Journal of Business Economics
ISSN 2682- 6933 | E-ISSN 2705-9944
2021 Volume 03 Issue 01:117-130

ANALYZING THE IMPACT OF CARBON DIOXIDE EMISSION ON ECONOMIC GROWTH, ENERGY CONSUMPTION AND POPULATION GROWTH FOR SAARC COUNTRIES USING ARDL BOUND TEST APPROACH

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Abstract

This research study examines the impact of economic growth, energy consumption and population growth on Carbon Dioxide Emission (CDE) as an indicator of environmental degradation by using an annual time series data from 1971 to 2018 for SAARC countries: Sri Lanka, India, Bangladesh, Pakistan and Nepal. Autoregressive Distributed Lag (ARDL) bounds test approach was used to employ both linear and non-linear relationships between variables. The test results revealed that CDE has increased significantly with increases in economic growth in Nepal and Pakistan, whereas it decreased insignificantly in Sri Lanka and Bangladesh. In the case of India, CDE decreased but it is not statistically significant. Also, in the case of energy consumption had a positive significant impact on CDE in Sri Lanka, Bangladesh, India and Pakistan but Nepal had positive impact on CDE whereas it was not statistical significance. Furthermore, CDE has increased significantly with population growth only in Pakistan. But, Bangladesh, Indian and Nepal have positively insignificant impact on CDE. In the case of Sri Lanka, CDE have decreased insignificantly with increases in population growth. Test results from the Environmental Kuznets Curve hypothesis implied that in the case of India and Pakistan, CDE will decrease over time with economic growth indicating that these two countries should not make immediate corrective actions and policies against CDE but in the case of Sri Lanka, Bangladesh and Nepal CDE increase over time with economic growth. So, these three countries should take immediate corrective actions and policies against CDE.

Keywords: Carbon Dioxide Emissions, Environmental Kuznets Curve, ARDL Model, VEC Models, SAARC Countries, Sri Lanka, India, Pakistan, Bangladesh, Nepal

1.0 Introduction

The environmental depletion can be assessed through the quality of water, air or land basically. In most of the research studies salinity of water, pH of the water, Biological Oxygen Demand (BOD) have used as the quality of water and pH of the soil, ion content of the soil, microbial content of the soil have used as the quality of soil. Also, greenhouse gas concentration in the atmosphere, ozone depletion have used as the quality of the air. In this research study, the quality of the air was used as an indicator of environmental depletion by using carbon dioxide emission to the atmosphere.

In recent years one of the nagging problem of facing adverse global climate change as a result of environmental degradation all over the world because of manmade causes. There are several environmental degradation indexes including mainly carbon dioxide emission. Global warming is caused by the emission of greenhouse gases 72% of the emitted greenhouse gas is carbon dioxide, 18% methane and 9% of nitrous oxide.

There are several other factors cause to carbon dioxide emission and mainly this research study we focused on the energy consumption, population growth and energy consumption. With industrial development, energy-production that is mainly based on fossil fuels has led to a rapid increase in greenhouse gas emissions, which leads to global warming.

The objective of this research study is that SAARC countries are developing economy but in recent years, those country's economy is shifting to an industrial economy from agricultural economy. So, the environmental degradation is also increasing with developing of the economy. In pre-industrialization periods, environmental degradation is minimum but with industrialization environmental degradation is increased. It is measured through the emission of a greenhouse gas called carbon dioxide as an index of environmental degradation with mainly economic growth. In literature and past research study indicate that carbon dioxide emission depends on energy consumption and population growth. Furthermore, there are several other factors that caused to carbon dioxide emission among them energy consumption, population growth and economic growth. Hence, in this research paper we analyze the impact of economic growth, energy consumption and population growth on carbon dioxide emission for SAARC countries Sri Lanka, India, Pakistan, Bangladesh and Nepal using ARDL bound test approach.

Energy is an important basic input used in the production process and it is used as widely as capital and labour. As a shortfall in energy supply affects economic growth, energy consumption in the process of production is considered as a precondition of sustainable economic development.

Population growth has a greater impact on carbon emission. A study conducted in 2009 by center for biological diversity that the association among population growth and global warming determined that the "Carbon Legacy" of just one child can produce 20 times more greenhouse gas than a person will save by driving a high-mileage car, recycling, using energy-efficient appliances and light bulbs, etc.

The association between economic development and environmental quality have a very close connection. According to the data from the World Bank database, one can observe the positive correlation between GDP per capita and carbon dioxide emission as a country's GDP per capita increases. Human activity which often leads to increase GDP such as good products and services frequently produces carbon emissions.

