Causal Relationship Among Carbon Dioxide (CO_2) Emissions, Renewable Energy, Population and Economic Growth in Bangladesh: An Empirical Study

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Abstract

Developing countries face environmental degradation crisis due to the consumption of nonrenewable energy for economic development induces ecological destruction. However, the consequences of environmental deterioration can no longer be overlooked. Using data from 1990 from 2018, this study scrutinized the long-run equilibrium along with the trend among consumption of renewable energy, carbon dioxide emissions, Population, and economic growth in Bangladesh. This study reveals the significant cointegration of renewable energy with controlled variables using the ARDL bound test. Also, ECM with ARDL unrestricted version enables us to decide the speed of adjustment is 27.647% addressed for short-run elasticity in the long run. Stability and further diagnostic tests are performed for model post estimation and validation. Also, it needs further steps from the government side to promote renewable energy that boosts economic development.

Keywords: renewable energy, Carbon Dioxide (CO_2) emissions, economic growth, ARDL, Bangladesh

JEL Classification: O10

1. Introduction

Climate change constitutes one of the earth's most fundamental challenges and will be so for the coming decades. Historical data reveals that amount of CO2; the main culprit of ecological imbalance- is sharpening more in industrialized countries compared to non- industrialized nations. The Inter-governmental Panel on Climate Change estimated in 2007 that the mean temperature will elevate around 1.1 and 6.4 ° C over the next century globally. Moreover, it was predicted that a major temperature escalation of 2 ° C would dismantle ecosystems and cause a rise in sea level that would adversely influence the lives of coastal people (Lau, Tan, Lee, & Mohamed, 2009). According to data from NASA (2016), for 650,000 years, atmospheric CO2 levels practically never exceeded 300 parts per million (ppm) is now approaching 400 ppm, which verifies a significant increase of CO2 since the Industrial Revolution. Though CO_2 prevails in the atmosphere naturally, it has conspicuously elevated by one-third mediated by the Industrial Revolution. The interrelationship of greenhouse gas emissions and global mean temperatures is clarified by the reports of the Intergovernmental Panel on Climate Change (IPCC) (Kasman & Duman, 2015). It has been contended by researchers as well as economists that the unfeigned economic and environmental consequences of global warming are long odds that we will not promptly and significantly reduce global carbon emissions. The rising sea levels are substantial issues that will be too threatening for low-lying countries, including The Philippines, India, and certain parts of China if the sea surfaces continue to elevate. Rising seas will even devour major cities of the world, such as Miami and New York. The world will experience an extensive global food shortage, and starvation leads to devastating effects on food supply due to droughts and floods. Hence, recognizing the causes of environmental hazards in recent years is very relevant.

Causality is now a day of a cup of tea for foreign policy, economic stability, and also for alleviating poverty. The relationship between economic growths mediated by energy consumption has been well studied for developed as well as developing countries. Experimental results are grounded on different time schedules resulting in outcomes that also predicted different and contradicted each other. Sundry on studies exposed the association of expending renewable and nonrenewable energy with blooming GDP, but there is a certain variation in studies inferences. Several studies establish that between expending energy and growth of GDP, there are losses in both ways. This association means the consumption of energy and growth of GDP are conjointly determined. Others have pointed to the unidirectional correlation between consumption of energy and GDP growth that indicates the conservation of energy will adversely affect GDP growth. Some studies have found losses directed from the development of GDP to expending energy. This association is known as the conservation hypothesis. Moreover, a few studies found no direct connection between energy consumption and GDP growth (a phenomenon known as the neutrality hypothesis). Therefore, imposing conservation policies on the consumption of energy would exert no influence on economic development.

