Impact of Energy Consumption and Economic Growth on Environmental Degradation: Evidence from South Asian Countries

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Abstract

Environmental sustainability is one of the major concerns of countries worldwide regarding low carbon emissions. This study aims to investigate the impact of economic growth and energy consumption (EC) on carbon dioxide emission by utilizing panel methods. This study uses panel data from four selected South Asian countries for 30 years, from 1991 to 2020. The econometrics approach cointegration test (Pedroni, Kao, and Fisher), Fully Modified Ordinary Least Square (FMOLS) and Dynamic Ordinary Least Square (DOLS) used to examine long-run association and the impact of economic growth, EC (energy consumption), trade openness and urban population on carbon dioxide emission. The results of three-panel cointegration techniques, such as (Pedroni, Kao, and Fisher, confirm that all study variables are cointegrated. The study results show that all variables, such as energy consumption, economic growth, trade openness, and urban population, positively and statistically significantly impact CO2 emissions. The study results help all relevant stakeholders, including environmental scientists, professionals, and educators, make appropriate ecological sustainability policies, namely reducing carbon dioxide emissions in the study economy.

Keywords: CO_2 Emissions, Economic Growth, Energy Consumption.

Introduction

In the present era, the two chief concerns are global warming and international climate change. The greenhouse effect particularly increases the carbon dioxide (CO2) content. It has dramatically worsened the ecological condition of the world and worsened the globe (Rinkesh, 2017). Especially in the last three decades, these growing environmental problems have attracted the attention of scientists and policymakers to study the effects of these environmental problems on the world economy. They have devised ways to minimize greenhouse gas and global warming (GHG) discharges. It has been a central theme of international and national environmental policy agendas. For this purpose, greenhouse gas emissions have been estimated worldwide (Shahbaz et al., 2016).

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Earlier in history, manufacturing countries held environmental agendas and agreements; it was named the (UNFCC). Its primary aim was to control and bring a reduction in GHG emissions. "UNFCCC was properly approved in 1992 and signed by all the stakeholders at the UN Meeting in Rio de Janeiro on Growth and Environment. It is considered one of the most popular environmental conferences. It is designed to prevent carbon dioxide emissions so that all economies can control the effects of high-temperature concentrations on global climate change. Following this development, another international agreement was ratified by the UNFCCC (Kyoto Protocol signed on December 11.1997) into force, February (16, 2005). The contract aims to decrease greenhouse gas emissions in 37 industrial countries and European societies. The Kyoto Protocol states: "Developed countries have pledged to reduce greenhouse gas emissions by five per cent (5%) from 1990 to 2012".

Addressing environmental issues has been getting much consideration and attention at the global level because of the recent drastic environmental change. Notably, the arrangement of the Paris Treaty through the “UNFCCC” marked the beginning of an essential phase. It was held on 4th November 2016 and approved by 147 countries. This agreement was set to decrease GGHG emissions and maintain global temperature 0.2 degree Celsius (UN, 2015). Environmental changes are linked to greenhouse gases, which is not only an issue for developed countries. It was also specified by the World Bank in 2011. Developing countries such as India and China received 62% (34%) of world carbon emissions discharge. Low CO2 consumption because of excessive use of low fossil fuels hurts (GDP) growth, which is a central issue facing all nations, particularly low carbon efficiency (Fan et al., 2017). It is even more detrimental to global warming and climate change. However, energy is vital for running a business and for community, economic and environmental development throughout the economy. Growing processes and transporting or using mainstream goods without energy is challenging.

Therefore, insufficient energy reduces efficiency and productivity in many sectors of the country, such as transportation and other areas of social life (Yildirim, 2017). All these changes result in a severe negative impact on the world environment, which people have realized would dangerously affect humans (Jitpakdee & Thapa, 2012; Ekpoh & Bassey, 2016). As stated by Cooper and Michie (2015), there has been an increase in the emission of CO2 and other GHGs into the atmosphere, which is growing with time. Thus, the need and quest for economic growth have caused environmental degradation on a larger scale. It can be attributed to industrial improvement and growth in emerging and developed nations. The economic development of any economy is heavily based on different factors; these factors have injurious effects on the atmosphere. These adverse effects are mainly caused by exploiting environmental pollution, unstable resources, and environmental changes. Phimphanthavong (2013) reported that rapid economic growth and urbanization in many world economies have led to increased energy consumption (Ullah et al., 2023). Therefore, the key issue facing many nations is the significant increase in CO2 emissions caused by the growth of energy use and GDP. The findings of Kasman and Duman's (2015) study mentioned that a large part of the energy is contributed by fossil fuels- including natural oil, gas and coal. This has resulted in a considerable rise in CO2 emissions. The CO2 emissions are hidden and may take years to resolve (Bushell et al., 2017). According to Sohag et al. (2017), an increase in age in trade could reduce carbon emissions by 0.3%. In addition, introducing global trade has led to a rise in carbon emissions in developing countries. It has received mixed reactions from developed countries. (Apergis et al., 2010; Shahbaz et al., 2016).