There is a well-known theory called the Environmental Kuznets Curve (EKC) hypothesis developed by Kuznets (1955) to represent the relationship between environmental degradation and economic growth. It is used to graph the idea that as an economy develops market forces begin to increase and economic inequality decreases. It is important that as the economy grows initially the environment suffers but eventually, the association between the environment and the society improves.

The EKC adheres to the same idea of the hypothesized relationship between quality and development. When the economy of a country is in primarily pre-industrial, the environment is normally clean and untouched by pollutants from industrial activities. When the economy of a country moves towards development and industrialization, the environment is at a higher risk of harmed pollution and degradation of natural resources.

This study is important that an economically rich country is not valuable with less environmental quality because all living being depends on the environment. Most of the countries in the world are shifting to the industrialized economy instead of the agricultural economy with a huge development of technology and innovations. Therefore, environmental degradation is becoming a critical factor with this conversion. This paper is composed into five sections. Section two illustrates literature review, in section three study methodology is given. Results are discussions are comprehensively explained in section four. In section five conclusion is given.

2.0 Literature Review

Environmental Kuznets Curve (EKC) hypothesis is used to analyze the relationship between economic growth and environment degeneration. The EKC hypothesis illustrates that the environmental degeneration rises at the first stage with increasing economic growth and then turns to decline at the last stage after reaching at a threshold level given high level of income. That is, EKC hypothesis shows economic growth brings welfare for the environment in the long term. The hypothesis has been tested in recently in both single country and cross-country studies considering its policy implication for solving environmental degeneration issue, keeping economic growth sustainable by Dinda (2004). But, empirical evidence from the environmental degeneration-growth nexus did not reach at any conclusive consensus.

Baek and Kim (2013), Kanjilal and Ghosh (2013), Sephton and Mann (2013), Saboori et al. (2012), and Xuemei et al. (2012) analysed one group of studies and they found nonlinear inverted U-shaped relationship in both long run and short run between carbon dioxide emissions and economic growth and supported EKC hypothesis. But other group of studies analysed by Nasir and Ur-Rehman (2011) and Shahbaz et al. (2012) found evidence of EKC hypothesis in long run, and not in short run. Instead, Arouri et al. (2012) and Fodha and zaghdoud (2010) found that the relationship between carbon dioxide emissions and economic growth is linear.

The contradictory evidence from EKC hypothesis is found in both single country and cross-country studies. Single country studies analysed by He and Richard (2010) for Canada, Kanjilal and Ghosh (2013) for India, Saboori et al. (2012) for Malaysia, Nasir and Ur Rahman (2011) for Pakistan, Esteve and Tamarit (2012a) for Spain and Baek and Kim (2013) for Korea identified that the evidence of EKC hypothesis in between carbon emissions and economic growth. Whereas Al-Mulali et al. (2015b) for Vietnam, Akbostanci et al. (2009) for Turkey, Ozturk and Al-Mulali (2015) for Cambodia, did not identify the existence of EKC hypothesis in between economic growth and environmental degeneration.

Cross sectional country analyse, Narayana and Narayanan (2010) analysed EKC hypothesis for 43 developing countries and they identified the support of the hypothesis. 14 Asian countries analysed by Apergis and Ozturk (2015) and confirmed EKC hypothesis. Whereas Arouri et al. (2012) for 12 Middle East countries and North African countries, Ben Jebli et al. (2016) for 25 OECD countries, Musolesi et al. (2010) for 106 developed and developing countries and Jaunky (2011) for 36 high income countries did also not identify any evidence supporting the EKC hypothesis.

3.0 Methodology

3.1. Data and variables

This research study investigates the impact of carbon dioxide emission on population growth, energy consumption and economic growth employing an annual time series data from 1971 to 2018 for SAARC countries

including Sri Lanka, India, Bangladesh, Pakistan and Nepal. The data are collected from the World Development Indicator (WDI)-2019.
The variables included for this research study are carbon dioxide emission (CO_2) in metric tons per capita as dependent variable as well as the independent variables are GDP per capita (constant at 2010), population growth (POP_GRO) in annual % and energy consumption (ENEC) per capita in Kg of oil equivalent.

In this research study two types of models are used according to the research study of Mahmudul Alam, et al. (2016) which are given in equation (1) and (2).