According to EIA (2008), in 1990, initial total energy consumption in Asia was about 47.4 quadrillion British Thermal Units (BTU).In 2007 this number increased two-folds to approximately 127.1 quadrillions BTU. In 2009although the developing nations had been consuming global commercial energy at a smaller scale, nations under the Organization of Economic Cooperation and Development (OECD) consumed about 43 percent of the total energy, whereas the Asian countries except China consumed about 12 percent. EIA (2019) also estimates that energy consumption will climb by 50% between 2018 and 2050 globally, focusing mainly on Asia, where substantial economic advancement is in steering demand. The ultimate energy consumption for Bangladesh in 2017 was quadrillion BTU. The government has fixed a mark to generate 2000 M.W. of electrical power from renewable energy by 2021. Currently, the total electricity generation from such sources is 404 MW. The new renewable energy goal would be 10% of the entire electricity generation in 2021 and would increase to 20% percent by 2030 (Sharif, Anik, Al-Amin, & Siddique (2018).

Bangladesh is recognized as a developing country with comparatively few resource grants, deprived industrial history, poor infrastructure, low volume of literacy, dawdling administration, a higher level of economic instability, and a negative balance of payment endangered nations to global climate change consequences.

The following pattern defines the proportion of the remaining part of this study. The section of the literature review clarifies the evidence from past and current empirical studies. An image of the statistical techniques used in this work is the methodology portion. The data collection component, econometric strategy, statistical analysis, and empirical outcomes discussions are represented in the results & discussions section. While in the last section of this study, a conclusion with implications of policies is discussed for future envisions.

2. Literature Review

According to studies by Belloumi (2009); Lee & Chang (2008); Narayan, Narayan, and Prasad (2008); Mehrara (2007), it can be perceived that there is various empirical research that concern the relationships between economic growth, energy use, and pollutant emissions which have taken into account different countries, variables, and methodologies. Plenty of literature explained the Granger causal relationship among Carbon- Di Oxide (CO2) emissions, renewable energy, Population, and economic development in a linear multivariate framework. Ozturk (2010) stated that most studies concluded that there is no agreement on these theories in the literature. Understanding the link between variables is extremely important because of the active impacts of energy policy, often focused on causal relationships.

The Granger Causality between Carbon Dioxide (CO_2) emissions, Renewable energy, Population, and economic advancement can be categorized into four types of hypothesis: unidirectional causality initiating from economic development towards consumption of energy (conservative hypothesis), unidirectional causality initiating from consumption of energy towards economic development (growth development), no causality between economic development and economic development (neutrality hypothesis), and two-way causality between economic development and energy consumption (feedback hypothesis) in which individual hypothesis dispenses distinctive inferences. Asumadu-Sarkodie (2017) postulated that environmental destruction, energy consumption, economic development, and industrialization reflect consistent stability amidst them. The inconsistent disintegration findings showed utilization of electricity intensifies deterioration of the environment at the rate of 7% and by economic development at the rate of 20%. It was suggested that renewable energy usage could reduce the degradation of the environment in Sierra Leone in the future.

From 1980 to 2015, Işık, Ongan, and Özdemir (2019) examined 10 U.S. states to spectate the consequences of renewable and fossil energy expenditure, population density, and GDP on the emission of Carbon Dioxide. Outcomes revealed that the impacts being relatively lower in other states, fossil energy consumption exerted an adverse effect on Texas's Carbon Dioxide emissions. In contrast, it exerted a favorable effect on Florida Carbon Dioxide emissions, although this impact is lower than other U.S. states. From 1995 to 2015, analyzed the effects of renewable energy, fossil, and solid fuel expenditure, urbanization, and economic development on Carbon Dioxide emissions in the Sub-Saharan African nations assisted by the GMM model correlation between the inconsistent elements affiliated to the research. This study showed that fossil and solid fuel exerted a positive effect on the CO2 emission rate than fossil and solid fuel, whereas it was reduced using renewable energy.

Shahbaz, Zeshan, and Afza (2012) denoted a sustainable and symmetrical cohesion between renewable and nonrenewable energy consumption and economic development.

