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Exploring the Impact of Environmental Degradation on Life Expectancy in Bangladesh: An ARDL Bounds test Approach

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Abstract:
Environmental degradation affects the health status of many people all over the world. Bangladesh is one of the most polluted countries, and every year 96,000 children died before reaching their fifth birthday because of environmental pollution. The present study has attempted to explore the pollution effect on the life expectancy of Bangladesh by analyzing the annual data from 1974 to 2014. The study has relied on the ARDL bounds test for checking the long-run association that can allow the admixture of I(0) and I(1) series (but inapplicable for I(2) series). The study scrutinized the unit root problems by running the widely used Augmented Dickey-Fuller (ADF) test. Besides, other essential tests associated with the ARDL, like the normality test, serial correlation test, heteroskedasticity test, model specification test, and parameter stability test were also performed. The study found a significant negative impact of environmental degradation on life expectancy both in the short- and long-run. Therefore, the study suggests the proper implementation of environmental protection laws and regulations.

Keywords: Environmental degradation, life expectancy, Bangladesh, ARDL bounds test.

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Introduction

Environmental degradation affects the health status of many people all over the world through climate change (Costello et al. 2009; Doherty & O'Connor 2018; Kinney 2018; Majeed & Ozturk 2020). Various vector-borne diseases like Malaria (causes 400,000 deaths globally with 219 million cases per year), Dengue (causes 40,000 deaths with 96 million symptomatic cases per year), Chikungunya fever, Zika virus fever, yellow fever, etc. are the byproduct of climate change (Sellman & Hamilton, 2007; Kovats & Hajat, 2008; Bezirtzoglou et al., 2011; Caminade et al., 2019; World Health Organization-WHO, 2020). These diseases are responsible for more than 700,000 deaths annually around the world (WHO, 2020). Environmental Pollutions do not know any national boundaries, can fly from one region to another. The increasing concentration of the harmful pollutants in the air of any country not only affects the population of that country but also becomes detrimental to other neighboring countries. Bangladesh is a developing economy, which experiences an excellent growth rate over the last decades (Daily Star, 2019). But besides the excellent growth rate, Bangladesh also suffers from significant environmental degradation (Landrigan et al. 2018). According to the Particular Matters-2.5 concentration in the air (which is the most dangerous air pollution for human beings), Bangladesh was the most polluted country in the world in 2018 and 2019 (World Air Quality Report 2018, 2019). About 96,000 Bangladeshi children died before reaching their 5th birthday due to this air pollution (The Business Standard, 2020). CO_2 emissions are also increasing surprisingly in Bangladesh in recent years, from 0.15 metric tons per capita in 1991 to 0.52 metric tons per capita in 2017 (increases 246.67 percent within 27 years) (World Development Indicator (WDI) 2020). Increasing air pollutions are playing a destructive role in the general health status of the country. In 2015, about 261,000 people died in Bangladesh because of pollution-related diseases, and a total of $18.6 billion (9.7% of GDP) were lost (Landrigan et al. 2018). Besides, indirectly health status of many people have significantly deteriorated. According to Lelieveld et al. (2020), ambient air pollution is "one of the main global health risks" in the present world and is responsible for the loss of life expectancy. In this background, the study aimed to explore the impact of environmental degradation on life expectancy in Bangladesh by using ARDL bounds test method.

