP," which represents the total worth of all a nation's goods and services, is the most frequently used in economics and daily life. It is the most widely used measurement of the size of any economy. Almost all the commodity and service produced in a nation may have a direct connection to environmental factors like precipitation and temperature. Chowdhury (2016) revealed that overall increasing temperature reduce agricultural output in Bangladesh. This work will investigate the linkage with GDP, carbon emission, rainfall and temperature. In short it will be a climate change and GDP nexus exploration. Alagidede et al. (2015) studied on climate change effect on sustainable development and growth. Temperature, rainfall and real GDP per capita were the prime variables and result showed that above 24.9°C will diminish economic growth in Sub-Saharan Africa.

Carbon emission was the most talked topic around the world in the last two decades. Due the increasing carbon emission, human being might have fallen under the greatest threat by melting ice and rising sea level in the world. Sha Husain (2016) confirmed that long run cointegration remains in carbon emission, economic development, and non-renewable energy usage in Bangladesh.

Because of geographic location, Bangladesh stands in front of the most vulnerable condition among the south Asian countries. The scenario of carbon emission, rainfall, temperature and GDP flow of Bangladesh are portrayed in the figure 1. The temperature flow shows a lot of fluctuation with decreasing rate up to 1971 and after that it shows a gradual increment with fickleness in trend to 2010. After 2010, temperature experienced a big downfall up to 2015. In 2016 it started to rise again. Roy and Haider (2018) arrived in a decision that a rise in 1°C annual average temperature reduce average GDP growth rate by 0.44 percent in Bangladesh. The higher the temperature may lead to the lower growth rate (Dell et al 2012). In India, a negative correlation between temperature and economic development rate has been shown and comparatively poor states faced higher negative impact of temperature (Jain et al. 2020). In the figure 1, we can see the carbon emission stream from 1960 to 2016 where carbon emission trend to rise initially up to 1970. In 1971 carbon emission faced a gigantic downfall because of a drastic geopolitical change happened in this year was the liberation war of Bangladesh. After the independence of Bangladesh carbon emission increased year to year and never faced any decline in carbon emission up to 2016. Wahida et al. (2017) identified a cointegration link between Bangladesh's economic development and carbon emissions. According to Ghosh et al.

(2014), Bangladesh's economic development is negatively impacted by carbon emissions.

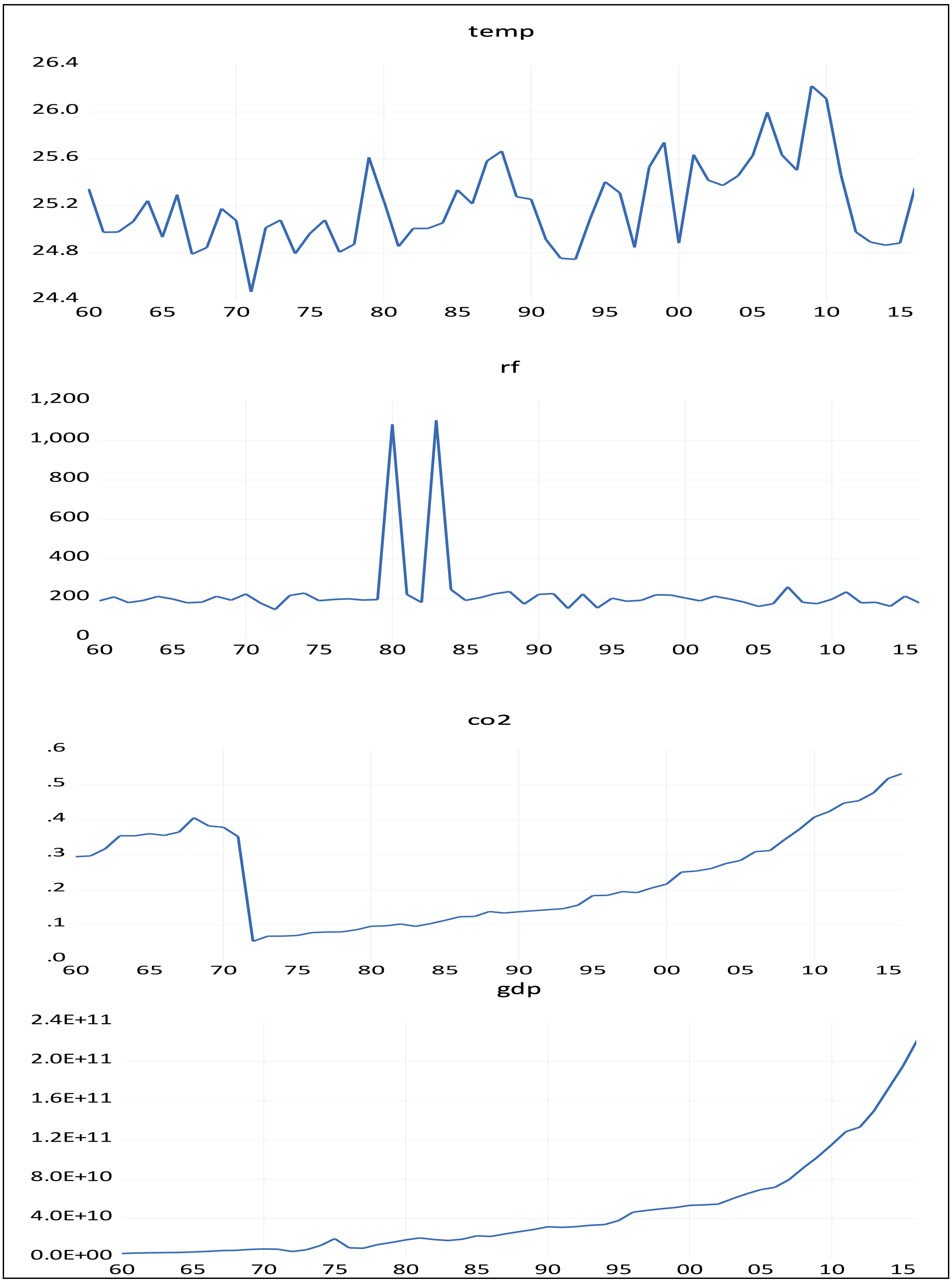

Figure 1. Plot of the temperature, rainfall, carbon emission and GDP in Bangladesh

In the figure 1, we also see the motion of rain fall in Bangladesh. The precipitation amount was always in a close fluctuation over the year except two outlier oscillation in 1980 and 1984 and the amount of rain fall was the highest in that two year in the history of Bangladesh. The GDP configuration in the figure 1 represents an increasing trend from 1960 to 1975 then a small decline was seen and after 1976 to 2016 it has experienced an upswing trend with increasing rate of GDP growth.

In the temperature GDP context, there have a deficiency in literature. The total value of the products and services generated on a nation's soil by its citizens and foreigners who resided there is known as the gross domestic product (GDP). Temperature by itself is a measurement that provides the degree of coldness and hotness of a body or environment. Climate changes have direct impact on environment in any country and environments have direct linkage with production as the spirit of economic activity. Climate change affects the economic growth in many ways. Choiniere and Horowitz (1999) employed Cobb-Douglas production function with neoclassical growth model to identify the nexus between per capita GDP and average temperature on 97 countries. The findings of the impact of climate change factor like temperature are verified empirically inverse relationship with per capita GDP. A nonlinear association between temperature and economic growth was identified by (Zhao et al. 2018). To determine the long-term effects of climate change on economic activity, Khan et al. (2019) employed a stochastic growth mode on 174 countries over the period of 1960 to 2014. Findings implied that the change in temperature negatively affect the economic growth while change in precipitation do not evidence to affect economic output growth significantly. Ng and Zhao (2010) discarded the argument of Nordhaus (2006) about temperature and output relationship depends on the measurement of output. Whatever the techniques to measure the output, a rise in 1°C temperature could be a more of 3% reduction of total income in G-7 countries.

