ENVIRONMENTAL IMPLICATIONS OF POPULATION GROWTH, FOREIGN DIRECT INVESTMENT AND TRADE OPENNESS IN SAARC AND ASEAN COUNTRIES: AN EXTENDED STRIPAT APPROACH

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Received: June 18, 2024 **Revised:** July 28, 2024 **Accepted:** August 06, 2024 **Published:** August 21, 2024

ABSTRACT
This study analyzes the environmental implications of population growth, FDI and trade openness in SAARC and ASEAN countries using the panel dataset from 1971 to 2019. Panel unit root tests, Pedroni test of cointegration, panel ARDL method and Granger causality tests are used to estimate the results. The outcomes reveal that population growth rate, GDP per capita, GCF, FDI and industrialization are positively and significantly related to environmental degradation. On the other hand, the relationship between trade openness and environmental degradation is positive but statistically insignificant. It is concluded that population growth and FDI inflows are creating environmental problems in SAARC and ASEAN countries. Therefore, it is suggested that policymakers should design policies to control the population, encourage environmentally friendly capital inflows, and encourage the use of green energy resources to reduce environmental degradation.

Keywords: Environmental Degradation, Population Growth, FDI, Trade Openness, SAARC, ASEAN

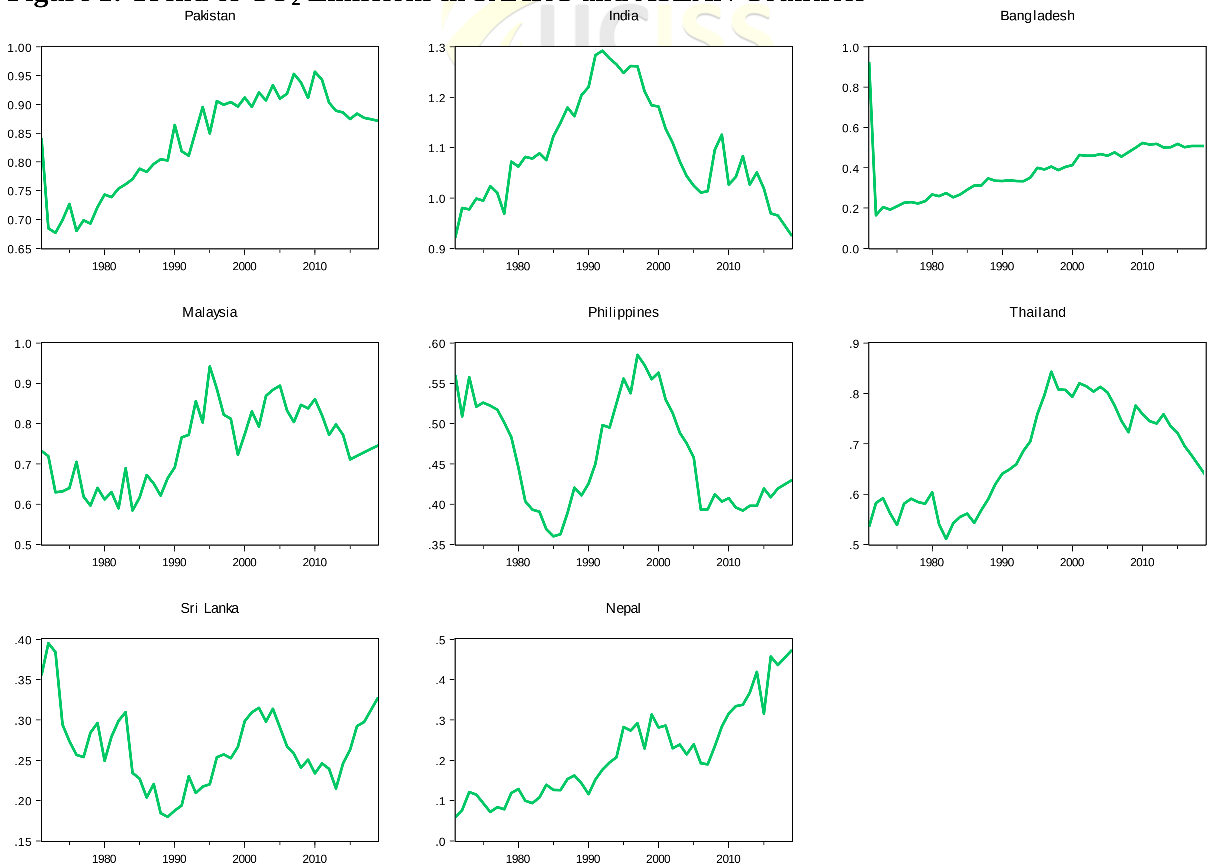
1. Introduction

Environmental degradation is one of the significant problems that every country faces (Iram et al., 2024). Different factors are responsible for raising environmental degradation (ED). Population is a significant source of development, although as it reaches the threshold limits, it becomes a major source of ED. Most developing countries are experiencing rapid population growth, causing ED, deforestation, increased water and air pollution, soil erosion, and disruption to marine and coastal habitats (Trainer, 1990). No matter how inventive, development initiatives cannot yield the desired results until the association between the expanding population and the life support system can be balanced. Environmental pressures, including habitat degradation, air and water contaminants, and an increased demand for arable land, are associated with an increasing population. It also has a detrimental effect on the environment, particularly through waste processing and utilizing natural resources (Ray & Ray, 2011). A larger population may increase energy demand for power, manufacturing, and transportation, resulting in increased CO_2 emissions. In the same way, the rapid expansion of the population can lead to the incineration of wood for fuel and the subsequent deforestation (Birdsall, 1992).