Literature Review

Life expectancy at birth is widely used as an indicator of well-being and human development. Many research works throughout the world also used it to represent the population heath status of a country (for example, see Rodgers, 1979, Rogers & Wofford, 1989, Gulis, 2000, Veugelers et al., 2001, Shaw et al., 2005, Kabir, 2008, Rayhan et al. 2019, Khaleda et al. 2020). Besides some biological factors or endowments, some socioeconomic determinants are also responsible for better life expectancy. Among them, economic growth is the single most important determinant of better life expectancy. The increasing per capita income means increasing purchasing power of the people. When the purchasing power of the people increases, the budget constraint shift outward and intersects with a higher indifference curve. Therefore, people will obtain a new optimum in the expansion path with the increasing income, and they can enjoy more medical and non-medical goods than before. Increasing consumption of non-medical goods means- people can consume more foods, more quality-full and nutrient foods, can spend more on children's education, etc. While increasing consumption of medical goods implies- now people can spend more on medical cares, can afford regular check-ups, can purchase reliable life insurance and health insurance, can access the treatment of any diseases initially, etc. As people with higher income can afford more medical and non-medical goods and services compare to lower income people, logically it can be concluded that economic growth or increasing real per capita income improve the life expectancy of the people. Empirically, the study of Ebenstein et al. (2015) found the positive significant impact of economic growth on life expectancy in China by analyzing the city level data from 1991-2012, Gilligan & Skrepnek (2015) found for 21 Mediterranean countries from 1995 to 2010 by employing multi-level mixed effects model, Shahbaz et al. (2019) found for 16 sub-Saharan African countries (except Gabon and Togo) from 1970 to 2012, Rayhan et al. (2019) found for five countries in South Asia, and Wang et al. (2020) found for Pakistan. Moreover, Bul & Moracha (2020) found that economic growth has positive impacts on the health outcomes in the Sub-Saharan countries. So, empirically various studies provided the evidence on the positive impact of economic growth on life expectancy.

Although economic growth has a positive impact on life expectancy, sometimes it can deteriorate the life expectancy too. Some countries do not follow the environmental rules and regulations at the production process. Increasing competition in the global trade put pressure on the governments and producers. To ensure the supply of commodities at a lower price in the global market, these countries lose environmental protection laws and monitoring. Sometimes, some countries loose the environmental laws and monitoring to attract the foreign direct investment. As a result, environmental degradation increases with increasing economic activities, and health status of the population suffer from these pollutions. For these reason, Lelieveld et al. (2020) indicated the ambient air pollution as one of the main global threat for health status in the present world. Some recent studies also included the environmental pollution as a risk factor in the life expectancy model and found significant negative impact. Kolasa-Więcek & Suszanowicz (2019) studied 20 European countries from 1992 to 2016 and found that air pollution has detrimental impact on life expectancy. Hill et al. (2019) analyzed the 49 states data of USA and also found that air pollution is detrimental to life expectancy. Study of Ebenstein et al. (2015) was also found the negative impact of city-level air pollution on city-level life expectancy in China. A recent study of Wang et al. (2020), which analyzed the annual data of Pakistan, concluded that energy consumption lead to decreasing life expectancy through the environmental degradation. Another recent study that is conducted by Wu et al. (2020) by covering the urban population data of China from 2013 to 2017 concluded that the reduction of air pollution can enhance the life expectancy. In the context of Bangladesh, the study of Metu & Khan (2019) revealed that indoor air pollution drastically hampered the life in Chittagong, a city of Bangladesh. Moreover, Sheraj (2017) also discussed the channel through which environmental degradation hampered the life in Bangladesh, besides China.

So, these empirical studies found the evidence that air pollution or environmental degradation is harmful for the population health status and life expectancy. As no rigorous work was conducted in the context of Bangladesh, the present study aimed to fill the gap.

Methods and Materials

In order to estimating the impact of environmental degradation on life expectancy, the study also include economic growth and fossil fuels energy consumption in the model (to reduce omitted variable bias problem), besides carbon dioxide emissions. Carbon dioxide emissions are widely used in the research arena to represent environmental degradation by many researchers (e.g., Rayhan and Islam (2015), Rayhan et al. (2018), Rayhan and Islam (2018), Khaleda et al. 2020). For this reason, we also include carbon dioxide emissions to represent the environmental degradation. Now, the logic behind including the other two variables is that economic growth is expected to be positively related to the life expectancy of a country on the basis of previous literatures. Increasing per capita income means increasing purchasing power, when other things remaining the same. When purchasing power increases, people can spend more money on healthy food and health care facilities which in turn improve the life expectancy. But, maintaining the growth rate, an economy needs to employ more energy. When these increasing energy demand is meet up from the burning of fossil fuels, our environment will degrade (Rayhan, 2020) because of carbon dioxide emissions, which in turns deteriorate the health and life expectancy. Many previous studies already confirmed that energy consumption increases carbon dioxide emissions, therefore, it is expected that economic growth will enhance life expectancy, but the byproduct of economic growth, environmental degradation will cause to deteriorate it. For this reason, we include the economic growth and fossil fuels energy consumption variables, besides carbon dioxide emissions, into our model to estimate the impact of environmental degradation on life expectancy in Bangladesh. Variables, their notations and sources of data are tabulated in table 1.