Ali et al. (2019) had studied to examine a contribution of climate change on economic change in Pakistan. They used yearly data from 1980 to 2013 to do an auto regressive distributed lag (ARDL) analysis on GDP, gross fixed capital formation, total carbon dioxide emissions (kt) and trade data as total trade annually as a percentage of GDP. They discovered that CO2 and temperature both had a major impact on economic growth. They indicated that CO2 and temperature negatively affect the GDP of Pakistan. They also found a positive and trivial effect of rainfall on GDP of Pakistan. Vatankhah et al. (2019) worked on the effect of climate change factors (temperature and precipitation) in the agriculture sector by using ARDL approach and the effect of climate change were estimated by Social Accounting Matrix (SAM) framework model in Iran. Chandio et al. (2020) have investigated the dynamic relationship among the carbon emission, temperature, and rain fall and cereal production in Turkey. They used 1968 to 2014 data on each variable to calculate the data to be stationary and then used the ARDL bound test to find the long- and short-term relationships between the variables under consideration. They discovered that whereas average temperature and carbon dioxide emissions have a detrimental impact on cereal output, average rainfall has a favorable impact on cereal production in the long and short terms. The Granger causality test showed that the components of temperature and rainfall had a unidirectional causal connection. Saboori et al. (2012) evaluated the Granger causality test and discovered that there was no causal association between economic development and carbon emissions in the short run, but that there was a long-term unidirectional causal relationship.

Newell et al. (2018) assessed the GDP temperature relationship conducted by cross-validation techniques for out of sample predictive accuracy of 401 variants of models. The response of temperature and precipitation were considered as dependent variables to evaluate the effect of whether temperature affects GDP levels or growth. Egbetokun et al. (2020) tested the EKC by considering six variables of environmental pollution like CO_2, nitrous oxide, suspended particulate matters, rainfall, temperature and total greenhouse emission in Nigeria. They included some control variables like foreign direct investments, education expenditure, population density, domestic investment and applied ARDL model for econometric analysis. They mentioned EKC is validated for CO_2 and, suspended particulate matters with significant impact on economic growth others variable did not show any significant influence on economic growth.

Aung et al. (2017) used yearly from 1970 to 2014 to study the dynamics of economic growth and CO_2 emissions as an environmental pollution indicator data with the ARDL model in Myanmar with annual data of 1970–2014. The findings implied that there has no evidence of existing EKC hypothesis for CO_2 and GDP in this country whereas EKC existed for CH_4 and N_2O. In the long run they got trade liberalization and financial openness good for environmental quality in Myanmar. Ameyaw and Yao (2018) identified a unidirectional causal link between GDP and carbon emissions in five West African countries. Mahmood et al. (2019) found the validation of inverted U- shaped connection existed between GDP per capita and CO_2 emission per capita. Ahmad and Du (2017) used Iran's energy output, CO_2 emissions, and GDP with additional factors including domestic and foreign investment, inflation, population density, and agricultural land to investigate nexus among the variables under consideration. The got CO_2 have positive relationship with GDP as like as energy production to economic growth. Here domestic investment is stronger to explain economic growth than foreign investment.

Most of the researcher used carbon emission as the indicators of environmental degradation. A lot of factors could be the indicator of environmental degradation such as temperature, rainfall, metal existence in air, amount of CH_4 and N_2O in the atmosphere, presence of ozone (O_3) in the environment, amount of ice melting in Antarctica, sea level rising etc. A lot of research is needed in this literature to explain the EKC hypothesis more valid in the context of different countries. Salim et al. (2019) have worked on climate change and growth relationship in Bangladesh. They used panel data covering the period of 1948–2008. They investigated the relationship among the variables. Climate change indicating by converting annual temperature and rain fall variation along with R and D expenditure, human capital and total factory output. They found temperature and rain fall were significantly negative in the long run on total factory output whereas human capital proxies by literacy rate have positive influence on total factory output. They suggest R&D and human capital could trade off the adverse effect of climate change.

Ergun and Rivas (2020) examined the validation of Environmental Kuznets Curve (EKC) in Uruguay and found the validity of EKC. Chandio et al. (2020) explored the linkage among the climate changing factors, (carbon emission, temperature, rainfall) area of cultivated land fertilizer consumption, energy consumption, and rural population and agricultural output in China. Data used from the period of 1982-2014, ARDL techniques employed to measure the relationship among the concerned variables. Unit root test of stationarity among the variables of I (0) and I (1) combination confirmed to adopt ARDL methods. Result mirrored that carbon emission has both short run and long run significant effect on agricultural production and temperature and rain fall have adverse effect in the long run. To assess the impact of temperature on GDP growth rate, Moore and Diaz (2015) employed the DICE model using two paths, total factor productivity growth and capital depreciation. Labor is the most crucial factor of production. Yildirim et al. (2009) exerted a significantly negative temperature and labor productivity relationship by analyzing cross section data for 111 countries. Choiniere and Horowitz (2000) analyzed GDP- temperature relationship in a simple regression model that mirrored the effect of temperature interpret 45% variance in income. Cobb-Douglas production implied that the marginal product of physical and human capital accumulation will be lower comparatively in hotter country. Bai et al. (2018) analyzed carbon emission and characteristics of agricultural output efficiency and examine the consequences of climate change on low carbon agricultural output in Habei, China. Agricultural productive efficiency had positively influenced by temperature and rainfall in Habei. Woillez et al (2020) showed two-way relationships between temperature to GDP growth and temperature to GDP level. Colacito et al. (2018) explained the rising temperature could impede productivity in difference industry in USA.

This study is basically focused on environmental phenomenon like carbon emission, temperature, rainfall in connection with economic growth in Bangladesh.

Research Method

To determine the relationship among the variables, the data has been gathered from World Bank Data. Islam et al. (2021) used time series yearly data using ARDL methodologies to investigate the relationships between carbon emission, rainfall, temperature, inflation, population, unemployment and economic growth in Saudi Arabia. Here I used time series yearly data collected from the period of 1960 to 2016. The initial temperature data in Bangladesh was monthly average data in the measurement of Celsius from which it has converted the data in to yearly average for the convenience of analysis. At this same way the data of rain fall is collected on monthly data and converted into yearly average rain fall in Bangladesh. Carbon emission data is in the form of metric tons per capita and GDP is in the form of current US dollar. Both Carbon emission and GDP data are accrued annual data from the World Bank Open Data. To define the mode of relationship among the variables of yearly time series data, ARDL methods were taken by (Akalpler and hove 2018). The ARDL approach is very universally used to evaluate relationships between time series variables over both the long run and short run period. As complex to measure environmental elements and economic development relationship, ARDL techniques applied to depict economic growth degraded environmental quality (Danish et al. 2019). Elkadhi et al. (2017) employed ARDL technique to find long run cointegration between energy consumption and environmental pollutants and also determine the effect of temperature and relative humidity on environmental pollutants. According to a study, average temperature, average rainfall, and carbon emission have all been linked to impacting cereal production in Turkey (Chandio et al. 2020). For the compatibility of this research analysis, we took all the four variables in logarithmic form. Variables description is given in the below table 1.

