URL: http://dx.doi.org/10.31703/ger.2021(VI-I).18 **DOI:** 10.31703/ger.2021(VI-I).18
p-ISSN: 2521-2974 **e-ISSN:** 2707-0093 **L-ISSN:** 2521-2974
Citation: Minhajuddin, Sumaira, & Gul, B. (2021). Economic Sustainability and CO_2 Emission in Pakistan: Revisiting the EKC Hypothesis. *Global Economics Review*, *VI*(I), 239-251. https://doi.org/10.31703/ger.2021(VI-I).18

Economic Sustainability and CO_2 Emission in Pakistan: Revisiting the EKC Hypothesis

Minhajuddin * Sumaira † Brekhana Gul ‡

Abstract *The public concern over the environmental degradation has received an increasing interest of the researchers in the last few decades. This paper intends to scrutinize the EKC hypothesis within the framework of the ARDL model over the period of 1976-2020. Along with ECM, different types of appropriate tests are also carried for the purpose of diagnosing the data and recognizing the pattern of causality. Findings reveal that growth in GDP per capita deteriorates the carbon emission at the initial stages of development but as economy grows it then helps in improving the quality of the environment. For environmental sustainability, the required level of growth threshold is calculated to be 4.61%. This study also finds one-way causality running from GDP and energy consumption to CO_2. Findings suggest that policymakers should concentrate on enhancing the consumption of renewable energies, implementing carbon-cutting policies in industries, and boosting the level of per capita income..*

Pages: 239 – 251

Vol. VI, **No.** I (Winter 2021)

Key Words:
Economic Sustainablity, CO_2 Emisison, Pakistan, EKC Hypothesis, ARDL Model, GDP

JEL Classification:

Introduction

The industrial revolution is considered the fundamental cause of economic growth worldwide. However, this revolution is also considered to be the main cause of reducing the quality of the environment (Dinda, 2004). In recent years, the public concern over the downfall of environmental quality has received an increasing interest of the researchers word-widely. Specifically, most of the researchers have utilized their efforts on analyzing the paradox of the pollution-income hypothesis. Conclusively, they are of the view that growth in GDP per capita (i.e. growth indicating variable) leads to deteriorating the quality of the environment at early stages of development but, in later stages, it helps in reducing the carbon emission and enhancing the quality of the environment. In literature, the phenomenon that links the growth indicating variables with the quality of the environment is known by *Environmental Kuznets Curve* (Grossman & Krueger, 1991; Dincer & Rosen, 1999).

* Assistant Professor, Department of Economics, Faculty of Business & Economics, Abdul Wali Khan University Mardan, KP, Pakistan, Email: minhaj_din@awkum.edu.pk
† Lecturer in Economics, Higher Education Department, KP, Pakistan.
‡ Lecturer, Department of Economics, Faculty of Business & Economics, Abdul Wali Khan University Mardan, KP, Pakistan.

Theoretically, it implies that at the initial stages of industrialization, people are more inclined towards job and income as compared to a clean environment and, hence, the huge cost is paid in the form of pollutant environment. However, when per capita income rises, people and government institutions become more reluctant about the quality of the environment by implementing appropriate policies for preserving a clean and friendly environment over the long run. The EKC phenomenon tells us about the growth-pollution nexus that can easily be shown in the form of a bell-shaped curve. Graphically, the EKC diagram can easily be drawn by plotting the environmental degradation indicators against the growth indicators. Figure 1 is the hypothetical sketch of this hypothesis.