Table 1. Variables name, definitions, units, notations, and sources of data

Variables	Definitions	Unit	Notation	Sources of Data
Life expectancy	Life expectancy at birth	years	LE	WDI, 2020
Economic growth	Real GDP per population	Dollars (Constant, 2010)	Y	WDI, 2020
Energy consumption	Fossil fuels energy consumption per population	Kg of oil per capita	FFEC	WDI, 2020
Environmental degradation	Carbon dioxide emissions per capita	Metric tons per capita	CE	WDI, 2020

Data of LE, Y, FFEC, and CE are taken over the period of 1974 to 2014. The study transformed all the variables into log form so that elasticities can be estimated. For checking the cointegration, the study has relied on ARDL bounds test that can allow the mixture of I(0) and I(1) series (but inapplicable for I(2) series). The study scrutinized the unit root problems by running the widely used "Augmented Dickey-Fuller (ADF)" test (developed by Dickey & Fuller (1979, 1981)). Besides, other essential tests associated with ARDL model, like normality test, serial correlation test, heteroskedaticity test, model specification test, and parameter stability test were also performed.

Results and Discussions

Table 2 represents the descriptive statistics of LNLE, LNY, LNFFEC, and LNCE. The Jarque-Bera statistic for LNLE is 2.8360 with a p-value of 0.2421, for LNY is 4.2974 with a p-value of 0.1166, for LNFFEC is 3.4200 with a p-value of 0.18086, and for LNCE is 2.3480 with a p-value of 0.30911. All the respective p-values are greater than 0.05 here, which indicates the acceptance of null hypothesis so that it can be concluded that the respective residuals of the variables LNLE, LNY, LNFFEC and LNCE are distributed normally. Now, time series plot of these variables are illustrated in Figure-1, from where it is observed that all the variables under this study shows an increasing trend within the study period. Table 3 includes the results of the unit root test (ADF). If we take the assumption of "with constant and trend" then the t-statistic of the LNCE, LNFFEC, LNLE and LNY becomes -2.7703, -0.9639, 3.0207, and -0.2934, respectively while the respective p-value becomes 0.2160, 0.9367, 1.0000, and