Ozturk & Acaravci (2010) depicted the causal relationship between GDP growth and Carbon Dioxide emission is nonexistent for Turkey. But multiple types of research showed a causal relationship between GDP growth and Carbon Dioxide emission. To relate Pao and Tsai (2011) uncovered a two-way causality in addition to the established correlation between GDP growth and emission of Carbon Dioxide for Brazil. Again, Chang (2010) and Halicioglu (2009) revealed a two-way causal dependency between GDP and CO2. Shahbaz, Lean, and Shabbir (2010) in Pakistan investigate their causal relationship to reveal that energy consumption elevates Carbon Dioxide release temporarily and permanently conducted a Granger causality test and EKC. Chang (2010) pursued the prior research by implementing multivariate cointegration Granger causality techniques for determining the interconnection among consumption of energy, CO2 emission, and economic expansion. A unidirectional causality was detected, leading from energy consumption to emission of Carbon Dioxide, which validates the disclosure, by Zhang and Cheng (2019).

No study has enlightened the effect of renewable energy on carbon emissions on previous studies' Bangladesh context insight. Most studies are concerned with the EKC hypothesis, some works for panel data while it valid for developed or oil-based economic countries. This study fills the gap by neglecting the EKC hypothesis and including control variables- like population growth. As comprehended, concentrated anatomy of the empirical relationship between Carbon Dioxide emissions, renewable energy consumption, Population, and GDP (Gross Domestic Product) per capita in Bangladesh has not been conducted yet. Hence, this research aims to evaluate the causal relationships among these four variables in Bangladesh over 1990-2018 using a multivariate framework.

3. Methodology

This study examines the impacts of renewable energy consumption on Carbon Dioxide emission, economic development, and population density by using time series data from 1990 through 2018 (missing values are extrapolated). Annual data collected from the World Bank for the time of 1990-2018. The preference of time was based on the accessibility of the data. For analysis purposes, we use STATA software.

Hence, our required regression model is:

$$REN_t = \beta_0 + \beta_1 CO_{2t} + \beta_3 LGDPGR_t + \beta_4 LPOPD_t + u_t \tag{1}$$

Here, u_t is the stochastic error term. REN refers to the consumption of Renewable energy (percentage of total final energy consumption), CO_2 refers to Carbon Dioxide emissions (metric tons per capita), and the others two are LGDPGR is GDP per capita growth (annual %), and POPD is Population density (people per sq. km of land area), both converted to lateral log form due to reducing heteroscedasticity.

Besides ADF, this study also performed Phillips & Peron (P.P.) unit root test. In time series, unit root testing is one fundamental step in constructing univariate and multivariate econometric models. This study employs the Autoregressive Distributed Lag (ARDL) model analyzing both short-term and long-term elasticity. Along with this, the study utilizes a bound testing approach to cointegration to examine $I(0)$. Here the model is:

$$\Delta RENt = \alpha_0 + \sum_{i=1}^{n1} \theta_i \, \Delta REN_{t-i} + \sum_{i=1}^{n2} \varphi_i \, \Delta CO2_{t-i} + \sum_{i=1}^{n3} \vartheta_i \, \Delta LGDPGR_{t-i} + \sum_{i=1}^{n4} \kappa_i \, \Delta LPOPD_{t-i} + \lambda_1 REN_{t-1} + \lambda_2 CO_{2t-1} + \lambda_3 LGDPGR_{t-1} + \lambda_4 LPOPD_{t-1} + e_t \tag{2}$$

Where θ_i, φ_i, ϑ_i, κ_i are short-run parameters and λ_1 to λ_4are long-run parameters. To test cointegration, the null hypothesis is considered: H0: λ_1=λ_2=λ_3=λ_4=0 against the alternative hypothesis at least one is non zero. For specifying the specific lag length of model selection criteria, information criteria like Akaike's Information

Criteria (AIC), Schwartz (Schwarz, G., 1978) Information criteria (SIC), etc. are available. As there is a risk of over-fitting the model, this study employs SIC. If there is a long run (cointegration) relationship among the variables, in the Eq. (2), ΔREN_t=ΔCO_{2t}=$\Delta LGDPGR_t$=$\Delta LPOPD_t$=0, then the long-run model can be formulated as:

$$\Delta RENt = \omega_1 + \omega_2 REN_{t-1} + \omega_3 CO_{2t-1} + \omega_4 LGDPGR_{t-1} + \omega_5 LPOPD_{t-1} + \xi_{1t} \quad (3)$$