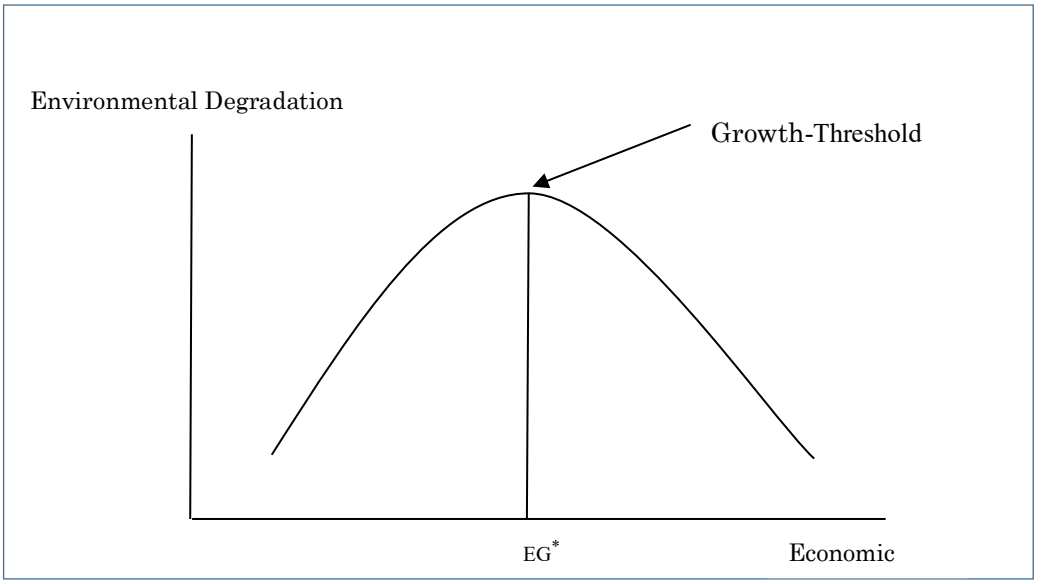


Figure 1: Environmental Kuznets Curve

Environmental amelioration is a sensitive and crucial issue that impedes socioeconomic progress globally. So it stands radical to analyze the validity of the EKC phenomenon for Pakistan, a developing economy that is surrounded by a number of rapidly growing economies like India and China. Several studies have been carried for this purpose; however, due to differences in their analytical frameworks and nature of the extracted data, these studies have ended with a mixture of results. Controversies in the findings of previous studies, abandonment of agricultural land, expansion of developmental projects, use of fossil fuels, and degradation of environmental quality are the reasons that enlarge the need that this area may be investigated yet further. In line with such studies, this paper also intends to analyze the EKC hypothesis by, *first*, examining the applicability of this hypothesis in Pakistan, *second*, estimating the level of growth-threshold which is necessary to be determined for the purpose of controlling the environmental amelioration, *third*, investigating the granger causality among the targeted variables and, *fourth*, recommending results-oriented policies and guidelines for effective policymaking.

The remaining study is arranged as follows. A review of the empirical and theoretical literature is composed in the

coming section. Analytical and theoretical frameworks are presented in section 3. The last two sections are about the data analysis, conclusions and policy implications.

Literature Review

While analyzing the relationship between income inequality and economic sustainability, Kuznets (1955) presented the concept of the Kuznets curve by arguing that the distance between growth and income inequality enlarges at the initial stages of development. However, this gap reduces as the economy hits the hallmark of growth. Grossman and Krueger (1991) replaced income inequality with pollutant indicators and argued that this relationship is like a bell-shape or inverted-U shape. Several researchers have tested the application of this hypothesis globally. Following is a brief summary of their findings.

Other Countries

Andreoni and Levinson (2001) examined the income-pollution nexus for US but failed to detect any linkage between the two. Harbaugh et al. (2002) analyzed the data of the world most air-polluted cities and found a weak relationship between the two. Jalil and Mahmud (2009) used the ARDL model for the investigation of this hypothesis. They succeeded in concluding the EKC phenomenon in China. They also highlighted that, in the long-run, consumption of energy and growth in income are the factors of CO_2 emission. This relationship was also confirmed by Narayan and Narayan (2010) and Apergis and Ozturk (2015).

Zaman et al. (2016) also confirmed this hypothesis for panel data of three diversified regions and concluded that the relationship between carbon emission and per capita income is strictly concave. Sugiawan and Managi (2016) deployed the ARDL model for estimating the relationship between these two variables in Indonesia and confirmed that the EKC hypothesis exists in this country. Naryan et al. (2016) analyzed this relationship for 181 countries worldwide but succeeded to detect it only in 49 countries. Ogundari et al. (2017) revisited this relationship by incorporating two proxies in their model as pollutant indicators and revealed that the EKC hypothesis is associated with the second proxy of pollutant indicator, i.e., the agriculture greenhouse gas emission indicator. Katircioglu et al. (2018) classified the population into two samples, the urban population sample and the urban-rural population sample, and found that the EKC hypothesis exists only in the sample drawn from the total population. Sample drawn from the urban population denied the validity of this hypothesis.