To assess the relationship between underlying variables that the linear model is used as:

$$CO_2 = f(GDP, ENEC, POP\_GRO).$$

Then, regression form as follows:

$$ln(CO_2) = \beta_0 + \beta_1 ln(GDP) + \beta_2 \ln(ENEC) + \beta_3 POP\_GRO + \epsilon_t. \quad (1)$$

To check the EKC hypothesis the effect of economic growth on carbon dioxide emission (as an indicator of environmental degradation) was re-estimated as quadratic model by considering GDP square as follows and it was proposed by Ahmed et al. (2016), Begum et al. (2015), Al-Mulali et al. (2015) and Mahmudul Alam, et al. (2016). Hence, the second linear model as follows:

$$CO_2 = f(GDP, GDPS, ENEC, POP\_GRO).$$

Then, regression form as follows:

$$ln(CO_2) = \beta_0 + \beta_1 \ln(GDP) + \beta_2 \ln(GDP^2) + \beta_3 \ln(ENEC) + \beta_4 POP_{GRO} + u_t. \quad (2)$$

To check the validity of the EKC theory requires coefficient β_1 should be positive and statistically significant whereas β_2 should be negative and statistically significant in equation (2) to satisfy the inverted U-shaped EKC hypothesis between environmental degradation and economic growth. The EKC hypothesis argues that the initial phase of economic growth has negative consequences to the environment, but the negative consequences reduce as the growth rate exceeds a certain point.

The standard co-integration techniques used in time series analysis are Engle and Granger (1987) and Johansen and Juselius (1990). Engle and Granger co-integration method is a bi-variate technique so multivariate analysis approach is violated under this technique. Another important thing is that of estimating the long-run equilibrium relationship using Ordinary Least Squares (OLS) approach without making the variables stationary. Johansen method is known as a system-based approach which is more efficient than Engle and Granger approach because it provides multiple co-integration vectors. Both Engle and Granger, and Johansen techniques have been failed on the basis of the validity of the presence of the mix order of integration in the regression. Therefore, the ARDL approach is used instead of above two methods to check the co-integration relationship.

ARDL technique developed by Pesaran et al. (2001) in order to assess the long-run relationships. There are some important characteristics of this method including, (i) co-integration relationship estimated by using Ordinary Least Squared (OLS), and this estimation was done after choosing the appropriate lag order of the model used. (ii) unlike Engle and Granger, and Johansen methods, this method remains statistically significant irrespective of the nature of the variables either being I(1) or I(0) or combination of both. (iii) the test is validated for small and finite data size but it is not validated if an I(2) series.

But, the following Khan et al. (2005) and Fosu and Magnus (2006) the ARDL version of the vector error correction models (VECM) can be developed as:
The linear model:

$$\ln(CO_2) = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \ln(CO_2)_{t-i} + \sum_{i=0}^{q} \beta_{2i} \ln(GDP) + \sum_{i=0}^{q} \beta_{3i} \ln(ENEC) + \sum_{i=0}^{q} \beta_{4i} (POP\_GRO) + \epsilon_t. \quad (3)$$

The quadratic model:

$$\ln(CO_2) = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \, ln(CO_2)_{t-i} + \sum_{i=0}^{q} \beta_{2i} \ln(GDP) + \sum_{i=0}^{q} \beta_{3i} \ln(GDP^2) + \sum_{i=0}^{q} \beta_{4i} \ln(ENEC) + \sum_{i=0}^{q} \beta_{5i} (POP\_GRO) + \epsilon_t. \quad (4)$$

In this process, the Schwarz Information Criterion (SIC) was used to select the appropriate lag length of the ARDL model for all respective variables under study. Then, after establishing the long-run model of ARDL that bound test was utilized to check the long-run relationship between dependent and independent variables by considering linear and quadratic models.

In the next step, if there was a co-integration relationship between dependent and independent variables, error correction models (ECM) were estimated to evaluate short-run dynamics employing the linear and quadratic relationships as follows:

The linear model:

$$\Delta\ln(CO_2) = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta\ln(CO_2)_{t-i} + \sum_{i=1}^{q} \beta_{2i} \Delta \ln(ENEC)_{t-i} + \sum_{i=1}^{q} \beta_{3i} \Delta \ln(GDP)_{t-i} + \sum_{i=1}^{q} \beta_{4i} \Delta(POP\_GRO)_{t-i} + \delta ECM_{t-1} + \epsilon_t. \quad (5)$$

The quadratic model:

$$\Delta\ln(CO_2) = \beta_0 + \sum_{i=1}^{p} \beta_{1i} \Delta ln(CO_2)_{t-i} + \sum_{i=1}^{q} \beta_{2i} \Delta\ln(ENEC)_{t-i} + \sum_{i=1}^{q} \beta_{3i} \Delta\ln(GDP)_{t-i} + \sum_{i=1}^{q} \beta_{4i} \Delta ln(GDP^2)_{t-i} + \sum_{i=1}^{q} \beta_{5i} \Delta(POP\_GRO)_{t-i} + \delta ECM_{t-1} + \epsilon_t. \quad (6)$$

Then the coefficient of ECM was considered to show how much short-term unbalance will be eliminated in the long term where the coefficient of error term should be negative and statistically significant.