Table 1. Variables Description

Variables	Description
LNTEMP	Natural log of Temperature
LNCO2	Natural log of Carbon Emission
LNRF	Natural log of Rain Fall
LNGDP	Natural log of Gross Domestic Product

Initially, the time series data must be determined to be stationary. Because of this, we do the ADF test to check the variables' stationarity. Then, we go on to the ARDL bound test method to ascertain the long-term connection between the variables in question If the ARDL outcome suggests that the variables are cointegrated, the short run elasticities and equilibrium for the short to long run will be calculated using the error correction model. Some diagnostic tests like Breusch-Godfrey Serial correlation LM test, Breusch-Pagan-Godfrey heteroskedasticity test, Jarque-Bera Normality Distribution test and so on are also be employed for obtaining stable, reliable, consistent, and efficient estimators.

The ADF test: Testing for unit root

The ADF test was conducted by adding the previous values of the dependent variable $\Delta Y t$-i as explanatory variables. The three different aspects of ADF test are explained below.
No constant and no trend

$$\Delta Y_t = \gamma_1 Y_{t-1} + \sum_{i=1}^{m} \alpha i \Delta Y_{t-i} + \mu t \quad (1)$$

Constant and no trend

$$\Delta Y_t = \gamma^0 + \gamma_1 Y_{t-1} + \sum_{i=1}^{m} \alpha i \Delta Y_{t-i} + \mu t \quad (2)$$

Constant and trend

$$\Delta Y_t = \gamma^0 + \gamma_1 t + \delta_2 Y_{t-1} + \sum_{i=1}^{m} \alpha i \Delta Y_{t-i} + \mu t \quad (3)$$

Where, μ_t is a pure white noise error term. By using the above equations, we can see whether the data set is stationary or not. The time series data may be stationary in multiple order like integrated of order zero or I(0), integrated of order one or I(1) and integrated of order two or I(2).

ARDL bound test for Cointegration Analysis

The autoregressive distributed lag (ARDL) bound test for cointegration is performed after determining the stationary of each variable. ARDL method developed by Pesaran et al. (2001) which is only applicable when the data sets are found I(0) or the data sets are I(1) or the data sets are compound of I(0) and I(1). Additionally, if any of the time series data showed signs of being integrated of order two or I(2), ARDL model would not be possible to apply it. The ARDL bound test that is employed in this study is implied by the equations below.

$$\Delta LNTEMP_t = \alpha_1 + \alpha_2\, t + \alpha_3 LNTEMP_{t-1} + \alpha_4 LNCO2_{t-1} + \alpha_5 LNRF_{t-1} + \alpha_6 LNGDP_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta LNTEMP_{t-i} + \sum_{i=1}^{q} \beta_1 \Delta LNCO2_{t-i} + \sum_{i=1}^{r} \beta_1 \Delta LNRF_{t-i} + \sum_{i=1}^{s} \beta_1 \Delta LNGDP_{t-i} + U_{it} \tag{4}$$

$$\Delta LNGDP_t = \alpha_1 + \alpha_2\, t + \alpha_3 LNTGDP_{t-1} + \alpha_4 LNCO2_{t-1} + \alpha_5 LNRF_{t-1} + \alpha_6 LNEMP_{t-1} + \sum_{i=1}^{p} \beta_1 \Delta LNTGDP_{t-i} + \sum_{i=1}^{q} \beta_1 \Delta LNCO2_{t-i} + \sum_{i=1}^{r} \beta_1 \Delta LNRF_{t-i} + \sum_{i=1}^{s} \beta_1 \Delta LNTEMP_{t-i} + U_{it} \tag{5}$$

In the ARDL study, these equations will allow us to determine whether or not the variables have a long-term relationship. Pesaran et al. (2001) proposed two set of purely I(0) lower and purely I(1) upper critical values for regressors. When the F statistic value exceeds the upper critical value, we may say that there is evidence of a long-term association between the variables. The variables will have a long-term cointegrating connection if the t statistic value is greater than the upper critical value. In same way we can compare F and t statistic with the lower critical value as if F statistic and t statistic is smaller than the lower critical value, we can say that there have also a long run relationship among the variables. Otherwise there have no long run relationship and we need to explain only ARDL model. If the variable is cointegrated we will move on for ECM estimation.

Error Correction Model

Initially Error Correction Mechanism was developed by Sargan and for the correction of disequilibrium. Engle and Granger made this mechanism well established. It represents the short run dynamics of long run equilibrium.

$$\Delta LNTEMP_t = \alpha_1 + \alpha_2 t + \sum_{i=1}^{p} \beta_{1i} \Delta LNTEMP_{t-i} + \sum_{i=1}^{q} \beta_{2i} \Delta LNCO2_{t-i} + \sum_{i=1}^{r} \beta_{3i} \Delta LNRF_{t-i} + \sum_{i=1}^{s} \beta_{4i} \Delta LNGDP_{t-i} + \lambda ECT_{t-1} + \varepsilon_{1t} \quad (6)$$

$$\Delta LNGDP_t = \alpha_1 + \alpha_2 t + \sum_{i=1}^{p} \beta_{1i} \Delta LNGDP_{t-i} + \sum_{i=1}^{q} \beta_{2i} \Delta LNCO2_{t-i} + \sum_{i=1}^{r} \beta_{3i} \Delta LNRF_{t-i} + \sum_{i=1}^{s} \beta_{4i} \Delta LNTEMP_{t-i} + \lambda ECT_{t-1} + \varepsilon_{2t} \quad (7)$$

Where ε_t represents the white noise error term, βs are the short run elasticities and λ is the corresponding parameter that measures the speed of adjustment for each period to equilibrium. It was assumed that the value of λ lies in between -1 to 0 and it was expected to be negative. It is essential for some diagnostic test to make our estimation reliable. Serial correlation test Normality distribution test, Homoscedasticity test, Ramsey RESET test and Recursive estimates of CUSUM and CUSUM square test are implemented for the robustness of these models of analysis.

Granger Causality Test

Granger causality (Granger, 1996) test detect the direction of causal relationship among the variables such as unidirectional or bidirectional causality.

$$LNTEMP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} LNTEMP_{t-i} + \sum_{i=1}^{q} \alpha_{2i} LNCO2_{t-i} + \sum_{i=1}^{r} \alpha_{3i} LNRF_{t-i} + \sum_{i=1}^{q} \alpha_{4i} LNGDP_{t-i} + e_{1t} \quad (8)$$

$$LNGDP_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} LNGDP_{t-i} + \sum_{i=1}^{q} \alpha_{2i} LNCO2_{t-i} + \sum_{i=1}^{r} \alpha_{3i} LNRF_{t-i} + \sum_{i=1}^{q} \alpha_{4i} LNTEMP_{t-i} + e_{2t} \quad (9)$$

Result and Discussion

The estimated result will be interpreted in this section. Initially the descriptive analysis is mentioned below.