With the turn of this century, steady growth has been studied in the worldwide economies and energy use. As a result, more energy is used than fossil fuels, which increases the ratio through regular fog. GHS emissions are spreading at an incredible speed that negatively affects the environment. The issues concerning energy have directly affected GDP growth and societal growth. The recorded number of (35.6 BMT IN 2020) is anticipated to reach (43.2 BMT in 2040) which could warm the world globally. Compared to the last forty years, the world economy has more than tripled. Despite rising GDP growth, emissions levels in most countries still worked to reduce general resources and increase GHG emissions. Some figures suggest that by 2050, resource scarcity will become a significant challenge for the world because of rapid population and GDP growth, which will slow down the pace of economic growth, especially in poor areas (Association for Financial Co-Operations and Development, 2012) (Zahonogo, 2016). By 2018, total carbon-related emissions are up 1.7 per cent, reaching 33.1 per cent of gaga tons of carbon dioxide emissions. Since 2013, it has been at the best level of development, 70% above the standard development rate since 2010. More recently, the growth of 560 Mt has compared to the total output of an international aircraft. The increase in gas emissions is because of the strong global economy and high energy consumption because of climate change in some parts of the world, increasing the demand for heating and cooling (IEA, 2019).

As a recent global phenomenon, the link between CO2 emissions and gross domestic product (GDP) energy consumption has drawn the attention of economists and environmentalists. Energy consumption ends up being a growing function of CO2 emissions. There is a strong link between gross domestic product, trade openness, energy use, and carbon dioxide emissions (CO2). The organization has important proposals for economic, trade and environmental policies. To date, in the view of many scholars, the nexus among power growth, the commercial environment, and the growth environment in the various texts is a problem left out. Economic growth in South Asian countries (Pakistan, India, Sri Lanka and Bangladesh) is not creating unnecessary pollution. Also, trade-offs for economic development (GDP) require strategic policies to avoid natural economic costs. Later, the concept of power use and trade openness policies played a significant role in environmental deprivation.

Research Hypothesis

H1: There is no significant impact of energy use on environment degradation in South Asian countries.

H2: There is no significant impact of economic growth on environmental degradation in South Asian countries.

Objectives

The study at hand is set with the following stated objectives:

To examine the impact of energy consumption on environmental degradation in South Asian countries.

To suggest policy prescription based on findings of the study.

Literature Review

The rising risk of climate change and global warming has drawn global attention to the connection between GDP growth, use of energy, and carbon dioxide emissions (CO2). There are many studies on carbon dioxide emissions, economic growth, and energy consumption. Naseem et al. (2021) investigated the effect of (EC) on ecological dilapidation in BRICS states from 1990 to 2017. The researcher used the (EKC) hypothesis and Autoregressive, Distributed, Lag (ARDL) approaches. The study's outcomes prove that economic growth (EG) and ecological deprivation in the long run.

ED and (CO_2 emissions) are destroyed by constant economic growth. Running of energy demands and energy disasters is the implementation of environmentally sustainable policies.

Jun et al. (2021) documented energy consumption, EC, and environmental damage across several Asian countries between 1985 and 2018. The researcher employed a fully modified ordinary empirical result, showing that globalization is connected with CO_2 emissions. The results also show that (non-renewable) energy consumption is causing environmental pollution. The empirical outcomes suggest that the administration should support and promote renewable energy sources to tackle the problem of environmental degradation.

Chihoho et al. (2020) considered the energy used and the actual profit per capita income on CO_2 in BRICKS countries from 1989 to 2016. These studies include retrospective models, random and constant research outcomes, energy expenditure results, and integration of character incomes among brick carbon dioxide nations.