On the other hand, ED in the host countries may result from foreign influx as foreign investors bring technologies to the host economies that have severe environmental implications (To et al., 2019). Environmental degradation is caused by the depletion of natural resources, harm to infrastructure, and loss of human life and health (Cohen et al., 2018). The growth of the economy is affected by atmospheric pollutants. The disturbing reality of ED and its detrimental long-run impacts can have detrimental effects on the economy and well-being of people. Consequently, healthcare and welfare expenses may increase (Borhan et al., 2012). Therefore, by decreasing the efficiency of labor and capital created by humans, CO2 emissions may directly diminish productivity. In this instance, pollution appears to be a negative externality. The quality of industrial equipment is deteriorating, resulting in air pollution and health problems (Abdouli & Hammami, 2017).

Similarly, Trade openness (TR) can favor carbon emissions for developing nations like Pakistan because they emphasize generating investment and jobs more than guaranteeing green manufacturing (Shahzad et al., 2017). Furthermore, trade openness affects the environment in three ways: composition, scale and technological effect (Antweiler et al., 2001). According to the technology impact, increased trade contributes to technological advancement and lower carbon emissions. According to the scale effect, free trade harms the environment by increasing trade volume and output. Lastly, in terms of composition effect, emerging nations draw industries that produce a lot of pollution, exacerbating environmental degradation. It suggests that the scale and composition effects enhance the CO_2 emissions and ED while the technology effect positively impacts environmental quality. Trade openness's overall impact on the ED is unclear since it relies on different effects and also based on which effect is most prominent.

Figure 1: Trend of CO_2 Emissions in SAARC and ASEAN Countries



Source: WDI Indicators

Rapid population growth combined with low per capita income has exacerbated environmental factors, which tend to be mainly eroding the social and economic development of the SAARC (South Asian Association for Regional Cooperation) and ASEAN (Association of Southeast Asian Nations) regions over the last four decades. The environmental circumstances in the SAARC and ASEAN countries have worsened due to a significant influx of FDI, economic growth, rising demand of energy, and population expansion (Asghar et al., 2024). India and Indonesia, the two largest carbon dioxide emitters, are found in the SAARC and ASEAN regions. Specifically, the cities in the SAARC region have the worst air pollution in the world, and most people are forced to drink tainted water. Furthermore, diseases like cholera, malaria, and dengue are brought on by the severe air and water pollution in the SAARC nations. By 2050, the region's GDP is predicted to have declined by 1.8% due to environmental degradation (UNEP, 2014; Ahmed, 2014). Therefore, considering the above discussion, analyzing the influence of population growth, FDI and TR on ED in SAARC and ASEAN countries is imperative. The study's outcomes will provide important implications on how population growth, FDI and trade openness influence the environment and what policies should be adopted to control the ED in these countries.