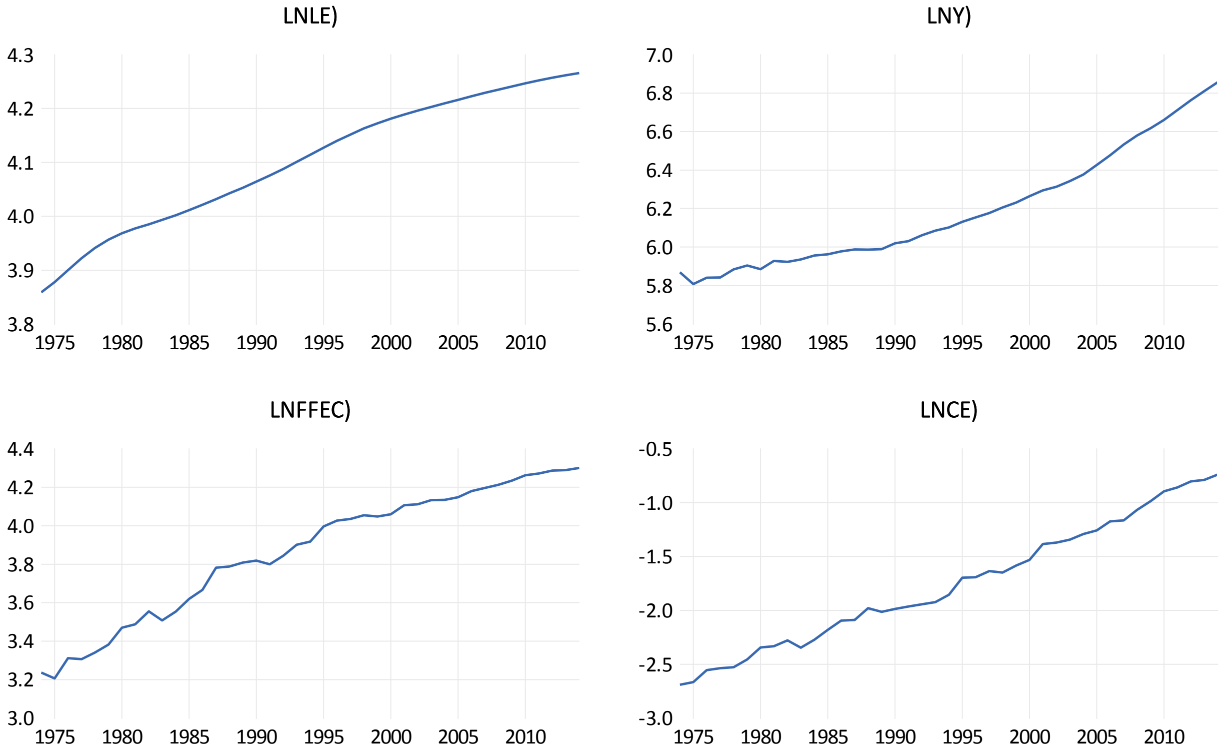
0.9882. All the respective p-values are greater than 0.05 so that in level form LNCE, LNFFEC, LNLE and LNY are non-stationary. Now, after taking the 1st difference of LNCE, LNFFEC, LNLE and LNY, the respective t-statics become -7.6772, -5.9081, -6.1166, and -10.1993, and the p-values become 0.0000, 0.0001, 0.0001, and 0.0000, respectively. As all the p-values are less than 0.05 now, rejection of the null hypothesis becomes possible and all the variables are now stationary. Therefore, LNCE, LNFFEC, LNLE, and LNY are I(1) series.

Table 2. Descriptive statistics of LNLE, LNY, LNFFEC and LNCE

	LNLE	LNY	LNFFEC	LNCE
Mean	4.101087	6.192585	3.863114	-1.754885
Median	4.113984	6.101786	3.917032	-1.856033
Maximum	4.265928	6.857845	4.300938	-0.739535
Minimum	3.858538	5.807806	3.206191	-2.691186
Std. Dev.	0.120973	0.303020	0.337706	0.581222
Skewness	-0.309787	0.719353	-0.465371	0.165932
Kurtosis	1.870281	2.332411	1.934309	1.875571
Jarque-Bera	2.836068	4.297401	3.420050	2.348060
Probability	0.242190	0.116636	0.180861	0.309119
Sum	168.1446	253.8960	158.3877	-71.95029
Sum Sq. Dev.	0.585379	3.672836	4.561808	13.51276
Observations	41	41	41	41

Source: Software output

Figure 1. Time series plot of LNLE, LNY, LNFFEC and LNCE



We apply ARDL bounds test technique to find out the cointegration among LNLE, LNY, LNFFEC, and LNCE in the context of Bangladesh. The F-statistic of bounds test is 20.17515, which is much greater than the 1% critical value of upper bound of Pesaran et al. (2001) 6.36 so that it can be concluded that LNLE, LNY, LNFFEC, and LNCE are cointegrated. Moreover, the statistic of the t-Bounds test is -9.551270, which is also much greater than the 1% critical value of the upper bound value of Pesaran et al. (2001) -4.73 in absolute term, therefore, the possibility of the degenerate lagged dependent variable is also rejected. So, it can be concluded that variables under this study are cointegrated, and they have long-run convergence.