Manta et al. (2020) investigated the nexus among (CO_2) emissions, strength use, and FD and EG. In important ten (CEEC) international nations from 2000 to 2017, the used (FMOLS) models were used. The result shows that (CO_2) significantly affects economic growth, meaning that CO_2 use no longer affects GDP growth. Similarly, Jian et al. (2019) explored the influence of EG and strength used on (CO_2) emissions from 1982 to 2017.

The study conducted by Kahia et al. (2019) utilized panel vector autoregressive, multi-area, and Granger causality methods to investigate the effect of renewable energy utilization and GDP on CO_2 emissions in MENA (12 nations). Thus, the effects of the economic boom suggest environmental degradation; renewable energy inflows, global trade, and overseas direct investment have caused a discount in carbon dioxide emissions (DinhHong and Lin., 2015). Ntanos et al. (2018) analyzed the connection between renewable energy consumption and economic growth of 25 EC international locations over the duration (2007–2016). The result confirmed that the monetary intake of nations with a higher GDP is higher than those with a lower GDP. Research finished using unit root test, cointegration, and cointegration models. Look at Johansen-Fisher and cointegration models (Baker et al., 2005; Van der Linden, 2017).

Apergis and Payne (2010) examined the association between (economic growth and renewable energy consumption) for OECD countries from 1985 to 2005. The researcher used EC (error correction) and cointegration for panel models. The result from cointegration suggests a long-term correlation linking GDP and renewable electricity utilization, while labour pressure and capital also have a statistically positive correlation.

Ang (2007) studied CO_2 release from energy consumption and yield in France during 1960-2000. This empirically illustrated the effects by using vector and error-correction cointegration models. The findings from these models show a positive impact of energy utilization on ED in the short term and long term, as well as a "bidirectional causality" of energy utilization on production. Everything is managed at the executive level, from electricity consumption, exchange openness, and population to CO_2 emissions (Peterson, 2017).

Kais and Mbarek (2017) explored the relationship between CO_2, used energy, and EG in three selected African countries from 1980 to 2012. The researcher uses penal cointegration, unit root, Granger causality, and panels. The result is a short-term unilateral association between economic growth to energy. The one-way correlation between used EC and CO_2 emissions has been exposed. The results further show that, in the long run, there is a significant link between EC and EG. The study found that the authorities, who had to formulate comprehensive fiscal, energy and environmental policies to keep the economy afloat, meant that these three variables could play a key role in the adjustment process as the system operates on its own (Akadiri et al., 2019; Khobai et al., 2017; Khan et al., 2019).

Therefore, Rahman (2020) supports a one-way link between energy use and carbon emissions in which there is no reaction; there is a bilateral business relationship between carbon emissions (CO2) and economic growth throughout the region. Furthermore, studies suggest that environmental and energy policies must recognize the nexus between energy consumption and economic growth to sustain economic growth in the MENA region.

Ghosh et al. (2014) results show that energy consumption positively and significantly impacts economic growth. However, carbon emissions have a negative and insignificant effect on economic growth, so Bangladesh can be realized without demeaning the environment. Kais and Mbarek (2017) revealed that, in the long run, there is an interdependence between GDP growth and the EU.

Koengkan (2017) showed a positive link between GDP, energy, and consumption in the Caribbean and Latin American countries, while a uni-directional relationship exists between energy usage, development, and growth. Sinha's (2017) result indicates that non-renewable energy is indirectly associated with GDP. In the long run, renewable energy uses directly and significantly affect GDP growth. Ajide (2018) described a significant role of (EC) and (CO2 emission) in economic progress has been determined by empirical study, yet the direction is opposite (Dogan, 2018). Bhat (2018) explored BRICS countries, including Brazil, Russia, China, India, and South Africa; researchers looked at the link between GDP growth, disaggregated energy use, and (CO2) emissions.

Ahmad et al.'s (2019) outcome indicates that non-renewable energy was positively associated with carbon dioxide emissions, but renewable energy was found to be negatively related. Zaidi (2019) and Khan (2019) examined the association between the EU and EG and ecological degradation in Sub-Saharan nations. The results support Rahman's (2020) study, "bi-directional causality between energy consumption and economic growth, as well as a bi-directional relationship between electricity consumption and energy consumption; nonetheless, all variables highlighted pollution's detrimental influence on electricity consumption". Philip et al. (2020) investigated the fifteen economies and the asymmetric association between economic growth, energy consumption, and carbon dioxide emission. Therefore, the results indicated nonlinear co-integration between variables in the research.