In model outputs, R^2, adjusted R^2, probability of F-statistics, SIC, Akaike Information Criterion (AIC) measurements were considered to model evaluation and comparison between constructed linear and quadratic models to select the best model for underlying variables. AIC and SIC values were used to compare the linear and quadratic models which was the best one for these relationships.

Also, residual analysis are used to check the validity of the constructed models. Normality of residuals by Jarque-Bera test, serial correlation of residuals by Breusch-Godfrey serial correlation LM test, Heteroscedasticity of residuals by Breusch-Godfrey Heteroscedasticity test were carried out for this purpose. In order to check the stability of the constructed model, CUSUM and CUSUM of square tests were used. In both CUSUM and CUSUM square test if the graph lies between the ranges of the 5% significance level boundaries that it is concluded, the model has good stability under 5% error rate and vice versa.

4.0 Results and Discussion

4.1 Descriptive Statistics Analysis

Descriptive statistics analysis results are given in Table 1. From these results, it can be said that India was the highest carbon dioxide emitted country on annual average of 0.899699 metric tons per capita among other countries and followed by Pakistan, Sri Lanka, Bangladesh on an annual average of 0.656781, 0.448490, 0.223961 metric tons per capita respectively and Nepal was the lowest carbon dioxide emitted country on an annual average of 0.100948 metric tons per capita among other countries.

Whereas, in terms of the pattern of population growth Pakistan was the highest on annual average 2.697314% followed by Bangladesh, India, Nepal and Sri Lanka on annual average 1.918967%, 1.855181 %, 1.760899% and 1.148628% respectively.

Besides, Pakistan was the highest energy consumed country on an annual average 5.987306 Kg of oil equivalent followed by India on an annual average 5.966581 Kg of oil equivalent, Sri Lanka on an annual average 5.936602 Kg of oil equivalent, Nepal on an annual average 5.804624 Kg of oil equivalent as well as Bangladesh was the lowest energy consumer among selected SAARC countries on an average 4.932957 Kg of oil equivalent.

Sri Lanka had the highest economic growth with an annual average of 7.328924 % GDP per capita followed by Pakistan an annual average of 6.623456 % GDP per capita, India an annual average of 6.597200 % GDP per capita, Bangladesh an annual average of 6.234870 % GDP per capita as well as Nepal had the lowest GDP with an annual average of 6.021565 % GDP per capita per capita for the considered period.

Table 1: Descriptive Statistics of the variables

	VARIABLE	OBS	MEAN	STD.DEV	MIN	MAX
Sri Lanka	CO2	48	0.448490	0.243024	0.200191	1.011938
	POP_GRO	48	1.148628	0.479365	0.128994	2.077316
	ln(ENEC)	48	5.936602	0.229828	5.651601	6.394381
	ln(GDP)	48	7.328924	0.533250	6.536190	8.278035
Bangladesh	CO2	48	0.223961	0.148494	0.049252	0.566778
	POP_GRO	48	1.918967	0.579807	1.050045	2.718203
	ln(ENEC)	48	4.932957	0.308515	4.463206	5.492140
	ln(GDP)	48	6.234870	0.368551	5.775590	7.004171
India	CO2	48	0.899699	0.448805	0.362530	1.837950
	POP_GRO	48	1.855181	0.430034	1.037323	2.331908
	ln(ENEC)	48	5.966581	5.588404	5.588404	6.514676
	ln(GDP)	48	6.597200	0.522629	5.944215	7.651673
Nepal	CO2	48	0.100948	0.077964	0.016068	0.268463
	POP_GRO	48	1.760899	0.797393	-0.190908	2.729223
	ln(ENEC)	48	5.804624	0.118768	5.693050	6.062504
	ln(GDP)	48	6.021565	0.329835	5.601923	6.699791
Pakistan	CO2	48	0.656781	0.216145	0.308381	0.978207
	POP_GRO	48	2.697314	0.421993	2.055880	3.363941
	ln(ENEC)	48	5.987306	0.183123	5.652401	6.215472
	ln(GDP)	48	6.623456	0.279340	6.116923	7.087235

Note: CO2 stands for annual carbon dioxide emission in metric tons per capita, POP_GRO stands for annual population growth in percentage, ln(ENEC) stands for natural logarithm of annual energy consumption in Kg of oil equivalent, ln(GDP) represent for natural logarithm of annual GDP in current US $ constant at 2010, OBS stands for number of observations, MEAN indicate the annual mean values of the variables and STD.DEV, MIN and MAX represent standard deviation, minimum and maximum values of the variables respectively.