Table 3. Unit root test results

		LNCE	LNFFEC	LNLE	LNY
With Constant	t-Statistic	0.2176	-3.9405	-1.7508	5.2617
	Prob.	**0.9704**	**0.0044**	**0.3969**	**1.0000**
		n0	***	n0	n0
With Constant & Trend	t-Statistic	-2.7703	-0.9639	3.0207	-0.2934
	Prob.	**0.2160**	**0.9367**	**1.0000**	**0.9882**
		n0	n0	n0	n0
		d(LNCE)	d(LNFFEC)	d(LNLE)	d(LNY)
With Constant	t-Statistic	-7.7476	-1.8343	2.0506	-2.1026
	Prob.	**0.0000**	**0.3582**	**0.9998**	**0.2448**
		***	n0	n0	n0
With Constant & Trend	t-Statistic	-7.6772	-5.9081	-6.1166	-10.1993
	Prob.	**0.0000**	**0.0001**	**0.0001**	**0.0000**

Source: Software output

Table 4. Bounds test results

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	20.17515	10%	3.47	4.45
K	3	5%	4.01	5.07
		2.5%	4.52	5.62
		1%	5.17	6.36
t-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
t-statistic	-9.551270	10%	-3.13	-3.84
		5%	-3.41	-4.16
		2.5%	-3.65	-4.42
		1%	-3.96	-4.73

Source: Software output

Short-run results of this study are tabulated in Table 5, from where it is observed that a one percent increase in LNY and LNFFEC will increase LNLE insignificantly in the context of Bangladesh while the impact of environmental degradation, LNCE, on life expectance, LNLE, is statistically significant at less than 1% level and it is negative; implying that environmental degradation negatively affect the population health status in the short-run in Bangladesh. The error correction term is statistically significant and it is negative; implying the long-run convergence. The speed of convergence is low in this model, which is 4.2591 percent.

Table 5. Estimates of ARDL Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.147101	0.015131	9.721858	0.0000
@TREND	0.000784	8.35E-05	9.387670	0.0000
D(LNLE(-1))	1.255613	0.036539	34.36376	0.0000
D(LNLE(-2))	-0.493154	0.032566	-15.14322	0.0000
D(LNY)	-0.003880	0.002490	-1.558373	0.1328
D(LNY(-1))	0.006917	0.002766	2.500244	0.0200
D(LNFFEC)	-0.001635	0.001333	-1.226803	0.2323
D(LNFFEC(-1))	-0.002471	0.001313	-1.881680	0.0726
D(LNCE)	-0.003189	0.000790	-4.037984	0.0005
D(LNCE(-1))	0.005055	0.001191	4.244410	0.0003
D(LNCE(-2))	0.002975	0.000834	3.568744	0.0016
CointEq(-1)*	-0.042591	0.004459	-9.551270	0.0000

* p-value incompatible with t-Bounds distribution. Source: Software output

Table 6 represents the long-run elasticities. LNY is found statistically insignificant in the long-run too, which implies that current economic growth is not the significant contributor of increasing life expectancy in Bangladesh within this timeframe. The elasticity of FFEC is statistically insignificant at 5% level of significance, which also implies that in the long-run fossil fuels energy consumption is not the significant contributor of life expectancy in Bangladesh. The variable environmental degradation is statistically significant at less than one percent level of significance. The result reveals that a one percent increase in environmental degradation will deteriorate the life expectancy by 0.22 percent in the context of Bangladesh.

Table 6. Long-run elasticities

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNY	-0.069565	0.043243	-1.608707	0.1213
LNFFEC	0.091073	0.048440	1.880132	0.0728
LNCE	-0.219900	0.052616	-4.179330	0.0004

Source: Software output

Figure 2 illustrates the result of normality test, from where it is clear that the residuals are distributed normally (as the JB statistic is 0.743793 with a p-value of 0.74793).