On the other hand, Osobajo et al. (2020) results of both the pooled OLS and fixed approaches demonstrated that economic growth and energy consumption had a largely beneficial influence on CO2 emissions. Chukwunonso Bosah et al. (2020) shows a nonlinear relationship between variables. Dabachi et al. (2020) examined the causal association between energy consumption, economic growth, energy intensity, carbon emission, and energy prices in OPEC African economies. The period covered in this study is from 1970-2018. Aydin (2019) examined the association between biomass energy usage and GDP growth for low- and middle-income countries. The panel data was applied in this study. The period covered in this study is from 1971-2013. The econometric approach of the Konya panel causality test was used. Parallel study support results of this study such as Soava et al. (2018), Hanif (2018), Matthew (2019), Wang et al. (2018) and Gozgor et al. (2020) result revealed that the degree of causality between GDP growth and bio-mass energy use differed according to the nation's dimensions and period.

Tong et al.'s (2020) study revealed no correlation between economic growth and CO2 emissions in China, Indonesia, Turkey, Mexico, Brazil, India, and Russia. CO2 outflows in the output and EC are the explanatory variables—co-integration found in Russia and India. Islam et al. (2017)

studied the impact of economic growth, energy use, population, poverty, and (CO2) emissions (Mikayilov et al., 2018; Aye & Edoja, 2017). These studies also support the results of Sulaiman and Rahim (2017), Khan et al. (2019), and Khan et al. (2020).

Zahonogo's (2016) findings revealed that trade openness occurs under the surface and that more trade openness positively influences GDP growth. The results are in line with trade liberalization changes and electoral model parameters. Balanika (2017) revealed that trade liberalization positively and negatively affected GDP. However, exchange in Sub-Saharan Africa is characterized by high common borders and a reliance on essential goods. Insufficient overland connectivity to far-flung major markets may explain why more trade openness does not lead to increased economic growth (Manteli, 2015; Keho, 2017; Khalid, 2016)

The primary purpose of this research is to analyze the association between economic development, environmental degradation, and energy consumption. We will use the latest panel data and methods to achieve these objectives. Moreover, all the previous studies were conducted from different perspectives. This research will contribute to formulating policies based on research findings in the four South Asian countries (Pakistan, Bangladesh, Sri. Lanka and India).

Research Methodology

Data Sources

The study investigated the impact of energy use and economic growth on environmental degradation in our sample of the four economies of South Asia. This study used Panel data variables from 1991 to 2020 for four selected regions developing the South Asian economy, including "Pakistan, India, Sri Lanka and Bangladesh; the time is selected because of the data availability for each variable. Emissions of carbon dioxide (CO2) are measured by (Mt/capita), which is a dependent variable, current GDP per capita per capita per capita (US $), energy consumption per kg of per capita oil, urban population growth (per year%), and trade (Exports + Exports / GDP)" are independent variables. Data is collected from various sources. Data was collected from four selected South Asian economies from the WDI (World Development Index, 2021), and energy consumption was found in the—International Energy Agency (IEA, 2021), shown in table 1.

Table 1: Variable Representation, Definitions and Source

Variables	Representation	Description	Data Source
Carbon dioxide Emissions	CO_2	(Mt /Capita)	WDI (2021)
Economic Growth	EG	(Current US$) GDP/ Capita	WDI (2021)
Energy Consumption	EC	kg of oil equivalent per capita	IEA (2021)
Urban Population	UP	Per years %	WDI (2021)
Trade Openness	TO	Export +Import/GDP	WDI (2021)

Theoretical Framework

This section covers theoretical and conceptual components related to the connection with GDP growth, EC, and CO_2 emissions for a sample of four South Asian countries based on the STIRPAT and technology. (Stochastic Impacts by Regression on Population, Affluence, and Technology) Model and Shi (2003) for theoretical work, the STIRPT model was used in this study. Ehrlich & Holdren (1971) described the STIRPT model, which was based on "(IPAT)" (influence, of population, and machinery). The IPAT model combines environmental effects (I), such as resident's size (p), each capital consumption (A), and technical, level (T). IPAT status can be given considering several features that affect carbon emissions:

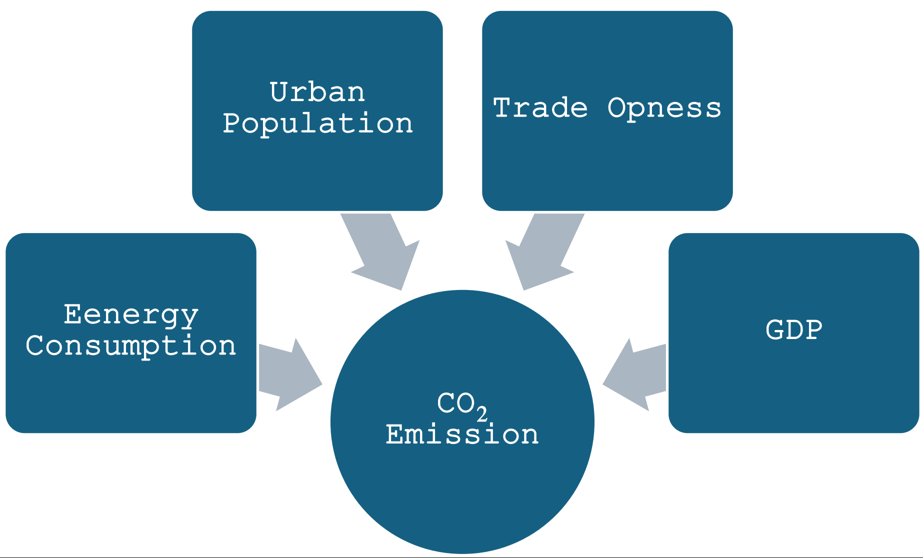
$I = P\times A\times T$ ……………………………………………………………………………………. (1)

Dietz and Rose (1994) pointed out two flaws in the IPAT model developed by Dietz and Rose: First, it supposes, that there is an association, among, the variables, then the ratio, are strict. Second, it, speculate, that there, is an association, among, the variables, still the ratio is strict. It presented the following random types of IPAT frameworks to address these considerable limitations:

$I_{it}=\beta_o P^{\beta 1}{}_{it} A_{it}^{\beta 2} T^{\beta 3}{}_{it} e_{it}$ …………………………………………………………………………. (2)

T can be linked to various components other than A and P that can affect the climate (Shi, 2007). In previous studies, different types of experts were used to demonstrate the effects of technology or human activities on the climate. Shi (2003), for example, looked at the role of services and trade in GDP growth, while Pominionwang et al. (2012) looked at urbanization and grassroots to look at wealth. The affects, of totally nominated variables, such as carbon releases, energy consumption, GDP growth, trade, openness, and regression on rural population, population, wealth, and technology, are described in the Stochastic Impacts model. As a result, the STIRPAT theory investigates the elements that contribute to carbon dioxide emissions.

Figure 1: Model



Econometric Model

The research explores the connection amongst GDP (Economic growth), energy consumption, and carbon dioxides emissions form selected four South Asian economies. The model is also used by (Karim *et al*., 2020) based on multiple regression (MLR) model.

Model Specification

$CO_{2it}=\alpha_0 + \alpha_1 GDP_{it} + \alpha_2 EC_{it} + \alpha_3 U_{it} + \alpha_4 T_{it} + \mu_{it}$ ……………………………………………………………………… (3)

In the economic model mentioned above CO_2 represents endogenous variable, while GDP, EC, U, T are independent. "Variables, the error term represented by ε it

GDP = (Gross. Domestic. Product current US$)

EC= (Energy Consumption kg of oil equivalent per capita)
UP= (Urban Population annual %)
T= trade openness (Exports + Imports / GDP)
μ = Error Term
All independent variable estimated coefficients are specified as: αj I where j = 1.... 5subscript I = 1... 4 indicate nation / area, index, t = 1... 30 indicate period.

Estimation

The following economic methods are used in panel data.