Where long-run coefficients are ω_1= -α_0/λ_1, ω_2= -λ_2/λ_1, ω_3= -λ_3/λ_1 , ω_4= -λ_4/λ_1. To estimate the short-run relationship, the conventional error correction model version model from the ARDL model in Eq. (2) is used as follows:

$$\Delta \mathrm{REN}_t = \alpha_2 + \sum_{i=1}^{n1} \theta_{2i}\, \Delta REN_{t-i} + \sum_{i=1}^{n2} \varphi_{2i}\, \Delta CO2_{t-i} + \sum_{i=1}^{n3} \vartheta_{2i}\, \Delta LGDPGR_{t-i} + \sum_{i=1}^{n4} \kappa_{2i}\, \Delta LPOPD_{t-i} + \delta ECT_{t-1} + \xi_{2t} \quad (4)$$

The coefficient of the error correction term (ECT_{t-1}) in Eq. (4) is the speed of adjustment from the short run to the long run, which is expected to be negative and statistically significant. To test the goodness of fit of the ARDL model stability tests, the cumulative sum of recursive residuals (CUSUM) and cumulative sum of squares of recursive residuals (CUSUMSQ) are also employed. This paper also showed Descriptive statistics of variables.

4. Results and Discussions

Table 01 showed illustrative statistics, mean, median, standard deviation, skewness, and kurtosis. Except for population density (in natural logarithm), all variables are range from 0 to 2. None has so much deviated from central value as the standard deviation is too small. Except for Carbon dioxide emission, all variables skewness is negative. This indicates that variables have slight left tailed distribution. Also, kurtosis enables us to know whether the shape of the distribution is flatted or peaked. As each variable's kurtosis is less than 3, so the distribution is slightly platykurtic; Jarque-Bera statistic enables us a hypothesis-based test whether the univariate distribution is normal or not. As J.B. statistic's probability value is rejected at a 5% level of significance, we conclude that each variable is normally distributed.

Table 1. Basic statistics of study variables

Characteristics	**REN**	**CO_2**	**LGDPGR**	**LPOPD**
Mean	1.695763	0.308756	1.701438	6.933137
Median	1.717034	0.275240	1.694273	6.958796
Maximum	1.864272	0.543006	2.062258	7.122527
Minimum	1.436915	0.150558	1.248533	6.675311
Std. Deviation	0.121499	0.128143	0.202748	0.135768
Skewness	-0.428218	0.442430	-0.312217	-0.378852
Kurtosis	2.208088	1.800736	2.507240	1.923150
Jarque-Bera	1.644068	2.683963	0.764548	2.094915
Probability	0.439537	0.261327	0.682308	0.350829
Observations	29	29	29	29

Source: Estimated.

For acknowledging the relationship or the response of sign among variables, the correlation matrix is displayed in Table 02. It has also assisted us in concern about higher-order correlation and removing unnecessary or multicollinearity affected variables. Renewable energy is negatively correlated with each other, so it's an obstacle for economic growth, population density, and the environment culprit. Whereas, Environment disorder or carbon dioxide emission is correlated strongly with population density.

Table 2. Correlation matrix of study variables

	CO_2	LGDPGR	LPOPD	REN
CO_2	1			
LGDPGR	0.751	1		
LPOPD	0.941	0.722	1	
REN	-0.990	-0.766	-0.955	1

Source: Estimated.

To ensure the variables are not integrated at I (2) we have applied the unit root test before conducting the bounds test for cointegration. Besides ADF, this study also performed Phillips & Peron (P.P.) unit root test. Both suggested that variables have no risk of I(2). Except for population density (LPOPD), the remaining variables are stationary at first difference. For conveying a more crystal view, we check unit root for intercept with and without a trend. The result is provided in Table 03.