Figure 2. Plot of Normality test result

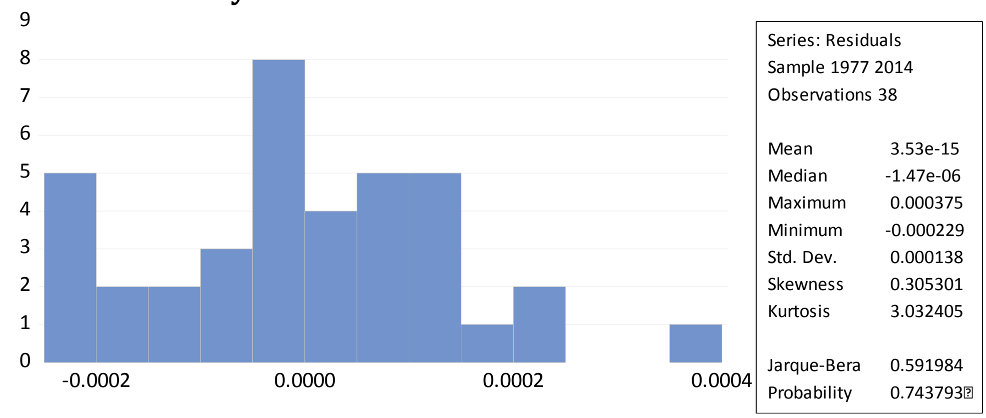


Table 7 include the results of various diagnostic test, from where it is clear that the residuals are not serially correlated (null hypothesis of "no serial correlation" is not rejected at 5% significance level), there is no heteroskedasticity problem (null hypothesis of homoscedasticity is not rejected at 5% significance level), and the model is correctly specified (null hypothesis of correct specification is not rejected at 5% significance level).

Figure 3 and Figure 4 illustrate the plot of CUSUM and plot of CUSUM of squares to check the structural stability of the estimated parameters. From the plot of CUSUM it is observed that a slight structural break exist around 2012, but the squares of CUSUM are within the bounds of 5% confidence level, so, we can conclude that the long-run parameters are structurally stable.

Table 7. Various diagnostic tests results

Test Name	F-statistic	p-value of F-statistic	Decision
Serial Correlation LM Test	2.880980	0.0784	No serial correlation
ARCH heteroskedasticity test	0.165829	0.6863	No heteroskedasticity
Ramsey RESET test	2.203652	0.1519	Model is correctly specified

Source: Software output

Figure 3. Plot of CUSUM

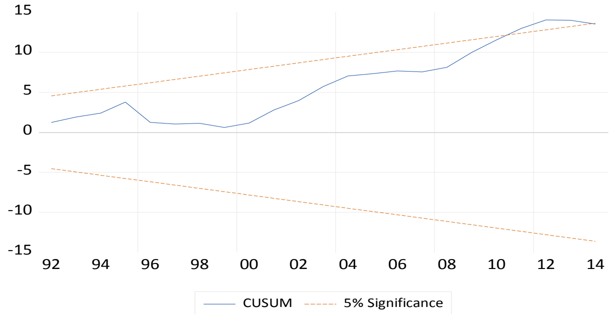
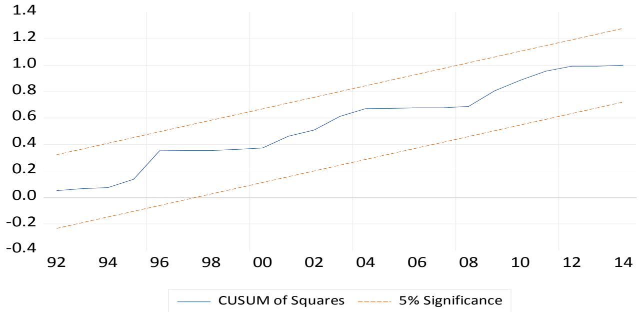


Figure 4. Plot of CUSUM of squares



Conclusions

Bangladesh is a developing country that experiences a good growth rate over the last decade. But, besides this good growth rate, environmental degradation in Bangladesh also increases significantly. Environmental pollutions are responsible for much premature death all over the world, besides many chronic health outcomes. In this context, to examine the impact of environmental degradation on life expectancy in Bangladesh, annual data of life expectancy at birth, real GDP per capita, fossil fuels energy consumptions per capita, and carbon dioxide emissions per capita have been collected from WDI for 1974 to 2014. The ADF test confirmed that neither of the series is I(2). The ARDL bounds test approach confirmed that the variables of this study are cointegrated. Various diagnostic tests confirm that there is no serial correlation and heteroskedasticity problem, data is normally distributed and the model is correctly specified. Empirical results reveal that environmental degradation has a detrimental impact on life expectancy in Bangladesh. So, policymakers have to aware of environmental pollutions to improving the population health status of Bangladesh. Environmental protection policy should be implemented with integrity. Exiting environmental law should be followed accurately, and regular monitor of environmental quality should be monitored by law enforcement authorities. Strict implemental of environmental law can prevent degradation and enhance our life expectancy.

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