Table 2. Descriptive Statistics

Variables	Observation	Mean	Median	Std. Dev.	Min	MAX
Temperature	57	25.20478	25.09390	0.361110	24.47165	26.22205
Carbon Emission	57	0.241252	0.216416	0.135219	0.052672	0.533299
Rainfall	57	227.6520	194.5551	168.0849	143.4134	1102.899
GDP	57	4.57E+10	2.66E+10	5.05E+10	4.27E+09	2.21E+11

In table 2 shows the descriptive analysis for the determine variables where the minimum and maximum value of each variable are mentioned with number of observations, mean, median value and standard deviation.

Results of Unit Root Test

The Augment Dicky-Fuller test is most widely used technique for determining the time series data to be stationary or not. Stationary time series data is necessary condition for the further analysis of other econometric techniques. The result of ADF test is given below.

Table 3. Unit Root Test Result

Variable	Test	t-statistic	Critical Value			Prob.*
Level (Intercept)			1%	5%	10%	
LNTEMP	ADF	-4.172126	-3.552666	-2.914517	-2.595033	0.0017*
LNCO2	ADF	-1.233223	-3.552666	-2.914517	-2.595033	0.6540
LNRF	ADF	-2.576079	-3.557472	-2.916566	-2.596116	0.1041
LNGDP	ADF	0.996951	-3.560019	-2.917650	-2.596689	0.9960
Level (Trend and Intercept)						
LNTEMP	ADF	-4.848131	-4.130526	-3.492149	-3.174802	0.0012*
LNCO2	ADF	-1.654012	-4.130526	-3.492149	-3.174802	0.7583
LNRF	ADF	-2.651169	-4.137279	-3.495295	-3.176618	0.2604
LNGDP	ADF	-5.389159	-4.133838	-3.493692	-3.175693	0.0002*
Level (None)						
LNTEMP	ADF	0.050815	-2.608490	-1.946996	-1.612934	0.6947
LNCO2	ADF	-0.723939	-2.606911	-1.946764	-1.613062	0.3986
LNRF	ADF	-0.129598	-2.608490	-1.946996	-1.612934	0.6345
LNGDP	ADF	5.821607	-2.609324	-1.947119	-1.612867	1.0000
First Difference (Intercept)						
LNTEMP	ADF	-8.778196	-3.557472	-2.916566	-2.596116	0.0000*
LNCO2	ADF	-7.756055	-3.555023	-2.915522	-2.595565	0.0000*

LNRF	ADF	-13.21078	-3.557472	-2.916566	-2.596116	0.0000*
LNGDP	ADF	-8.066546	-3.560019	-2.917650	-2.596689	0.00008*
First Difference (Trend and Intercept)						
LNTEMP	ADF	-8.697926	-4.137279	-3.495295	-3.176618	0.0000*
LNCO2	ADF	-7.919900	-4.133838	-3.493692	-3.175693	0.0000*
LNRF	ADF	-13.10317	-4.137279	-3.495295	-3.176618	0.0000*
LNGDP	ADF	-8.164810	-4.140858	-3.496960	-3.177579	0.0000*
First Difference (None)						
LNTEMP	ADF	-8.867586	-2.608490	-1.946996	-1.612934	0.0000*
LNCO2	ADF	-7.815583	-2.607686	-1.946878	-1.612999	0.0000*
LNRF	ADF	-13.33944	-2.608490	-1.946996	-1.612934	0.0000*
LNGDP	ADF	-6.037132	-2.608490	-1.946996	-1.612934	0.0000*

*, **, *** represent significance at 1%, 5% and 10% level respectively.

In table 3, we can see our ADF test result where the time series data of temperature in logarithmic form is stationary in integrated of order zero that is I(0) along with GDP time series data is also integrated of order zero like I(0). Both of these series LNGDP and LNTEMP are stationary at I(0) with 1% level of significant. In addition to the time series CO2 and rain fall are stationary in the form of first difference or integrated of order one. So, I could say by referencing the ADF result that both of the time series LNCO2 and LNRF are stationary at I(1) with statistically significant at 1% level. On the whole this analysis is a combination of I(0) and I(1) order of integrated time series data which is perfectly suitable for ARDL bound testing approach.

Optimal Lag Selection

For analyzing the ARDL model we need to know the optimal lag by which we can fix the length of regressand and regressors.

Table 4. Details of the Optimal Lag Length Selection by VAR

Lag	LogL	LR	FPE	AIC	SC	HQ
0	189.4807	NA	9.37e-09	-7.133875	-6.983779	-7.076332
1	340.6747	273.3122	5.18e-11	-12.33364	-11.58317*	-12.04593*
2	345.1264	7.362430	8.18e-11	-11.88948	-10.53862	-11.37159
3	363.1699	27.06518	7.78e-11	-11.96807	-10.01683	-11.22001
4	394.2945	41.89857	4.60e-11	-12.54979	-9.998164	-11.57156
5	420.2803	30.98303*	3.45e-11*	-12.9338*	-9.781849	-11.72545

The * sign in the above table 4 indicates the several lag length selection criterions. The optimal lag length for the ARDL analysis would thus be determined by any one of the criteria. LR stands for sequential modified LR test statistic, AIC: Akaike information criterion, SC: Schwarz information criterion, HQ: Hannan-Quinn information criterion, FPE: Final prediction error.

Here, we have the five criteria in which the majority criteria suggest the optimal lag would be lag five for analyzing the ARDL bound test. In the below figure 2 and 3 depicts the top 20 models with lag associated with Akaike information criteria. Figure 2 suggest that ARDL (1, 0, 0, 3) is the suitable model for our analysis when the dependent variable is LNTEMP. On the other hand, figure 3 suggested that for the model with dependent variable LNGDP the appropriate model is ARDL (3, 5, 3, 0) that is selected for our study.

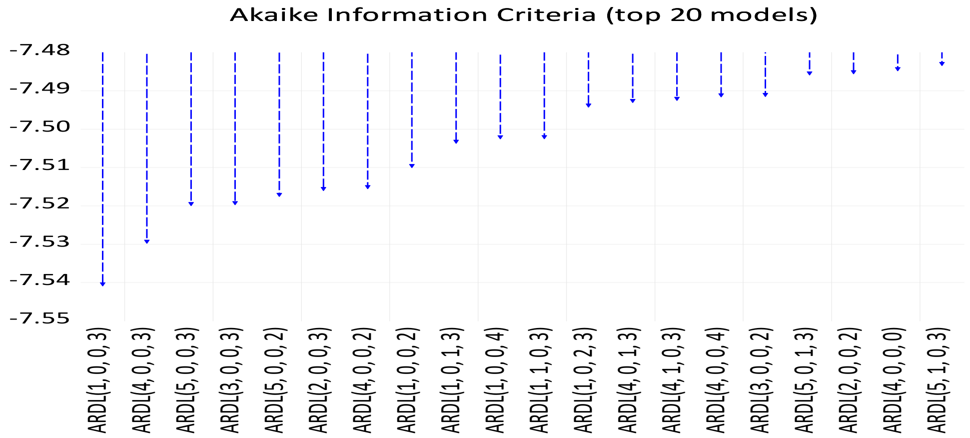

Figure 2. Top 20 models based on AIC with Lag 5(Dependent variable LNTEMP)