Table 3. Unit root test of study variables

Variables	Augmented Dickey-Fuller (ADF) Test		Phillips-Perron (P.P.) test	
	Intercept	**Intercept & Trend**	**Intercept**	**Intercept & Trend**
CO_2	1.5791	-1.1575	2.4242	-1.6527
LGDPGR	-2.2703	-4.3665**	-2.2695	-5.7778***
LPOPD	-4.0817***	-2.6264	-10.1817***	-1.261
REN	2.3247	0.7820	4.6459	0.3177
D(CO_2)	-1.0579	-3.9513**	-4.3375***	-4.874***
D(LGDPGR)	-5.0203***	-4.945***	-14.0514***	-13.6784***
D(LPOPD)	-1.7876	-2.6422	-1.0914	-1.1836
D(REN)	-3.0313**	-3.654**	-3.0313**	-3.4773*

Notes: Here, (*) indicates significant at the 10%; (**) indicates at significant at the 5% and (***) significant at the 1% for specific t-statistic.

Source: Estimated.

This study performs a single- equation-based unrestricted with no trend ARDL model. For supporting this, our first target is to check whether there is cointegration or not based on the ARDL bound test. Since our calculated F-statistic is 10.4083 that surpassed our lower bound (L.B.) and upper bound (U.B.) range at 10%, 5%, and even 1% level of significance (Table 04). So there is a cointegration of renewable energy with endogenous variables.

Table 4. F-bound test for ARDL (2, 4, 1, 2) model

	Value	Significant level	I(0)	I(1)
F-statistic	10.4083	10%	3.008	4.15
Lag	3	5%	3.71	5.018
		1%	5.333	7.063

Source: Estimated.

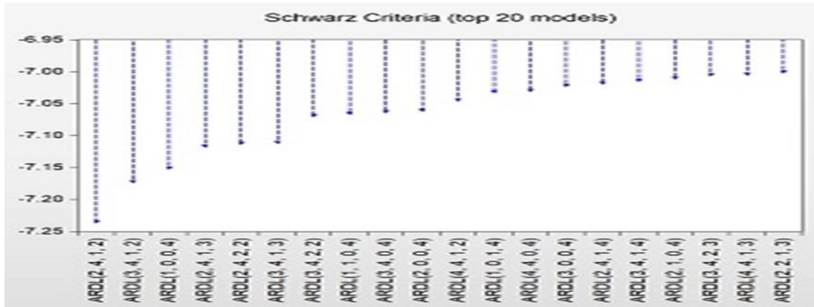

Figure 1. Information criterion graph of ARDL model

Source: Estimated.

As Akaike's Information Criteria (AIC) is sometimes hampered due to the overfitted model, we performed this parsimonious model based on Schwartz Information Criteria (SIC) in figure 01. Also, the value of information criteria out of 20 models is exhibited, and the best model is suited as ARDL (2, 4, 1, 2) where the SIC value is -7.2342.

Table 5. Short-run coefficients for ARDL (2,4,0,2) model

Variable	**Coefficient**	**Std. Error**	**t-Statistic**
C	0.878545***	0.120831	7.270856
D(REN(-1))	0.588286***	0.082048	7.17003
D(LGDPGR)	-0.04604***	0.006717	-6.854836
D(LGDPGR(-1))	0.085522***	0.012133	7.048719
D(LGDPGR(-2))	0.040036***	0.010032	3.990955
D(LGDPGR(-3))	0.02527***	0.006399	3.948896
D(CO2)	-0.74925***	0.080436	-9.314836
D(LPOPD)	11.17652**	2.469553	4.525726
D(LPOPD(-1))	-16.2614**	2.916258	-5.576114
ECT(-1)	-0.27647***	0.038324	-7.213974

Notes: Here, (*) indicates significant at the 10%; (**) indicates at significant at the 5% and (***) significant at the 1% for specific t-statistic.

Source: Estimated.

Now, in short, run coefficients (table 05), all are statistically significant at a 1% level of significance. As renewable energy increases, economic growth will increase in the short-run at a positive rate. Carbon dioxide will decrease more rapidly as renewable energy increases. Also, population density growth will decrease.