4.2 Stationary Test of Study Variables

Stationary test of the variables are tested by Augmented Dickey-Fuller (ADF) test. Test results are given in Table 2, from these results, it can be said that in the case of Sri Lanka, Bangladesh, India, Nepal and Pakistan, variables of carbon dioxide emissions, energy consumption and GDP are not stationary at level, whereas variable population growth of India is stationary at level. However, all first difference variables are stationary at 5% significance level. Hence, first difference of the variables are used for the model building purpose.

Table 2: Unit root test results at level (Intercept) and first difference

ADF test	At Level (Intercept)					At First Difference				
	Sri Lanka	Bangladesh	India	Nepal	Pakistan	Sri Lanka	Bangladesh	India	Nepal	Pakistan
ln(CO2)	0.2351	-0.2682	-2.3708	-3.3671	-0.5110	-6.9474	-6.3812	-7.1935	-6.6168	-10.056
	(0.972)	(0.921	(0.389)	(0.068)	(0.880)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln(ENEC)	0.6211	1.0185	-1.5615	-1.3255	-1.8981	-6.6244	-8.6621	-3.6088	-4.2164	-5.9137
	(0.989)	(0.996)	(0.793)	(0.869)	(0.330)	(0.000)	(0.000)	(0.041)	(0.009)	(0.000)
ln(GDP)	2.0738	2.7991	-1.5667	-0.5981	-1.1608	-5.999	-5.4359	-8.6504	-8.2999	-5.5889
	(0.999)	(1.000)	(0.791)	(0.974)	(0.683)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
POP_GRO	-1.9885	-1.0997	-3.8606	-2.3620	-0.6510	-7.5831	-3.6421	-1.7286	-1.5688	-3.5885
	(0.291)	(0.706)	(0.023)	(0.159)	(0.848)	(0.000)	(0.008)	(0.004)	(0.005)	(0.000)

4.3 Analysis of co-integration

The ARDL bond test results summarized for linear model and given in Table 3. If the F-statistics value greater than the upper bound which indicates that the rejection of null hypothesis expressing that there is co-integration relationship and F-statistics value less than the lower bound indicates there is no co-integration, as well as the F-statistics value lies between lower and upper bounds that the test is inconclusive. From the Table 3 results it can be concluded that except India other countries were co-integrated.

Table 3: Co-integration test output for linear relationship

Country	Equation	F-statistic	Critical Values		Outcome
			I(0)	I(1)	
Sri Lanka	f(ln(CO_2)|ln(ENEC),ln(GDP), POP_GRO)	4.328656	2.79	3.67	co-integrated
Bangladesh	f(ln(CO_2)| ln(ENEC),ln(GDP), POP_GRO)	4.530944	2.79	3.67	co-integrated
India	f(ln(CO_2)| ln(ENEC),ln(GDP), POP_GRO)	2.178171	2.79	3.67	not-cointegrated
Nepal	f(ln(CO_2)| ln(ENEC),ln(GDP), POP_GRO)	4.859516	2.79	3.67	co-integrated

Pakistan	$f(\ln(CO_2)\mid \ln(ENEC),\ln(GDP), POP\_GRO)$	50.43588	2.79	3.67	co-integrated

Note: Critical values belong to 5% significance level and I(0) and I(1) stand for lower and upper bounds.

For the quadratic model ARDL bond test results summarized and given in Table 4. From these results it can be said that all countries were co-integrated.

Table 4: Co-integration test output for quadratic relationship

Country	Equation	F-statistic	Critical Values		Outcome
			I(0)	I(1)	
Sri Lanka	$f(\ln(CO_2)\mid\ln(ENEC),\ln(GDP),\ln(GDP^2),POP\_GRO)$	3.550955	2.56	3.49	co-integrated
Bangladesh	$f(\ln(CO_2)\mid\ln(ENEC),\ln(GDP),\ln(GDP^2),POP\_GRO)$	3.662458	2.56	3.49	co-integrated
India	$f(\ln(CO_2)\mid\ln(ENEC),\ln(GDP),\ln(GDP^2),POP\_GRO)$	3.668032	2.56	3.49	co-integrated
Nepal	$f(\ln(CO_2)\mid\ln(ENEC),\ln(GDP),\ln(GDP^2),POP\_GRO)$	5.832530	2.56	3.49	co-integrated
Pakistan	$f(\ln(CO_2)\mid\ln(ENEC),\ln(GDP),\ln(GDP^2),POP\_GRO)$	46.91200	2.56	3.49	co-integrated

4.4 Analysis of long-run scenario

The long-run test results are given in Table 5. According to the test results in the linear model, GDP has a positive and statistically significant impact on carbon dioxide emissions in the case of Nepal and Pakistan whereas GDP is positive but not statistically significant in India. In the case of Sri Lanka and Bangladesh, there was negative and statistically non-significant impact of GDP on carbon dioxide emissions. Considering the presence of EKC hypothesis for GDP and carbon dioxide emissions, the quadratic model shows there was a positive and statistically significant impact on carbon dioxide emissions in India and Pakistan.