Churchill et al. (2018) deployed four different estimation techniques to pool data of 20 OECD member nations and validated the presence of this theory in these countries collectively. Individually, this hypothesis was found valid only in nine countries. Armeanu et al. (2018) used the OLS technique for analyzing the relationship between GDP and greenhouse gas emission in 28 Europe Union economies. They also confirmed the existence of the EKC hypothesis in these countries. Joshi and Beck (2018) divided the sample of 109-countries into 22-OECD and 87 non-OECD countries for the analysis of the same EKC relationship but failed to detect no such relationship in these countries. Lau et al. (2018) used the data of 100 developed and developing countries and concluded that EKC

prevails only in developed countries.

Zulfa and Resha (2020) classified the sample drawn from East Asian and

Southeast Asian countries into moderate-income groups and high-income groups to examine the non-linear relationship of FDI and trade-openness with CO_2 emission. They also found the existence of the EKC phenomenon in these countries. Dogan and Inglesi-Lotz (2020) incorporated the total development indicators in the EKC model and concluded that this variable has a bell-shaped link with CO_2 emission in the European nations. Adeel-Farooq et al. (2020) tried to validate the EKC theory between methane emission and economic sustainability in six ASEAN economies. They also came with the same results as given by most of the earlier researchers. In contrast, Beyene and Kotosz (2020) failed to detect this relationship in 12 East African economies. Similarly, Murshed, Haseeb, and Alam (2021) succeeded in verifying the EKC hypothesis in four (out of five) South Asian economies but failed to detect it in Pakistan. Arnaut and Lidman (2021) also failed to detect the presence of this hypothesis in Greenland.

Pakistan

In panel data analysis, we find few studies that have analyzed this relationship for Pakistan and have ended with a mixture of results (for example, Apergis & Ozturk, 2015; Murshed, Haseeb & Alam, 2021). That's why it seems important to present the summary of those studies which have specifically analyzed the validity of the EKC hypothesis for Pakistan.

Shahbaz et al. (2012) used the ARDL model and emphasized analyzing this linkage between growth and pollution. They concluded that this relationship is like a bell shape. Ahmed and Long (2012) also used the ARDL model and emphasized on the analysis of the EKC hypothesis. They succeeded in confirming its validity in Pakistan. Ahmed et al. (2015) analyzed this hypothesis and indicated an inverted-U shape relationship between growth and CO_2 emission. Trade and energy consumption were also found to be the causes of CO_2 emission. Danish et al. (2017) used renewable and non-renewable energies in their study and concluded that CO_2 emission is directly proportional to the non-renewable energies but indirectly to the renewable ones. Growth in GDP was found to exert upward pressure on pollutant indicators below the growth threshold. However, this pressure was found reducing beyond the threshold point. In contrast, Ali et al. (2017) tried to explore the presence of a trade-off between green revolution and pollution but failed to perceive any evidence of such linkages between these two.

Gokmenoglu and Taspinar (2018) tried to explore the pattern of correlation between agricultural products, economic sustainability, usage of energy, and pollutant indicators by applying the FMOLS and ARDL models. The findings of this study not only revealed the presence of EKC theory but also magnified the existence of two-way causality among these variables. The same kinds of results were also reported by Nazir et al. (2018). Khan and Ullah (2019) triggered to inspection the trade-off between globalization and carbon emission. They also found the presence of the same relationship between the two. In contrast, Mahmood et al. (2020) negated the notion of this hypothesis. Ali et al. (2021) also extended the support of EKC theory after finding a constructive link between growth and CO_2 emission. Last but not least, Khan (2021) incorporated the structural breakdowns in the EKC model and applied appropriate estimation techniques for the purpose of analyzing this non-linear relationship. He also

confirmed the existence of the bell-shape relationship and structural breakdowns in the model.

Methodology

This study incorporates the energy consumption, exports, inflows of FDI, industrial production and urbanization in the augmented growth-driven pollution model. The data period is from 1976 to 2020 and all data is extracted from a single source WDI (2021). Along with ECM, different types of appropriate tests are also carried for diagnosing the data and recognizing the pattern of causality.