Table 6. Long run coefficients for ARDL (2,4,1,2) model

Variable	**Coefficient**	**Std. Error**	**t-Statistic**
LGDPGR	-0.380264	0.127522	-2.981959**
CO2	-1.130227	0.301815	-3.744771***
LPOPD	-0.024161	0.297309	-0.081266

Notes: Here, (*) indicates significant at the 10%; (**) indicates at significant at the 5% and (***) significant at the 1% for specific t-statistic.

Source: Estimated.

On long-run coefficients (table 06), all variables reflect a negative sign on the increase of renewable energy per unit. As a one percent increase in GDP growth, renewable energy will statistically decrease by 0.38 percent at a 5% level of significance. This result is crucial for being in line with the literature (Menegaki, 2011; Apergis & Payne, 2012; Jaforullah & King, 2015; Özbuğday & Erbas, 2015; Ackah & Kizys, 2015; Naeimi, Askariazad, & Khalili-Damghani, 2015); Jebli & Youssef, 2015; Bento & Moutinho, 2016, Akar, Tekin, & Ayton, 2020). Moreover, it reveals the negative effect of carbon emission on renewable energy use, which is one of the dynamics of clean and sustainable growth in terms of energy. Also, for a single percent increase in environmental degradation, renewable energy will statistically decrease by 1.13 percent at a 1% level of significance. Results provided here of reducing carbon emission by renewable energy is consistent with several types of research of different countries Isik et al. (2019) for 10 U.S. states, Erdogan, Okumus, and Guzel (2020) for 25 OECD countries; Alola, Bekun, & Sarkodie (2019), Bhat (2018) for five emerging economies, Ito (2017) for developing countries and Khan, Khan, and Binh (2020) for 190 developing countries).

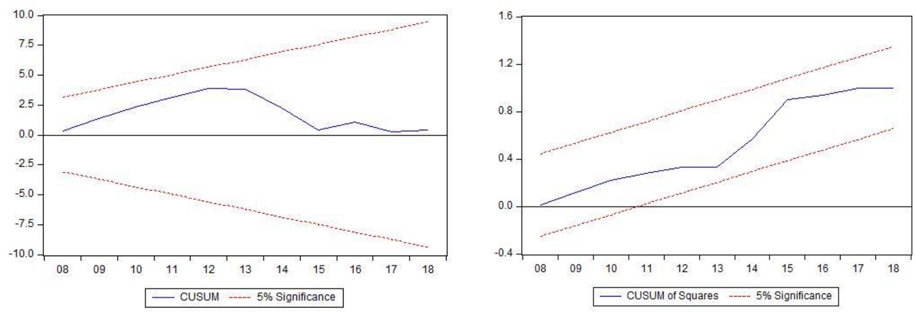

Figure 2. Stability test (CUSUM & CUSUMSQ test)

Source: Estimated.

A graphical demonstration of CUSUM and CUSUMSQ is shown in Figure 2. For further validation and acceptability of the model, we assess diagnostic tests (Table 07). Heteroscedasticity, serial correlation Lagrange Multiplier (L.M.) test, normality test, and specification of model-Ramsey RESET test enable us to accept the model at a 5% level of significance.

Table 7. Diagnostic test

Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.116954	**F(11,13)**	0.4194
Observed R-squared	12.14729	**Prob. Chi-Square(11)**	0.3527
Serial Correlation test: Breusch-Godfrey Serial Correlation L.M. Test			
F-statistic	1.909666	**F(2,10)**	0.1984
Observed R-squared	6.909401	**Prob. Chi-Square(2)**	0.0316
Model Specification: Ramsey RESET test			
Test statistic	**Value**	**df**	**p-value**
t-statistic	0.008295	11	0.9935
F-statistic	0.00000865	(1,11)	0.9935
Jarque-Bera Normality test			
test statistic	0.8181089		
p-value	0.66724		

Source: Estimated.