Variable energy consumption shows a statistically significant impact on carbon dioxide emissions in Sri Lanka, Bangladesh, India and Pakistan but not significant relationship was found in Nepal in both linear and quadratic model.

There was a positive and statistically significant impact of population growth on carbon dioxide emissions only in Pakistan for linear model whereas it is negative and insignificant in quadratic model.
Further, in the quadratic model the coefficients of variable ln(GDP) is positive and statistically significant and coefficient of variable $\ln(GDP^2)$ is negative and statistically significant were found for countries India and Pakistan. So, inverted U-shaped relationship between economic growth and carbon dioxide emissions was found in the countries India and Pakistan compare with other five selected SAARC countries for this study.

Table 5: Estimated long-run coefficients using ARDL approach

Model	Variable	Sri Lanka	Bangladesh	India	Nepal	Pakistan
Linear Model	ln(GDP)	-0.038441 (0.7320)	-0.002265 (0.9928)	0.027501 (0.7552)	1.270525 (0.0131)	0.465715 (0.0000)
	ln(ENEC)	0.993402 (0.0093)	1.215260 (0.0000)	1.301763 (0.0000)	2.218792 (0.1275)	1.118949 (0.0000)

	POP_GRO	-0.064763	0.002265	0.085048	0.229463	0.037909
		(0.1616)	(0.9376)	(0.3598)	(0.5797)	(0.0045)
	c	-5.931679	-1.022522	-1.240650	-22.63577	-10.30106
		(0.0027)	(0.4355)	(0.2619)	(0.0062)	(0.0000)
Quadratic	ln(GDP)	-0.568678	-0.102776	5.126135	-4.112825	3.575858
Model		(0.7160)	(0.9503)	(0.0176)	(0.5598)	(0.0138)
	$\ln(GDP^2)$	0.035639	0.007545	-0.408060	0.530819	-0.229045
		(0.7337)	(0.9507)	(0.0168)	(0.3871)	(0.0302)
	ln(ENEC)	0.964949	1.217094	1.747241	2.020119	0.949506
		(0.0143)	(0.0000)	(0.0000)	(0.1770)	(0.0000)
	POP_GRO	-0.088425	0.001277	0.017453	0.181471	-0.009995
		(0.2927)	(0.9695)	(0.8570)	(0.6558)	(0.6856)
	c	-3.776483	-0.621027	-12.22863	-9.493739	-19.70843
		(0.5684)	(0.9254)	(0.0024)	(0.7049)	(0.0000)

4.5 Analysis of short-run scenario

The analysis of short-run test results is summarized and given in Table 6. The test results from this table, it can be said that in both linear and quadratic models the coefficients of the error correction term was negative and statistically significant for Sri Lanka, Bangladesh, Nepal and Pakistan but the coefficient of error correction term was negative and statistically significant only in quadratic model for India because it had not co-integration relationship in linear model.

The coefficients of error correction term were found to be -0.43092 and -0.433866 for Sri Lanka which indicate that the adjustment takes place 43.092% and 43.3866% per year towards the long-run relationship in the linear and quadratic model respectively.

In the case of Bangladesh, the coefficients of error correction term were found to be -0.103353 and -0.096642 which indicate that the adjustment takes place 10.3353% and 9.6642% per year towards long-run relationship in linear and quadratic models respectively.

The coefficient of error correction term was found to be -0.433962 for India which indicate that the adjustment takes place 43.3962% per year towards the long-run relationship in the quadratic model.In the case of Nepal, the coefficients of error correction term were found to be -0.603498 and -0.860182 which indicate that the adjustment takes place 60.3498% and 86.0182% per year towards long-run relationship in linear and quadratic models respectively.

Finally, the coefficients of error correction term were found to be -0.858436 and -0.892209 for Pakistan which indicate that the adjustment takes place 85.8436% and 89.2209% per year towards the long-run relationship in the linear and quadratic model respectively.

Table 6: Coefficients of Error Correction Model

Model		Sri Lanka	Bangladesh	India	Nepal	Pakistan
Linear Model	ECM(-1)	-0.430920	-0.103353		-0.603498	-0.858436
		(0.0009)	(0.0000)		(0.0020)	(0.0000)

Quadratic Model	ECM(-1)	-0.433866 (0.0001)	-0.096642 (0.0000)	-0.433962 (0.0000)	-0.860182 (0.0062)	-0.892209 (0.0088)

Note: ECM represents the error correction term. Probability values are in the parenthesis and 5% significance value is used.