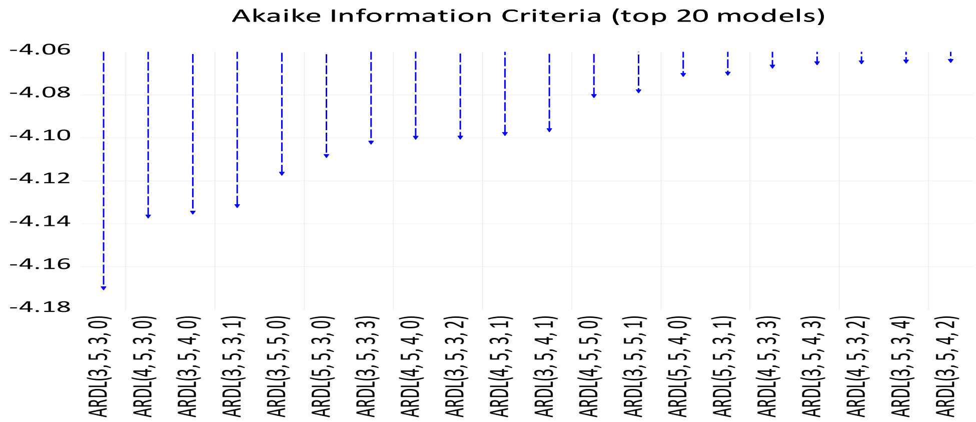

Figure 3. Top 20 models based on AIC with Lag 5 (Dependent variable LNGDP)

Details of Selected ARDL Model

In the Table 4 depict two different ARDL model where first model is selected by Akaike Information Criterion is ARDL (1, 0, 0, 3) and the second model is also selected by Akaike Information Criterion is ARDL (3, 5, 3, 0). Here R-square and adjusted R-square represent the goodness of fit of the model with Durbin Watson Stat measures autocorrelation of the residuals from these regression model. Its value always lies in between 0 to 4 where 0 to less than 2 values means positive autocorrelation and values in between 2 to 4 implies negative autocorrelations.

Table 4. Details of the Selected ARDL Model

Dependent variables	Regressors	Coefficient	Standard Error	t-statistic	Prob.
LNTEMP	LNTEMP (-1)	0.219073	0.146660	1.493752	0.1422
	LNCO2	0.002294	0.003052	0.751544	0.4562
	LNRF	0.001167	0.005150	0.226498	0.8218
	LNGDP	-0.021984	0.014006	-1.569577	0.1235
	LNGDP (-1)	-0.006376	0.017231	-0.370033	0.7131
	LNGDP (-2)	-0.019077	0.016916	-1.127730	0.2654
	LNGDP (-3)	-0.028007	0.015797	-1.772982	0.0830**
	C	1.813299	0.372100	4.873152	0.0000
	@TREND	0.002221	0.000684	3.246592	0.0022
R-squared 0.446343	Adjusted R-squared 0.347915		Durbin-Watson stat	1.893070	
Dependent variables	Regressors	Coefficient	Standard Error	t-statistic	Prob.
LNGDP	LNGDP (-1)	1.088492	0.079738	13.65080	0.0000*
	LNGDP (-2)	-0.408727	0.089858	-4.548566	0.0001*
	LNGDP (-3)	0.319344	0.069105	4.621143	0.0000*
	LNCO2	0.221968	0.034240	6.482648	0.0000*
	LNCO2(-1)	-0.271593	0.046548	-5.834635	0.0000*
	LNCO2(-2)	-0.047888	0.048034	-0.996955	0.3251
	LNCO2(-3)	-0.116846	0.049320	-2.369151	0.0230**
	LNCO2(-4)	0.524457	0.044712	11.72970	0.0000*
	LNCO2(-5)	-0.303177	0.044908	-6.751099	0.0000*
	LNRF	0.053061	0.030095	1.763103	0.0859***
	LNRF (-1)	-0.012448	0.026023	-0.478355	0.6351
	LNRF (-2)	-0.030712	0.026499	-1.159016	0.2537
	LNRF (-3)	-0.082829	0.028130	-2.944495	0.0055*
	LNTEMP	0.157532	0.130168	1.210219	0.2337
R-squared 0.997157	Adjusted R-squared	0.996184	Durbin-Watson stat	2.008562	

*, **, *** represent significance at 1%, 5% and 10% level respectively.

Results of ARDL Bound Tests

The ARDL bound test clearly identifies whether or not there are long run links between the variables. The procedure is simple to compare F-statistic with the lower bound and upper bound as well as to compare t-statistic with upper and lower critical values.

Table 6. ARDL Bound Test Results

Dependent Variable	Critical value	F-Statistic	8.016437
LNTEMP		I (0)	I (1)
	10%	3.47	4.45
	5%	4.01	5.07
	2.5%	4.52	5.62
	1%	5.17	6.36
Dependent Variable	Critical value	t-Statistic	-5.324750
LNTEMP		I (0)	I (1)
	10%	-3.13	-3.84
	5%	-3.41	-4.16
	2.5%	-3.65	-4.42
	1%	-3.96	-4.73
Dependent Variable	Critical value	F-Statistic	14.48461
LNGDP		I (0)	I (1)
	10%	2.01	3.1
	5%	2.45	3.63
	2.5%	2.87	4.16
	1%	3.42	4.84
Dependent Variable	Critical value	t-Statistic	-0.080037
LNGDP		I (0)	I (1)
	10%	-1.62	-3
	5%	-1.95	-3.33
	2.5%	-2.24	-3.64
	1%	-2.58	-3.97

Table 6 shows the results of the ARDL bound test, which was used to determine the long run relationship existed. When the variable LNTEMP the F-statistic value is 8.016437 and the absolute value of t-statistic is 5.324750 which both are greater than the upper critical value of 1%, 2.5%, 5% and 10%. So, I could say that there have long run relationships among the estimated variables. Now for the dependent variable LNGDP, the F-statistic value 14.48461 is quite high than the all the 1%, 2.5%, 5% and 10% upper critical value and the absolute value of t-statistic is 0.080037 lower than all the 1%, 2.5%, 5% and 10% lower critical value. So, the statistical result evidenced a cointegrating relationship among the estimated variables.

Short Run and Long Run Result Analysis

In the table 7, we can see the short run dynamics of long run relationship. Here the dependent variable is LNTEMP. The GDP growth effect on temperature is found significant at 10% level in the short run and 1% level in the long run. In the short run 1% increase in GDP will decrease temperature in 0.022 % in the environment. As well as if GDP rise in 1% in the economy, temperature will fall in 0.097% in the environment in long run. This means that economic growth is helpful to promote environmental quality in Bangladesh. Sometimes economic growth deteriorates environmental quality. A rise in 1% of real GDP increased 0.98% of carbon emission in Ethiopia (Hundie 2017). In addition to our other variables like rain fall and carbon emission both have positive impact on temperature but insignificant in the long run. The value of the coefficient of cointegrating equation is -0.780927 and is statistically significant at less than 1% level implies short run disequilibrium to be convergence toward equilibrium in the long run. The disequilibrium will be corrected at the speed of adjustment is 78% annually toward long run if there was a shock in the short run.