5. Conclusion and Policy Implications

On the verge of the 21st century, renewable energy is now a matter of solving economic degradation, reducing atmosphere imbalance, and converting fuel or nonrenewable energy to renewable energy. This study assesses time-series data from 1990 to 2018 of renewable energy consumption, carbon dioxide emission, economic growth, and population density. For performing ARDL, we consider the unit root test for checking stationarity. Except for population density, all are integrated at 1st order. Then, the bound test is assessed under the F-statistic of a 5% level of significance and suggests a cointegration among variables. For short-run elasticity, each variable statistically responds with renewable energy where economic growth is positively associated. However, in the long run, renewable energy consumption is statistically significant but negatively. Stability test through CUSUM & CUSUMSQ test suggests this model relates short-run elasticity with a long-run diagnostic test for autocorrelation, heteroscedasticity, model specification, and normality test validates our model.

As stated in empirical findings, increasing renewable energy consumption diminishes environmental degradation (Erdogan et al., 2020). Therefore, sponsoring renewable energy sources (wind, solar, wave, and biomass energy) will be a solution to combat environmental pollution. In addition to its benefits in the context of environmental quality, it may also reduce production costs and may create new job opportunities and contribute to economic growth (Lehr, Lutz, & Edler, 2012; Bhattacharya, Paramati, Ozturk, & Bhattacharya, 2016). On the other hand, economic growth also triggers renewable energy consumption. Al-Mulali and Sheau- Ting (2014) and Ocal and Aslan (2013) propose that using renewable energy instead of fossil fuel energy increases economic growth. Nevertheless, Menyah and Wolde-Rufael (2010) debated that renewable energy is favorable for environmental quality while the consumption of renewable energy in most of the countries has not yet reached the anticipated level to help reduce emission.

So, for performing economic growth faster, renewable energy consumption needs more contribution and government advocacy. Also, climate change is reckoning negatively with economic growth. Hence, balancing the environment and being the economy more stable requires more steps for renewable energy strategy. As a subtropical country, sunlight is plentiful 70% of the year (Chowdhury, Uddin, & Saleh, 2014). This marks the consumption of solar panels instrumental in Bangladesh. Solar radiation on each day is 4-6.5 kWh/m^2, while maximum radiation is generally received in the months of March-April and minimum in December-January. The effect would be reducing the traditional fossil fuel-based power consumption, which will further ensure a green environment for our future generation (Tanvir, Shahadat, Ghosh, & Khan, 2017). There are two ways to harness solar energy- (1) Photovoltaic Cells and (2) Solar Thermal Energy. Hence, solar energy can be a viable solution for the power crisis in Bangladesh (Hussain, 1987). Another solution is wind energy. Since our country is in a tropical region, it has many winds flows throughout the year.

Nevertheless, not all areas have the potential to harness wind energy. The potential places for harnessing wind energy are- riversides, offshore islands, lands with large open space, coastal areas, Sea beach where the wind flows strongly. In coastal areas, the average annual wind speed has been recorded as over 5 m/s at the height of 30 m (Irfan, Zhao, Mukeshimana, & Ahmad, 2019; Rahman, Sohag Kumar Saha, Khan, Habiba, & Hosse, 2013). Wind energy has many benefits if it can utilize properly and to the full extent. It will improve environmental quality by reducing GHG emissions. The standard of living will also go up with its development. The region can save a lot of money, and energy security will be increased by reducing dependence on imported fossil fuels Irfan et al. (2019). Besides, the government, along with NGOs, has implemented some new projects such as hydropower, geothermal energy, biogas, biofuel, tidal power to harness renewable energy and meet the long-run gap of the energy crisis.

For future research purposes, studies can ghettoize the impact of economic growth, renewable energy, and control variables on both renewable and non-renewable energy demand, since the current study limits its findings on aggregate energy demand in our economy. Also, different components of clean and dirty energy consumption can be explored to assess the impact of energy use and carbon emissions in future research studies.

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Declaration of competing interest

There is no conflict of interest among the authors

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