Model Specification

This study is using the modified version of the models used by Murshed and Dao (2020), Khan (2021), and Ali et al. (2021). Help in determination of growth-threshold has been taken from Minhajuddin, Gul and Khan (2021). The ARDL Bound-test format of the proposed model will take the following shape.

$$\Delta CO_{2_t} = \delta_0 + \sum_{i=1}^{m} \delta_1 \Delta CO_{2_{t-1}} + \sum_{i=0}^{m} \delta_2 \Delta GDP_{t-1} + \sum_{i=0}^{m} \delta_3 \Delta GDP^2{}_{t-1} + \sum_{i=0}^{m} \delta_4 \Delta FDI_{t-1} + \sum_{i=0}^{m} \delta_5 \Delta EC_{t-1} + \sum_{i=0}^{m} \delta_6 \Delta EXP_{t-1} + \sum_{i=0}^{m} \delta_7 \Delta IND_{t-1} + \sum_{i=0}^{m} \delta_8 \Delta URB_{t-1} + \pi_1 EC_t + \pi_2 EXP_t + \pi_3 FDI_t + \pi_4 GDPpc_t + \pi_5 GDPpc^2{}_t + \pi_6 IND_t + \pi_7 URB_t + \omega_t \ldots\ldots\ldots\ldots (1)$$

Where:

CO_2 = Carbon emission (metric tons/capita)

GDP = GDP per capita (annual growth in %)

FDI = FDI (inflows in % of GDP)

EC = Energy Consumption (Kg of oil/capita)

EXP = Exports of G & S (% of GDP)

IND = Industrial Products (% of GDP)

URB = Urbanization (% of population)

ω_t = Error term (with zero mean & constant variance)

δ_1 - δ_8 = SR coefficients

π_1 - π_8 = LR coefficients

To determine the LR and SR estimates of this model, this study will use the following two models:

$$\Delta CO_{2_t} = \pi_0 + \sum_{i=1}^{m} \pi_1 \Delta CO_{2_{t-1}} + \sum_{i=0}^{m} \pi_2 \Delta GDP_{t-1} + \sum_{i=0}^{m} \pi_3 \Delta GDP^2{}_{t-1} + \sum_{i=0}^{m} \pi_4 \Delta FDI_{t-1} + \sum_{i=0}^{m} \pi_5 \Delta EC_{t-1} + \sum_{i=0}^{m} \pi_6 \Delta EXP_{t-1} + \sum_{i=0}^{m} \pi_7 \Delta IND_{t-1} + \sum_{i=0}^{m} \pi_8 \Delta URB_{t-1} + \rho_t \ldots \text{(LR-Model)}$$

With $\pi_2 > 0, and\ \pi_3 < 0$ (Conditions of threshold)

$$\Delta CO_{2_t} = \delta_0 + \sum_{i=1}^{m} \delta_1 \Delta CO_{2_{t-1}} + \sum_{i=0}^{m} \delta_2 \Delta GDP_{t-1} + \sum_{i=0}^{m} \delta_3 \Delta GDP^2{}_{t-1} + \sum_{i=0}^{m} \delta_4 \Delta FDI_{t-1} + \sum_{i=0}^{m} \delta_5 \Delta EC_{t-1} + \sum_{i=0}^{m} \delta_6 \Delta EXP_{t-1} + \sum_{i=0}^{m} \delta_7 \Delta IND_{t-1} + \sum_{i=0}^{m} \delta_8 \Delta URB_{t-1} + \xi ECM_{t-1} + \rho_t \ldots \quad \text{(SR-Model)}$$

After regressing the LR-Model, the optimal level of growth-threshold will be calculated by simply putting the resulted coefficients of GDP "i.e. π_2" and GDP² "i.e. π_3" in the following threshold formula:

$$Growth\ in\ GDP\ per\ Capita = \left\{ \frac{Value\ of\ \pi_2}{(2 * Value\ of\ \pi_3)} \right\} \ldots\ldots\ldots\ldots\ldots (2)$$

Regression Results

Table 1 indicates that data is stationary, whereas Table 2 signifies that data is cointegrated in the LR as the CV of F-statistics > LB/UB values.

Table 1. Stationarity Results

Var.	ADF Test		PP Test	
	t-Stat.	Decision	t-Stat.	Decision
CO_2	-5.61510*	$I_{(1)}$	-5.63614*	$I_{(1)}$
GDP	-5.94642*	-do-	-5.96461*	-do-
GDP^2	-6.13047*	-do-	-6.13214*	-do-
FDI	-7.24782*	-do-	-7.24483*	-do-
EC	-5.44810*	-do-	-5.20731*	-do-
EXP	-5.44810*	-do-	-5.46092*	-do-
IND	-2.99831*	$I_{(0)}$	2.63291***	$I_{(0)}$
URB	-3.64915*	-do-	-14.73510*	-do-