Table 7. Short Run and Long Run Results (Dependent variable LNTEMP)

Cointegrating Form					
Dependent variable	Independent variables	Coefficient	Standard Error	t-statistic	Prob.*
LNTEMP	C	1.813299	0.309949	5.850305	0.0000*
	@TREND	0.002221	0.000382	5.815995	0.0000*
	D(LNGDP)	-0.021984	0.011875	-1.851226	0.0707***
	D (LNGDP (-1))	0.047085	0.012403	3.796119	0.0004*
	D (LNGDP (-2))	0.028007	0.013641	2.053245	0.0459**
	CointEq(-1)*	-0.780927	0.133529	-5.848373	0.0000*
R-squared 0.429220	Adjusted R-squared 0.369763		Durbin-Watson stat	1.893070	
Long run Coefficient					
Dependent variables	Independent Variables	Coefficient	Standard Error	t-statistic	Prob.*
LNTEMP	LNCO2	0.002937	0.003772	0.778853	0.4401
	LNRF	0.001494	0.006513	0.229352	0.8196
	LNGDP	-0.096609	0.027756	-3.480674	0.0011*

*, **, *** represent significance at 1%, 5% and 10% level respectively.

In table 8, we can see the short run cointegrating form and long run coefficient of our regressors when the dependent variable is LNGDP. In the short run, carbon emission and rain fall have significant positive relationship on GDP. In the short run a 1% rise in carbon emission will lead to a 0.22% increase in GDP and it is statistically significant in less than 1% level. In the same way if rain fall increase by 1%, GDP will enlarge by 0.053% in the short run and it also significant at 5% level. Carbon emission and temperature have positive impact and rain fall have negative impact on economic growth but all the three variables are insignificant in the long run. In the long run CO_2 emissions were positively affected by economic growth in Oman (Mohamed 2020). GDP per capita showed positive impact on carbon emission in four higher carbon emitting country: China, India, Indonesia and Brazil (Alam et al 2016). The cointegrating coefficient value is -0.000891 which is supposed to be negative and statistically significant and result is also significant at less than 1% level. The cointegrating equation indicates that the disequilibrium in the short run will be adjusted at the speed of 0.0891% to the long run equilibrium if there was a shock in the short run.

Table 8. Short Run and Long Run Results (Dependent variable LNGDP)

Cointegrating Form					
Dependent variable	Regressors	Coefficient	Standard Error	t-statistic	Prob.*
LNGDP	D (LNGDP (-1))	0.089383	0.072313	1.236057	0.2240
	D (LNGDP (-2))	-0.319344	0.063322	-5.043150	0.0000*
	D(LNCO2)	0.221968	0.030964	7.168560	0.0000*
	D(LNCO2(-1))	-0.056547	0.034845	-1.622797	0.1129
	D(LNCO2(-2))	-0.104434	0.033354	-3.131078	0.0033*
	D(LNCO2(-3))	-0.221280	0.033652	-6.575550	0.0000*
	D(LNCO2(-4))	0.303177	0.037842	8.011751	0.0000*
	D(LNRF)	0.053061	0.025323	2.095409	0.0429**
	D (LNRF (-1))	0.113542	0.027927	4.065662	0.0002*
	D (LNRF (-2))	0.082829	0.025406	3.260188	0.0024*
	CointEq(-1)*	-0.000891	0.000113	-7.906486	0.0000*
R-squared 0.881742	Adjusted R-squared 0.852898		Durbin-Watson stat 2.008562		
Long run coefficient					
Dependent variables	Independent Variables	Coefficient	Standard Error	t-statistic	Prob.
LNGDP	LNCO2	7.767945	95.06960	0.081708	0.9353
	LNRF	-81.85241	1015.805	-0.080579	0.9362
	LNTEMP	176.8077	2101.581	0.084131	0.9334

*, **, *** represent significance at 1%, 5% and 10% level respectively.

Diagnostic Test

Several diagnostic tests have been implemented for the estimated model to be rigorous and reliable. The figure 4 and 5 depicts the Jarque-Bera test of normality for the data used in this analysis. The result implies that in both cases of the dependent variable LNTEMP and LNGDP and other independent variables are normally distributed in this analysis. In table 9, both of the cases the probability of Jarque-Bera statistic is 0.696960 and 0.836790 which is much higher than 0.0500 or 5% level means all the time series data were used with normally distributed.

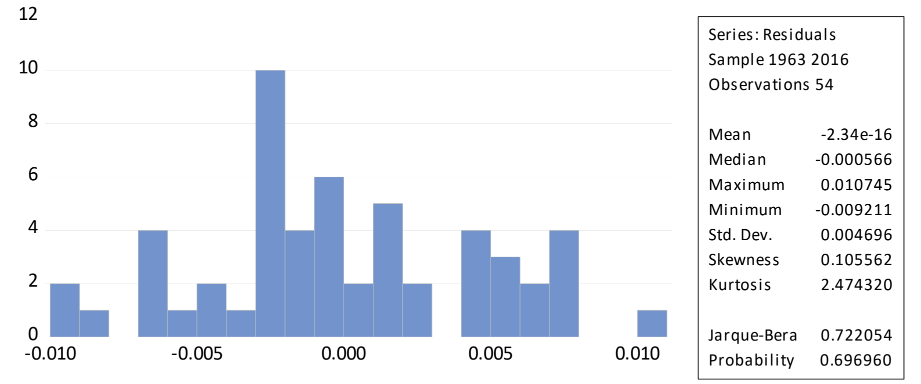

Figure 4. Jarque-Bera test of normality (dependent variable temperature)

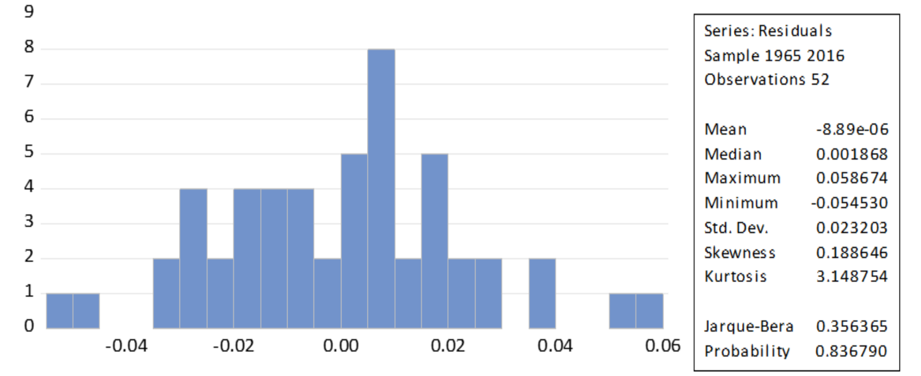

Figure 5. Jarque-Bera test of normality (dependent variable GDP)

Table 9 contains a vast set of diagnostic result. To screen out the problem of serial correlation we conducted the Breusch-Godfrey serial correlation LM test. The result illustrates no serial correlation exist in both cases of dependent variable LNTEMP and LNGDP model as we cannot reject the null hypothesis "No serial correlation at up to 5 lags". The estimated result Breusch-Godfrey serial correlation LM test for dependent variable LNTEMP, F-statistic is 1.006878 and Obs*R-squared is 6.036654 associated with Prob.F(5,40) is 0.4263 and Prob.Chi-square (5) is 0.3027 respectively. The probability value is higher than 5% critical value and indicates no serial correlation in this model.

The same things happen with the model of dependent variable LNGDP as the Breusch-Godfrey serial correlation LM test result is F-statistic 1.064441 and Obs*R-squared 7.221783 along with Prob.F(5,33) 0.3976 and Prob.Chi-square (5) 0.2047 respectively indicates no serial correlation in this model.