- The Panel Unit. Root Tests
- The. Panel Co-integration Test
- Fully and Dynamic. Ordinary Least Square

In this study, we use panel data, so various panel unit root tests can be used to determine the stationary of the series. The Panel unit roots are used to check the stationary of the data, such as the DF (Dickey-Fuller) and ADF (Augmented Dickey-Fuller) (ADF) tests (Jamal et al., 2024; Gul et al., 2023; Ikram & Gul, 2024; Gul et al., 2023) are expanded to analyse panel data, to check the data are stationary or not. In this research, we have used three types of panel unit root tests. In this study, we used three-unit root tests, the LLC, Im-Pesaran, and shin tests, as well as the Fisher ADF Tests, to expose the stationary of all variables. The next step in applying the panel .co-integration tests to confirm the long-term correlation between the selected variables is to evaluate the position of the variables. Pedroni, Fisher, and Kao panel co-integration is used to confirm long-term interactions between selected variables used in this thesis to investigate the impact of economic growth and energy use on carbon emissions in South Asian countries. Fully modified square dyn, amic square, and flexible square methods help find long-term relationships between variables.

Results and Discussion

Table 2: Descriptive Statistics

	Mean	Maxi	Mini	Std.Dev	Skewness	Kurtosis	Obs
CO_2	0.7124	1.7998	0.1025	0.3953	0.7435	3.4295	120
EC	392.11	636.5718	118.8983	142.2959	-0.4883	2.261	120
GDP	1138.604	4077.044	293.1604	940.9035	1.7644	5.5141	120
TO	41.8096	88.6346	16.9877	17.3253	0.9998	3.1365	120
UP	2.5438	4.5516	0.0474	1.1363	-0.5344	2.2471	120

Descriptive statistics are used to show the overall characteristics of a sample of data. From 1991 through 2020, the data was collected over 30 years. The descriptive data are presented in 4.1 tables; the arithmetic mean of CO2 emissions is 0.7124, with a minimum and maximum of 0.1025 and 1.7898 and a standard deviation of 0.3953. Energy consumption has an arithmetic mean of 39.11, with a minimum and maximum of 118.8983 and 33.12888, respectively, and a standard deviation of 26.364. Thus, the mean values of economic growth are 1138.604, with values at the lowest and maximum of 293.1604 and 4077.004; the standard deviation is 940.9035; the arithmetic means for trade openness is 41.8096 with the lowest and maximum values of 16.9877 and 88.6366 and the standard deviation is17.3253, the arithmetic mean of urban population growth is 2.5438 with the value of smallest and highest of the urban population of 0.0474 and 4.5516 and standard deviation of 1.1363. All variables are right-skewed except for energy consumption (EC) and urban population (UP), which are negatively skewed.

Table 3: Analysis of Correlation Matrix					
	CO2	**EC**	**GDP**	**TO**	**UP**
CO2	1				
EC	0.0783	1			
GDP	0.0369	0.5023	1		
TO	0.0276	0.2415	0.260	1	
UP	-0.2760	-0.5466	-0.5274	-0.7727	1

Table 3 describes the outcome of the correlation matrix between projected variables. There is a statistically significant positive connection between (CO2) emissions and energy consumption, (CO2) emissions and economic growth, and emissions of (CO2) and openness trade. In contrast, there is a statistically significant harmful relationship between them.CO2 emissions and the urban population and trade openness. In addition, no variable indicates any linear relationship, as seen in Table 3.

Table 4: Panel Unit Root Test Results				
Variables	**Levin, Lin and Chu test**		**Im- Pesaran, and Shin test**	
	I (0)	I (1)	I (0)	I (1)
CO_2	0.4267	-0.4548*	2.5851	-3.840*
GDP	2.2935	-1.3015*	3.4907	-1.5061**
EC	-1.2491	-5.1854*	0.6754	-6.8316*
UP	-0.5230	-2.9782*	0.9464	-3.8977*

* and ** indicate the presence of horizontal section dependency among economies at the significance level at 1% and 5% correspondingly.

Table 4 describes the results of the panel unit root test. The CO2 emission is non-stationary at a level during the same variable stationary first difference. Convert all variables from level to first difference, and all variables become stationary. The null hypothesis is rejected, but alternative hypotheses are accepted. It indicates that there are no unit roots in the data set. Carbon dioxide (CO2) emissions, economic growth, energy consumption, urban population and trade openness are all stationary at the first difference, according to the data in Table 4.