, & * indicate the level of significance*

Table 2. Cointegration Analysis

C/F-Stat.	6.2021	
	LB value	UB value
10 %	1.921	2.897
5 %	2.172	3.215
2.5 %	2.435	3.516
1 %	2.737	3.971

Table 3 summarizes the results of the LR-Model. Findings reveal that "π_2" and "π_3" have received their expected signs (i.e. $\pi_2 > 0$, $\pi_3 < 0$). Therefore, it is now easy to say that carbon emission is directly proportional to economic sustainability up to the threshold point, and as it crosses the threshold level, it converts to the indirect relationship. The signs of these coefficients validate the presence of the EKC phenomenon in Pakistan. Further, for calculating the growth-induced pollution-turning point, we are putting the values of "π_2" and "π_3" in equation 2. Mathematically:

$$Growth\ in\ GDP\ per\ Capita = \left\{\frac{0.10911}{(2 * 0.01183)}\right\}$$

$$Growth\ in\ GDP\ per\ Capita = \left\{\frac{0.06911}{0.02366}\right\}$$

$$Growth\ in\ GDP\ per\ Capita = 4.61\ \%$$

It implies that 4.61% is the required level of annual growth in GDP per capita for bringing a downward swing in environmental degradation.

Table 3. ARDL Results

Var.	Estimate	t-Stat.	Prob.
$(GDP)_t$	0.10911**	2.04472	0.04852
$(GDP^2)_t$	-0.01183*	-2.98032	0.00521
$(FDI)_t$	0.03887*	8.40395	0.00000
$(EC)_t$	0.82152*	21.92778	0.00000
$(EXP)_t$	0.11598*	9.01354	0.00000
$(IND)_t$	0.01875**	2.63171	0.01260

Var.	Estimate	t-Stat.	Prob.
$(URB)_t$	0.3731*	20.16231	0.00000
C	-0.0669	-2.01350	0.05184

** & ** indicate the levels of significance*

It is also clear from this table that an increase in inflows of FDI, increase in energy consumption, increase in exports, growth in industrial products, and growth in urban population is the root causes of carbon emission in Pakistan. One % growth in these variables is found to affect the carbon emission by 0.03%, 0.82%, 0.11%, 0.01% and 0.37% respectively. The impact of energy consumption and urbanization was found more deteriorating towards carbon emission in Pakistan. Table 4 summarizes the short-term estimates of the error correction model.

Table 4. Results of the SR-Model

Var.	Estimates	t-Stat.	Prob.
Δ(GDP)	-1.1853***	-1.91810	0.06333
$\Delta(GDP^2_t)$	0.10662**	2.06521	0.04641
Δ(FDIC)	0.03741*	4.48971	0.00010
$\Delta(EC_t)$	-0.16310	-0.67040	0.50701
$\Delta(EXP_t)$	0.10031**	2.14682	0.03881
Δ(IND)	-0.28470	-0.33021	0.74321
$\Delta(URB_t)$	0.37312*	3.08851	0.0039
$\Delta(ECM_t)$	-0.51662*	-5.96312	0.00000

, ** & * indicate the levels of significance*

In this table, we see that value of the "ECM < 0" and significant, which means that SR-Model is convergent to the LR-Equilibrium and that speed of adjustment is 51.6%.

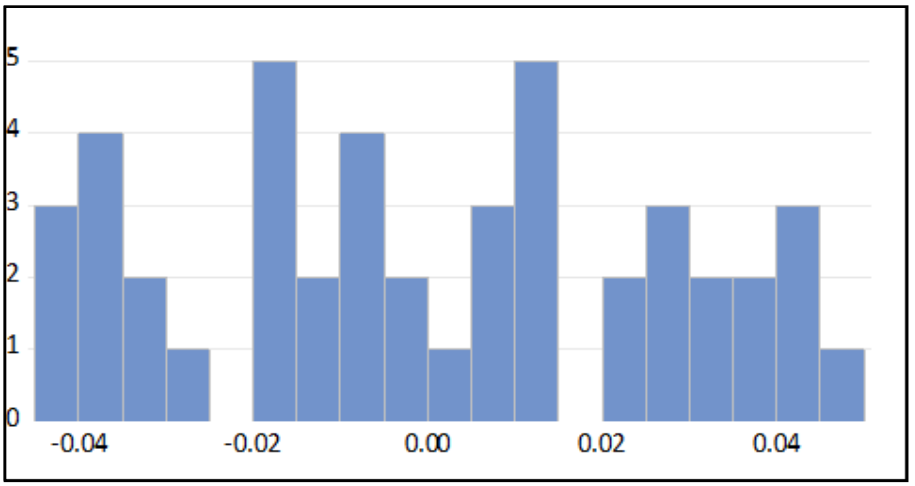
Diagnostic Tests

Table 5 and Figure 2 have summarized the detailed estimates of these tests.