4.6 Diagnostic Tests

According to the test results in Table 7, in the case of Sri Lanka, R^2 and adjusted R^2 were approximately 97% in both linear and quadratic models which indicate models have a good fit on data. Also, there was no serial correlation and heteroscedasticity problems in residuals of the models, as well as AIC and SIC values were greater in the linear model than the quadratic model.

For the country Bangladesh R^2 and adjusted R^2 were approximately 99% in both linear and quadratic models which indicate models have a good fit on data. Also, there was no serial correlation and heteroscedasticity problems in residuals of the models as well as AIC and SIC values were greater in the linear model than the quadratic model.

According to the results of India in table 4.7, R^2 and adjusted R^2 were approximately 99% in both linear and quadratic models which indicate models have a good fit on data. Also, there was no any normality, serial correlation and heteroscedasticity problems in residuals of the models, as well as AIC and SIC values were greater in the linear model than the quadratic model.

According to the results of Nepal, R^2 and adjusted R^2 were approximately 96% in both linear and quadratic models which indicate models have a good fit on data. Also, there was no serial correlation and heteroscedasticity problems in residuals of the models as well as AIC and SIC values were greater in the linear model than the quadratic model.

According to the results of Pakistan, R^2 and adjusted R^2 were approximately 99% in both linear and quadratic models which indicate models have a good fit on data. Also, there was no serial correlation and heteroscedasticity problems in residuals of the models as well as AIC and SIC values were greater in the linear model than the quadratic model.

Table 7: Diagnostics test results

Model	Type of test	Sri Lanka	Bangladesh	India	Nepal	Pakistan
Linear Model	R^2	0.975078	0.997981	0.998235	0.964445	0.996746
	Adjusted R^2	0.972704	0.997369	0.998019	0.958975	0.996436
	Normality	1.290096 (0.524637)	1.217226 (0.544105)	4.793577 (0.091010)	0.500635 (0.778554)	0.480717 (0.786346)
	Serial Correlation	0.017362 (0.8958)	1.983765 (0.1376)	2.269809 (0.0960)	0.832317 (0.4430)	0.678411 (0.5705)
	Heteroscedasticity	1.639187 (0.1823)	0.886395 (0.5552)	0.400444 (0.8457)	1.036854 (0.4165)	0.631171 (0.6430)
	AIC	-1.946429	-3.837695	-4.661391	-0.687573	-4.721345
	SIC	-1.749605	-3.391648	-4.425202	-0.409302	-4.524521
Quadratic Model	R^2	0.975149	0.997981	0.999273	0.973867	0.997102
	Adjusted R^2	0.972118	0.997287	0.998884	0.967147	0.996749

Normality	1.345202	1.172894	0.700504	2.519281	0.844075
	(0.510379)	(0.556300)	(0.704510)	(0.28375)	(0.655709)
Serial Correlation	0.002538	2.797369	0.129611	2.990123	0.222389
	(0.9601)	(0.0577)	(0.9416)	(0.0641)	(0.8802)
Heteroscedasticity	1.14332	0.933115	0.941113	0.562257	1.110816
	(0.3533)	(0.5225)	(0.5343)	(0.8181)	(0.3696)
AIC	-1.906733	-3.792362	-5.188593	-0.861381	-4.794716
SIC	-1.670544	-3.305765	-4.539797	-0.459901	-4.558527

Note: Probability values are in parenthesis and 5% significance level is used.

4.7 Model Stability Test

The results of CUSUM and CUSUM Square test results summarized and given Table 8. According to the results it can be said that except India other SAARC countries selected for this research study, parameters are found to be stable during the study period at 5% significance level.

Table 8: CUSUM and CUSUM Square test results to check stability of parameters

Country	Linear Model		Quadratic Model	
	CUSUM Test	CUSUM Square Test	CUSUM Test	CUSUM Square Test
Sri Lanka	Stable	Stable	Stable	Stable
Bangladesh	Stable	Stable	Stable	Stable
India	Not Stable	Not Stable	Stable	Not Stable
Nepal	Stable	Stable	Stable	Stable
Pakistan	Stable	Stable	Stable	Stable

5.0 Discussion

According to the empirical findings, in the case of Sri Lanka energy consumption (Kg of oil equivalent) per capita has a significantly positive relationship with per capita carbon dioxide emissions in both linear and quadratic models but the population growth and the per capita GDP have an insignificant negative relationship with carbon dioxide emissions in both models. The results also indicate that if there is any deviation from the long-run the equilibrium, it will take 2.30-2.32 years to return to the equilibrium level. Further, the results of the EKC hypothesis for carbon dioxide emissions do not significantly hold for Sri Lanka but the sign of the output indicates the level of per capita carbon dioxide emissions initially goes down but eventually goes up with the rise of GDP per capita over time.