Table 5: Co-integration test results				
Pedroni test				
Within Dimension	Statistics	W. Statistics	Between Dimension	Statistics
Panel PP Statistic	-2.358*	-1.431***	Group PP statistic	-1.286***
Panel ADF Statistic	-2.430*	-1.883**	Group ADF statistic	-2.522*
Kao test (ADF)	**Fisher test**			
Statistics prob.	Fisher statistics[a]	Prob.	Fisher statistics test[b]	Prob.
-2.066*	53.02*	(0.000)	28.74*	(0.000)

[a] and [b] indicate the trace test and max. eigen test respectively. Therefore, *, ** and *** shows the significance level at 1%, 5% and 10 % correspondingly.

To find long-run relationships among the variables, the panel performed co-integration tests. Padroni, Fisher, and who is the third person? Kao panel co-integration tests confirm the long-term link between selected variables. Table 5 displays the findings of these tests. The alternative hypothesis explains that all variables are cointegrated. According to the null hypothesis, not all variables are cointegrated. The outcomes of all panels' co-integration tests are presented in Table 5. The results of the Padroni with both dimension occurrences show a long-term connection among all selected variables. Long-run association founded for "economic growth, energy consumption, trade, urban population, and environmental degradation". Likewise, the consequences of the Kao panel test also confirmed a long-run connection among the study variables. Thus, the consequences of the Fisher test confirm that energy consumption, growth, trade, urban population, and (CO2) emissions have a long-term link in four selected South Asian economies.

Table 6: Fully Modified OLS (FMOLS)

Variables	Coefficient	Std. Error	t-statistic	Prob.
GDP	0.0121	2.4434	6.4904	0.0000*
EC	0.0018	0.0002	7.6164	0.0000*
UP	0.0351	0.0184	1.9057	0.0592**
TO	0.0026	0.0010	2.5354	0.0126**
R^2	0.50	Adjusted R^2		0.49

*, ** and *** shows the significance level at 1%, 5% and 10 % correspondingly.

The long-term relationships, fully modified least squire (FMOLS), verified that economic growth and energy use are statistically significant at a one (1) present significance level, while urban population and trade openness are statistically significant at a five (5) present significance level. Energy consumption has a long-term positive impact on carbon dioxide emissions; for every one per cent rise in energy consumption, carbon dioxide emissions rise by 0.0018%. This outcome is predicted, especially for emerging countries with inefficient manufacturing resources. The results of Halicioglu (2009), Ang (2007, 2009) and (Oganesyan, M. 2017) also funded the same results. Economic growth also positively and statistically significantly affects carbon dioxide emissions. Change in income leads to a 0.012 present increase in carbon dioxide emissions. This means that one change in independent variables increases or decreases the dependent variable. Previous studies support our outcomes (Yang et al., 2018). Trade openness also positively and significantly affects CO2 emission for every unit increase in trade openness. The coefficient values of FMOLS show a positive link with CO2 emission. It means a one% change in independent variables brings (0.012, 0.0018, 0.035, and 0.0026) change in independent variable CO2. The goodness-of-fit shows R squared. If the R-squared value is more significant than 0.05, it means the model is a good fit. The model variation is explained by an R-squire 0.50 % change in CO2 emission and is explained by independent variables.

Table 7: Panel Dynamic Least Squares (DOLS)

Variables	Coefficient	Std. Error	t-statistic	Prob.
GDP	0.8705	5.2405	1.8812	0.0451***
EC	0.0022	0.0006	3.3648	0.0014*
UP	0.0283	0.0496	0.5717	0.0198**
TO	0.0048	0.0023	2.1125	0.0391**
R^2	0.712	Adjusted R^2		0.701

*, ** and *** shows the significance level at 1%, 5% and 10 % correspondingly.

Table 7 shows the results of the DOLS (Dynamic Ordinal Least Square) emissions of CO2 as dependent variables. The outcomes of dynamic ordinary least squares were connected to the outcomes of completely modified ordinary least squares. Energy use is statistically significant at a one per cent (1%) significance level. In contrast, trade openness, economic growth, and urban population are statistically significant at a 5% significance level, according to the DOLS findings. According to our findings, if energy use rises by 1%, carbon dioxide emissions increase by 0.0022%. This means that the rise in energy use leads to increased carbon dioxide emissions in the sample for four selected developing South Asian economies during the studied period. Our results depend on (Oganesyan, M. 2017; Ang 2007, 2009; Halicioglu, 2009). Economic growth has a positive and statistically significant impact on (CO2) emissions. This suggests that a one-unit economic growth has increased carbon dioxide emissions by 0.8705%. This result is similar to the consequences (Yang et al., 2018). Similarly, the city populations have optimistic and statistically significant effects on CO2 emissions—a 1% increase in city population and an increase in carbon dioxide emissions by 0.02 %. The research supports the findings presented (Pata 2018 and Lin et al. Furthermore, trade openness positively and significantly affects (CO2) carbon dioxide emissions; for all one percentage (1%) rises in trade, carbon dioxide emissions rise by 0.0048%. Our findings are consistent with Hossain's findings (2011). We can be confident in our findings from Hossain (2011) and Jebli & Youssef (2015a).