Table 5. Summary of the Diagnostic Tests

Tests	H_0	t-statistics	F-statistics	Outcome
BG (Prob.)	No serial correlation	--------	2.1048 (0.15601)	Can't reject H_0
BPG (Prob.)	Homoscedasticity	--------	0.00132 (0.90791)	Can't reject H_0
Ramsey Test (Prob.)	No issue of Specification Error	0.02987 (0.97641)	0.0009 (0.97641)	Can't reject H_0

Tests	H_0	t-statistics	F-statistics	Outcome
Jarque-Bera (Prob.)	Residual is not distributed normally	2.354787 (0.308081)	--------	Reject H_0



Graph 2: Normality Test

Causality Tests

Results comprised on the pattern of causality are summarized in Table 6. The left-side column of this table portrays one-way causality among the identified variables of the model, whereas the right-side column of the table represents the two-way causality among the variables listed in this column.

Table 6. Estimates of the Granger Causality Test

Unidirectional Causality			Bi-directional Causality		
H_0	F-Statistic	Prob.	H_0	F-Statistic	Prob.
EXP ≠> CO_2	3.1808***	0.05251	URB ≠> CO_2	3.5118**	0.03961
CO_2 ≠> EC	6.3758*	0.00400	CO_2 ≠> URB	2.4126***	0.01280
CO_2 ≠> FDI	2.5391***	0.09191	URB ≠> EXP	3.9206***	0.05431
GDP ≠> CO_2	3.0411**	0.04130	EXP ≠> URB	7.8196*	0.00780
EC ≠> EXP	3.0695***	0.05781	URB ≠> FDI	5.7476**	0.02101
EXP ≠> FDI	5.3709*	0.00871	FDI ≠> URB	8.8650*	0.00481
EXP ≠> IND	3.4399**	0.04210	URB ≠> GDP	4.0253**	0.02570
IND ≠> FDI	3.6750***	0.06210	GDP ≠> URB	2.4459***	0.09981

Unidirectional Causality			Bi-directional Causality		
H_0	**F-Statistic**	**Prob.**	**H_0**	**F-Statistic**	**Prob.**
IND ≠> CO_2	3.1907**	0.03510	URB ≠> IND	3.8541**	0.02972
			IND ≠> URB	3.0526***	0.05870
			EC ≠> FDI	2.7829***	0.07422
			FDI ≠> EC	2.5161***	0.09381

*, ** & *** *Specify the Level of Significance*

Conclusion and Policy Recommendations

The industrial revolution is deemed as a crucial factor that reduces the quality of the environment. The public concern over the downfall of this quality has received an increasing interest of the researchers word-widely. The basic purpose of this research is to examine the applicability of *the Environmental Kuznets Curve* (EKC) in Pakistan. This study has tested the validity of this hypothesis within the framework of the ARDL bound test to cointegration. Along with ECM, appropriate diagnostic tests and normality tests were also conducted in this study. The Granger causality test is used to investigate the pattern of causality among the variables of the proposed model. Findings validated the presence of the EKC hypothesis and concluded that growth in per capita income deteriorates the carbon emission at the initial stages of development but, as the economy grows, it helps in improving the quality of the environment. An increase in inflows of FDI, increase in energy consumption, increase in exports, growth in industrial products, and urban population was also found to be the root causes of carbon emission in Pakistan. The growth threshold value implied that the required level of annual growth in GDP per capita is 4.61% which is necessary to be maintained for reducing environmental degradation. This study also found a number of one-way causality among a group of variable (Table 6). Two-way causality was also reported in this study. Importantly, the pattern of causality between GDP and carbon emission was unidirectional, running from GDP to carbon emission. Based on the research findings, this study recommends that government should work on enhancing the growth in GDP per capita, reducing the carbon emission in industries and urban areas, and should work for enhancing the inflows of FDI that is friendly to the environment.

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