To check the heteroscedasticity of the residuals of these two model Breusch-Pagan-Godfrey heteroscedasticity test was employed and the results indicate no heteroscedasticity in the residuals in both of the model of dependent variable LNTEMP and LNGDP. The "Null hypothesis: Homoskedasticity" cannot be rejected in both cases because the respected probability value of the two model is much higher than the 5% critical value.

Table 9. Results of Different Diagnostic Test

Dependent variable	**Breusch-Godfrey serial correlation LM test.**			
LNTEMP	F-statistic	1.006878	Prob.F(5,40)	0.4263
	Obs*R-squared	6.036654	Prob.Chi-square (5)	0.3027
LNGDP	F-statistic	1.064441	Prob.F(5,33)	0.3976
	Obs*R-squared	7.221783	Prob.Chi-square (5)	0.2047
Dependent variable	**Heteroskedasticity Test: Breusch-Pagan-Godfrey**			
LNTEMP	F-statistic	0.704788	Prob.F(8,45)	0.6856
	Obs*R-squared	6.012614	Prob.Chi-square (8)	0.6458
	Scaled explained SS	3.077958	Prob.Chi-square (8)	0.9294
LNGDP	F-statistic	0.414410	Prob. F (14,37)	0.9605
	Obs*R-squared	7.048558	Prob.Chi-square (14)	0.9328
	Scaled explained SS	4.043509	Prob.Chi-square (14)	0.9952
Dependent variable	**Normality Distribution test (Jarque-Bera)**			
LNTEMP	Jarque-Bera	0.722054	Probability	0.696960
LNGDP	Jarque-Bera	0.356365	Probability	0.836790
Dependent variable	**Ramsey RESET Test**			
LNTEMP	t-statistic	1.324410	Probability	0.1922
	F-statistic	1.754062	Probability	0.1922
	Likelihood ratio	2.110911	Probability	0.1463
LNGDP	t-statistic	1.161819	Probability	0.2527
	F-statistic	1.349823	Probability	0.2527
	Likelihood ratio	1.863264	Probability	0.1722

Moreover, to find out any model specification error or inappropriate functional form, this study employed Ramsey RESET. The probability value of Ramsey RESET test is 0.1922, 0.1922 and 0.1463 for t-statistic 1.161819; F-statistic 1.754062 and Likelihood ratio 2.110911 respectively suggest that the model of dependent variable LNTEM is well specified. Similarly, the Ramsey RESET test probability value is 0.2527, 0.2527 and 0.1722 associated with t-statistic 1.161819, F-statistic 1.349823 and Likelihood ratio 1.863264 respectively for the model of dependent variable LNGDP suggest that this model is also well specified.

Stability Test

Lastly, we employed CUSUM and CUSUM square test to assure the stability of this estimated parameter based on the recursive estimates developed by R. L. Brown, J. Durbin and J. M. Evans (1975). Parameter constancy and model stability will be confirmed if both plot of CUSUM and CUSUM square lies in between 5% critical bounds.

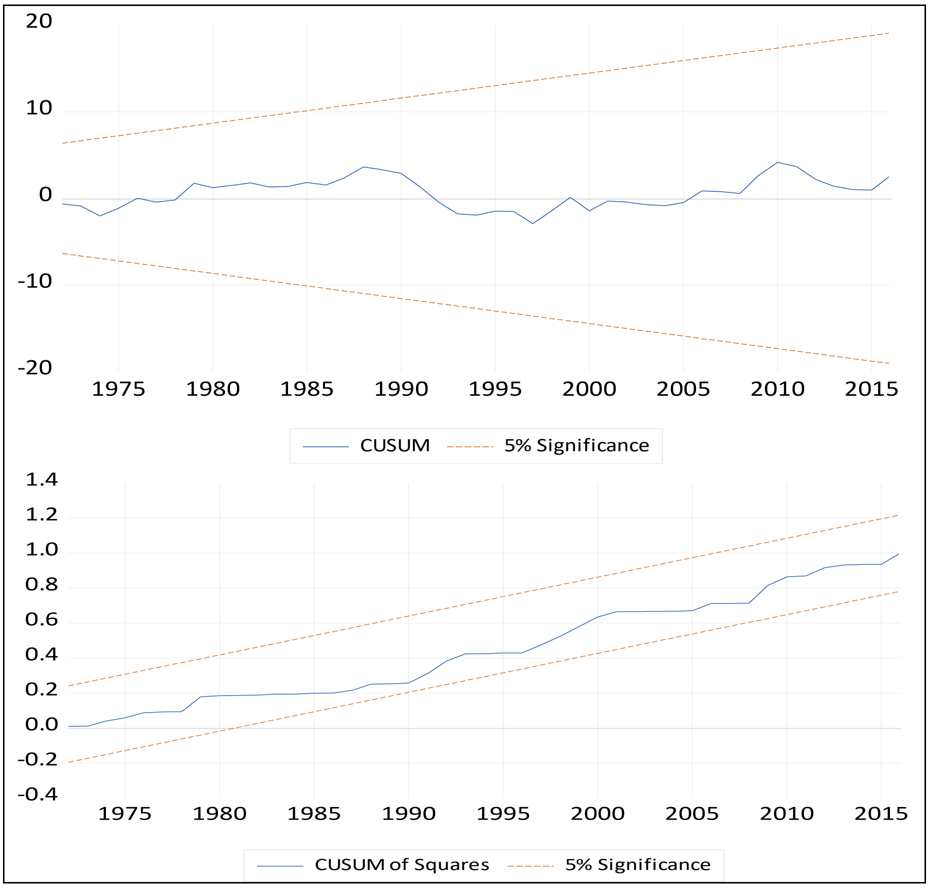

Figure 6. Plot of CUSUM and CUSUM of square (Dependent variable LNTEMP)

In the figure 6 delineate the plot of CUSUM and CUSUM square for the model of the dependent variable LNTEMP where both the plot of CUSUM and CUSUM square remained between the expected 5% critical bounds. So, I could say there have no structural brakes or systematic change in the coefficient and the model is well stable and consistence.

Figure 7 also portrays the plot of CUSUM and CUSUM of square when the dependent variable is LNGDP. Here both plot of CUSUM and CUSUM square existed in between the 5% critical bounds, thereby illustrating the structural stability of the coefficients of this analysis.