Table 8: Pairwise Granger Causality Tests

Null Hypothesis	F-Stat.	Probability	Outcomes
EC → CO_2	0.9408	0.393	
CO_2 → EC	7.176	0.001	Unidirectional causality
GDP → CO_2	1.641	0.008	Bidirectional causality
CO_2 → GDP	0.773	0.064	
TRADE → CO_2	2.026	0.136	No causality
CO_2 → TRADE	0.055	0.946	
UP → CO_2	0.069	0.933	No causality
CO_2 → UP	0.227	0.797	
GDP → EC	11.549	3.000	Unidirectional causality
EC → GDP	3.422	0.036	
TRADE → EC	3.307	0.040	Unidirectional causality
EC → TRADE	0.277	0.758	
UP → EC	0.327	0.721	No causality
EC → UP	1.644	0.197	
TRADE → GDP	1.503	0.026	Unidirectional causality
GDP → TRADE	1.354	0.262	
UP → GDP	1.779	0.073	Unidirectional causality
GDP → UP	2.999	0.053	
UP → TRADE	0.373	0.689	Unidirectional causality
TRADE → UP	5.199	0.006	

Pairwise Granger Causality (PWGT) was used to determine the relationship described in Table 8, which displays the outcomes of casualty testing. The consequences of the casualty test exposed a unidirectional casualty among carbon emissions and energy consumption, with the casualty running from (CO2) to energy consumption. In addition, bidirectional causality exists between (GDP) growth and carbon emissions. Further unidirectional casualty run from energy use and

(GDP). The path of casualty is running from EC to GDP. Likewise, unidirectional casualty between city population and GDP, urban population and trade, trade and EC, and trade and economic growth. Furthermore, there is no causality between trade and CO2, urban population and CO2, and energy consumption.

Conclusion

Environmental change is analyzed in developing economies, especially in the four selected South Asian economies, because of rapid population growth. Therefore, environmental degradation is a serious issue in these emerging economies. Global technological advancements are occurring alongside widespread environmental damage caused by human actions. These causes include fast population increase, excessive use of polluting energy, and rapid industrial development, all of which have significantly affected our environment. This research investigated the effects of economic growth, energy consumption and carbon dioxide emissions (CO2) in four South Asian economies. This study used secondary data for 30 years, from 1991 to 2020, to fulfil our objectives. We used (CO2) emissions as a dependent variable and economic growth (EG), energy consumption (EC), urban population (UP), and trade openness (TO) as independent variables. In this research, we have used the panel unit root tests to find data stability. We also implement an integration panel to confirm the long-run connection between economic growth, energy use and environmental degradation. In addition, fully converted regular and dynamic ordinary minimal squares are used to find long-term flexibility. We also use the correlation matrix to explore the problems of multiple linear relationships between variables. The results of our estimation agree with the previous literature. The unit root test results revealed that not all variables are stationary in the levels but are stationary in the first difference. The experimental outcomes of the Pedroni, Kao, and Fisher tests confirm the existence of a long-term association among the variables used in this thesis. Thus, the outcomes of the model's FMOLS and DOLS presented a positive correlation between carbon dioxide emissions and the four variables, namely (Economic growth, Energy consumption, Trade openness, and urban population). Four selected variables are statistically significant: economic growth, energy consumption, trade openness, and the urban population of the four selected South Asian economies. The results of the study are associated with previous studies. These studies have shown that energy plays a vital role in the national production of both emerging and industrialized economies, such as energy imports and exports. This study's results help relevant stakeholders, including environmental scientists, educators, and educators, formulate relevant policies for environmental sustainability and the reduction of CO2 emissions in four selected South Asian countries. Four selected South Asian countries should adopt additional energy-saving policies to decrease CO2 emissions. These countries should consider environmentally friendly energy-saving and protection policies.

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