In the case of Bangladesh, energy consumption (Kg of oil equivalent) per capita has a significantly positive relationship with per capita carbon dioxide emissions in both linear and quadratic models but the population growth and the per capita GDP have an insignificant negative relationship with carbon dioxide emissions in both models. Also, empirical results indicate that if there is any deviation from the long-run equilibrium, it will take 9.68-10.35 years to return to the equilibrium level. Also, the results of the EKC hypothesis for carbon dioxide emissions do not significantly hold for Bangladesh which indicates that carbon dioxide emissions level goes up with rises of GDP per capita over time.

In the case of India, energy consumption (Kg of oil equivalent) per capita has a significantly positive relationship with per capita carbon dioxide emissions in both linear and quadratic models but the population growth and the per capita GDP have an insignificant negative relationship with carbon dioxide emissions in linear model but per capita GDP has a significant positive relationship with carbon dioxide emissions in quadratic model. Also, if there is any deviation from the long-run equilibrium, it will take 2.3 years to return to the equilibrium level. Also, the results of the EKC hypothesis for carbon dioxide emissions does significantly hold for India which indicates that carbon dioxide emissions level initially goes up but eventually declines with rises of GDP per capita over time.

In the case of Nepal energy consumption (Kg of oil equivalent) per capita has a significantly positive relationship with per capita carbon dioxide emissions in both linear and quadratic models but per capita GDP has a significantly positive relationship with carbon dioxide emissions in linear model whereas it has an insignificantly negative relationship with carbon dioxide emissions in quadratic model. Also, if there is any deviation from the long-run equilibrium, it will take 1.16-1.66 years to return to the equilibrium level. The results of the EKC hypothesis for carbon dioxide emissions do not significantly hold for Nepal but the sign of the output indicates the level of per capita carbon dioxide emissions initially goes down but eventually goes up with rising of GDP per capita over time.
Finally, in the case of Pakistan, energy consumption (Kg of oil equivalent) per capita, population growth and per capita GDP have a significantly positive relationship with per capita carbon dioxide emissions in the linear model but only population growth has an insignificant negative relationship with carbon dioxide emissions in the quadratic model. Also, if there is any deviation from the long-run equilibrium, it will take 1.12-1.16 years to return to the equilibrium level. Also, the results of the EKC hypothesis for carbon dioxide emissions does significantly hold for Pakistan which indicates that carbon dioxide emissions level initially goes up but eventually declines with rises of GDP per capita over time.

Furthermore, empirical observations from the testing EKC hypothesis imply that in the case of India and Pakistan, carbon dioxide emissions will decrease over time with income increases then it can be recommended that these two countries should not take any economic or/and environmental policies, which might conservative impact on economic growth to reduce their carbon dioxide emissions.

But in the case of Sri Lanka, Bangladesh and Nepal, where carbon dioxide emissions and economic growth were found to have a positive relationship an increase in economic growth over time will not reduce carbon dioxide emissions in the country therefore, these three countries should take economic or environmental policies to reduce carbon dioxide emissions with economic growth of the country.

6.0 Conclusion

The study investigated the impact of economic growth, population growth and energy consumption on carbon dioxide emissions. It found that the presence of the EKC hypothesis based on carbon dioxide emissions as an indicator of environmental degradation in highly populated and top carbon dioxide emitters developing countries such as India and Pakistan. Also, economic growth and environmental degradation are different fields but their relationship cannot be avoided as evidenced by numerous studies including this. As well as, the impact of other core factor variables such as energy consumption and population growth on carbon dioxide emissions in two countries are noticeable as evidenced by numerous studies. However, it is not easy to develop economic and environmental policies simultaneously promoting economic growth and addressing environmental problems or protecting the environment from pollution effectively.

As effective policies in these high economic developing countries like India should consider converting energy source to natural gas, developing both traditional and technically developed clean coal technology, improving environmental monitoring and management, energy source management among others. We should simply understand that promoting economic growth and at the same time reducing environmental pollution as well. Today, it can be considered that more than 60% of total global carbon dioxide emissions come from the use of fossil fuels, it is necessary that decision-makers pay attention to the development of policies, rules and regulations. There are two types of models have used in this study called as linear model and quadratic model. According to the results of this study, it can be said that the quadratic model is more appropriate than linear model to describe the relationship between the variables.

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