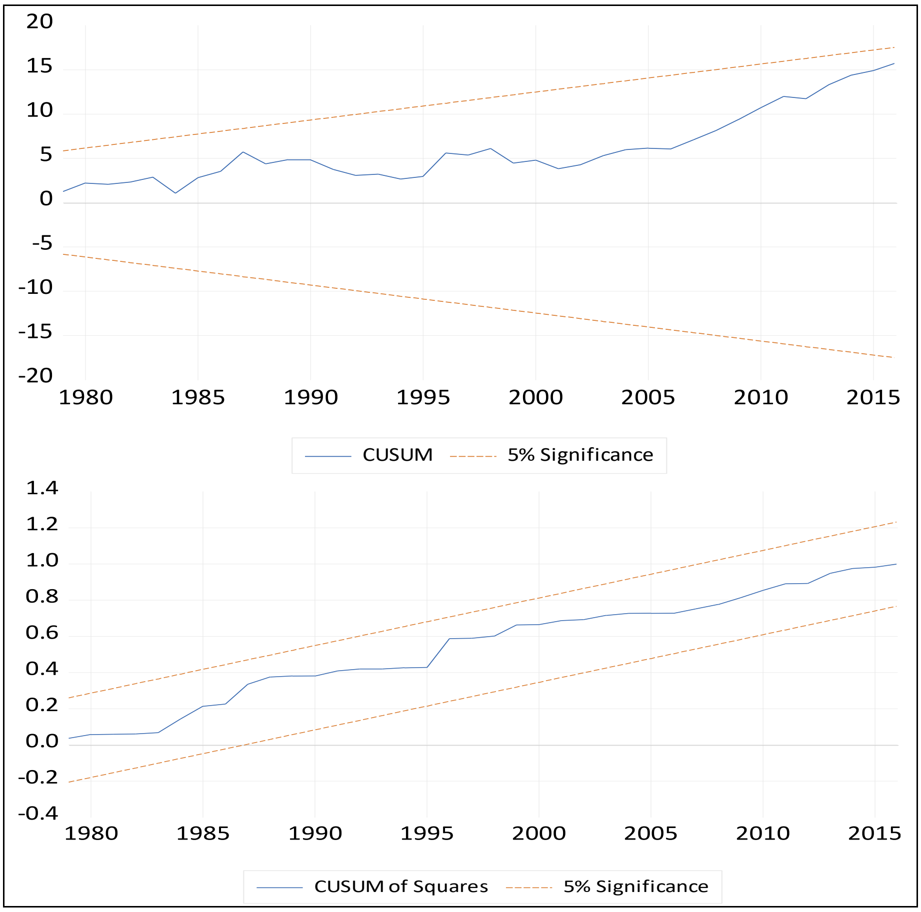

Figure 7. Plot of CUSUM and CUSUM of square (Dependent variable LNGDP)

Result of Granger Causality Test

Granger (1969) introduced the Granger causality test. It denotes a causal connection between the variables and the direction of causality. Estimated results suggest that there has no causal relationship between GDP and temperature. One significant causal relationship is identified in both model of the dependent variable LNGDP and LNTEMP that is LNCO2 Granger cause LNGDP because the probability of the null hypothesis "LNCO2 does not Granger Cause LNGDP" is lower than the 5% critical value. So, we reject the null hypothesis that indicates LNCO2 granger Cause LNGDP: a unidirectional causality running from LNCO2 to LNGDP. Study evidenced in India that carbon emission granger cause GDP (Tiwari 2011).

Table 10. Results of Granger Causality Test

Pairwise Granger Causality Tests (Dependent Variable LNTEMP)				
Null Hypothesis	Obs	F-statistic	Prob.	Decision
LNGDP does not Granger Cause LNTEMP	52	1.95951	0.1053	Accepted
LNTEMP does not Granger Cause LNGDP		1.51434	0.2065	Accepted
LNRF does not Granger Cause LNTEMP	52	0.61633	0.6880	Accepted
LNTEMP does not Granger Cause LNRF		0.89363	0.4944	Accepted
LNCO2 does not Granger Cause LNTEMP	52	0.10090	0.9914	Accepted
LNTEMP does not Granger Cause LNCO2		2.23456	0.0690	Accepted

LNRF does not Granger Cause LNGDP	52	1.04190	0.4063	Accepted
LNGDP does not Granger Cause LNRF		2.11733	0.0826	Accepted
LNCO2 does not Granger Cause LNGDP	52	9.22178	6.E-06	Rejected
LNGDP does not Granger Cause LNCO2		0.99502	0.4328	Accepted
LNCO2 does not Granger Cause LNRF	52	0.81469	0.5462	Accepted
LNRF does not Granger Cause LNCO2		0.14343	0.9809	Accepted
Pairwise Granger Causality Tests (Dependent Variable LNGDP)				
Null Hypothesis	Obs	F-statistic	Prob.	Decision
LNCO2 does not Granger Cause LNGDP	52	9.22178	6.E-06	Rejected
LNGDP does not Granger Cause LNCO2		0.99502	0.4328	Accepted
LNRF does not Granger Cause LNGDP	52	1.04190	0.4063	Accepted
LNGDP does not Granger Cause LNRF		2.11733	0.0826	Accepted
LNTEMP does not Granger Cause LNGDP	52	1.51434	0.2065	Accepted
LNGDP does not Granger Cause LNTEMP		1.95951	0.1053	Accepted
LNRF does not Granger Cause LNCO2	52	0.14343	0.9809	Accepted
LNCO2 does not Granger Cause LNRF		0.81469	0.5462	Accepted
LNTEMP does not Granger Cause LNCO2	52	2.23456	0.0690	Accepted
LNCO2 does not Granger Cause LNTEMP		0.10090	0.9914	Accepted
LNTEMP does not Granger Cause LNRF	52	0.89363	0.4944	Accepted
LNRF does not Granger Cause LNTEMP		0.61633	0.6880	Accepted

*, **, *** represent significance at 1%, 5% and 10% level respectively.

Conclusion

This essay aims to illustrate the relationship between temperature and economic growth. A lot of statistical data analysis has been conducted for this concern. The selected ARDL (1, 0, 0, 3) model, the dependent variable is temperature, implies that GDP and temperature have substantial relationship. The findings of the bound test show that the variables have a long run association. There is strong negative relationship between GDP and temperature over the short run and long run. GDP can change the temperature inversely by 1% increase in GDP stimulates 0.022 % decrease in the temperature in short run as well as in the long run, 1% increase in GDP led to 0.097% decrease in temperature in Bangladesh. The results inform that economic growth attainable without degrading the environmental quality. The error correction term explains that 78% of the disequilibrium will be adjusted per year to meet up the long run equilibrium with convergence in nature. The results help us to predict the economic growth is favorable to reduce temperature in Bangladesh.

We also examine the GDP, Carbon emission, rainfall and environmental temperature relationship in Bangladesh. The selected ARDL (3, 5, 3, 0) model, dependent variable is GDP that indicates the temperature has no influence on GDP. The result shows a substantial positive association in the short term but not in the long run because the p-value of the coefficient of carbon emission, rainfall and temperature are very high that is above 5% significant level. Having 1% level of significance in the short run if carbon emission increase in 1% level, GDP will increase 0.22%. Rainfall has also a positive influence to increase GDP. A 1% increase in rainfall led to 0.053% increase in GDP by 5% significant level in the short run. The correction of the disequilibrium in the short run will be adjusted at the speed of 0.0891% per year to long run equilibrium. From this assessment we could say that carbon emission and rainfall have influences on economic growth in the short run.

The Granger causality test determines how the variables are related causally where carbon emission causes GDP in both of the model. The estimated result demonstrates a unidirectional causal relationship between LNCO2 and LNGDP.

Lastly, we can conclude that in the short run, carbon emission and rainfall have positive influence on economic growth and dynamics of GDP have also positive impact on environmental temperature in short run. In the long run, economic growth is conducive to reduce temperature in Bangladesh that indicates sustainable environment and economic growth. The paper discusses the relationships among temperature, GDP, rainfall, and carbon emissions. Temperature decreases as GDP grows, addressing the possible underlying economic transitions such as shifts to greener industries or government interventions that promote sustainability. Therefore, policymakers should focus on economic growth to curb down environmental temperature in Bangladesh.

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