2. Literature Review

The association between population growth, FDI, trade openness and environmental degradation (ED) has received a lot of attention. Iram et al., (2024) employed data from OIC economies from 2003 to 2021 and showed that FDI and ICT use positively influence environmental degradation, while financial development and REC improve the environmental quality in OIC countries. Udeagha & Ngepah (2022) analyzed the relationship between TR and ED in South Africa using data from 1960 to 2020. Their study showed that TR, FDI and energy usage enhanced the CO_2 emissions. Likewise, Ali et al., (2020) utilized data from 1990 to 2018 in Pakistan and India to evaluate the influence of poverty and population growth on CO_2 emissions. Their study showed that poverty and population increase have a substantial impact on CO_2 emissions in the instance of India, whereas poverty has little influence of ED. Furthermore, Kausar et al., (2020) used data from 1990 to 2019 and ARDL and ECM methodologies to investigate how industrialization affects climate change in Pakistan. The STIRPAT model was exercised in this investigation to examine how human activity affects the environment. The outcomes demonstrated a positive link between population expansion and CO_2 emissions. In contrast, long- and short-term outcomes also revealed that U-shaped EKC outperformed Inverted U-type EKC.

Conversely, Nosheen et al., (2020) employed the STIRPAT model to estimate data from Asian nations from 1995 to 2018, investigating the effect of energy usage and urbanization on CO_2 emissions. The outcomes discovered that electricity consumption and urbanization significantly impacted CO_2 emissions. The outcomes also exhibited that financial development harms CO_2 emissions but has an optimistic influence on economic growth. According to short-run estimations, population density, energy resources, and financial development all contribute to environmental degradation, according to a study by Yahaya (2019). However, Ali et al., (2019) showed that Nigeria's urbanization raises carbon emissions over the long and short term. Urbanization and greenhouse gas emissions had a one-way, short-run causal relationship. This study made the case for promoting public transportation to reduce vehicle pollution in urban areas. Similarly, Salahuddin et al., (2019) evaluated the effect of globalization and urbanization on CO_2 emissions in South Africa, employing data spanning from 1980 to 2017. Urbanization was found to be the primary cause of CO_2 emissions, with globalization having a major long-term impact on emissions. Lastly, the Toda-Yamamoto causality test revealed that urbanization and CO_2 emissions have a bidirectional causal relationship.

According to Ghanem's (2018) study, Egypt's growing population has detrimental effects on the environment and the country's capacity for sustainable development. The population was negatively impacted by environmental degradation, particularly regarding public health. The lower labor productivity of these detrimental health effects hampers the state's capacity to maintain output. Furthermore, Hadi et al., (2018) investigated how FDI affected

CO_2 emissions, a measure of environmental quality. Additional macroeconomic variables were employed in addition to FDI to investigate how the climate affected the economy. The outcomes demonstrated that FDI has a significant favorable influence on rising CO_2 emissions. The two other factors that directly impacted CO_2 emissions were population increase and poverty.

Numerous research studies on the connection between TR, FDI, population growth and ED have been published in the literature; however, few of these studies look at the ASEAN and SAARC countries specifically. So, this study analyzes the environmental implications of population growth, trade openness, and FDI in SAACR and ASEAN countries by extending the STRIPAT model. The study used the new dataset from 1971 to 2019 of SAARC and ASEAN countries and employed panel unit root, ARDL model and Granger causality test for data analysis. The outcomes of the study will have important implications, and policymakers may adopt policies to reduce CO_2 emissions by considering the study outcomes.

3. Data and Methodology

The panel dataset of SAARC and ASEAN countries from 1971 to 2019 is used in the study. The data is taken from the World Development Indicators. Based on data availability, the study includes Pakistan, Thailand, India, Malaysia, Bangladesh, Philippines, Sri Lanka, Indonesia, Nepal and Singapore. On the other hand, the IPAT model is widely used to analyze the association between environment, population, affluence and technology (Ehrlich & Holdren, 1972). The IPAT model's equation is as follows:

$$I = P \times A \times T \quad (1)$$

Where I indicate the environment, P refers to the population, A indicates affluence as measured by GDP per capita and T represents the technology. When examining the goal of economic movement in carbon emissions at the industrial and national levels, the IPAT identification is primarily utilized. According to Xu & Lin (2016), IPAT identity is a mathematical formula that inadequately overlooks how certain factors affect the climate. Therefore, we used the STRIPAT model, which Dietz & Rosa (1994) proposed in order to discuss these constraints (based on IPAT). The STRIPAT model measures the influence of human activity on environmental circumstances in a nonlinear situation (Raza & Hasan, 2022). The STRIPAT model's mathematical form is as follows:

$$I = \beta_o P^{\beta_1} A^{\beta_2} T^{\beta_3} \varepsilon \quad (2)$$

Where I indicates environment, P represents population, A denotes to affluence, T indicates technology, ε signifies to the error term and β's are the coefficients of the variables to be estimated. We extend the STRIPAT model by adding variables such as FDI inflows, trade, and GCF to evaluate the influence on ED. The extended form of the STRIPAT model is as follows:

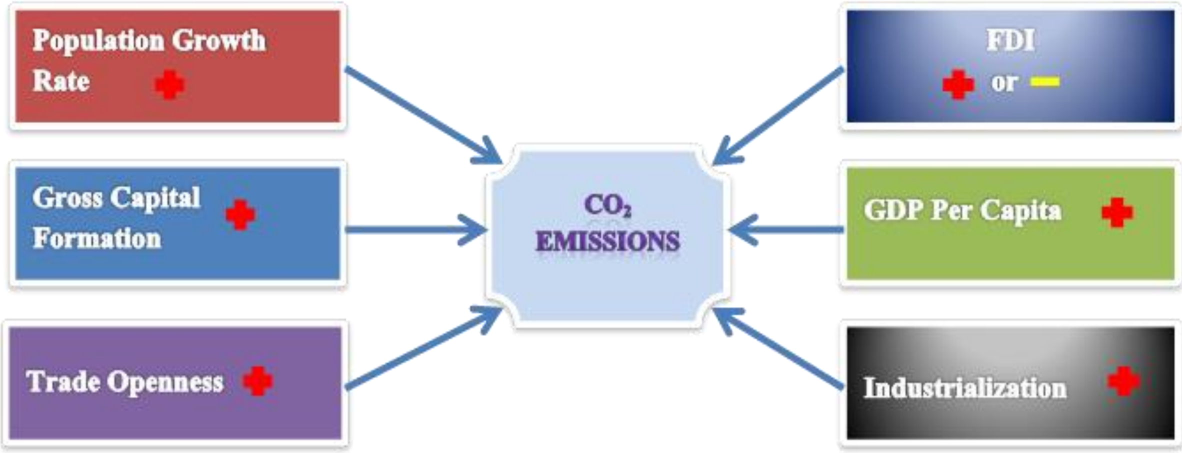
$$I = \beta_o P^{\beta_1} A^{\beta_2} T^{\beta_3} F^{\beta_4} G^{\beta_5} TR^{\beta_6} \varepsilon \quad (3)$$

Where F indicates FDI inflows, G indicates GCF, TR represents trade openness, ε refers to the error term and β's are the coefficients of the variables to be estimated. The econometric form of the extended STRIPAT model is as follows:

$$ED_{it} = \beta_o + \beta_1 PGR_{it} + \beta_2 GDPPC_{it} + \beta_3 IND_{it} + \beta_4 FDI_{it} + \beta_5 GCF_{it} + \beta_6 TR_{it} + u_{it} \quad (4)$$

Where ED indicates environmental degradation (CO_2 emissions metric ton per capita), PGR represents the population growth rate (Annual growth rate), GDPPC indicates the gross domestic product per capita (constant US dollars), IND refers to industrial production (constant US dollars), FDI refers to foreign direct investment (percentage of GDP), GCF indicates gross capital formation (percentage of GDP), TR indicates the trade openness (percentage of GDP) and u_{it} refers to the error term.

Figure 2: Expected Association between the ED and Independent Variables



Various econometric methods are used to analyze the data. First, the stationarity of the variables is evaluated using panel unit root analysis. Finding the best method for long-term parameter estimates requires careful consideration of this analysis. The study uses a variety of panel unit root tests, including the LLC, IPS, ADF, and PP tests, for this aim. Second, the Pedroni cointegration test verifies a model's long-term cointegration of the variables. Third, the long-run parameter estimation is analyzed using the panel ARDL model created by Pesaran et al., 1999. If the variables have integration order I(0) and I(1), this approach makes sense; in practical situations, a change may still affect the other variable even though it happens gradually across time and in multiple phases. These conditions can be evaluated using panel ARDL for long-term and short-term findings.

$$ED_{it} = \sum_{s=1}^{p} \delta_{is} ED_{i,t-s} + \sum_{s=0}^{q} \beta_1 PGR_{i,t-s} + \sum_{s=0}^{q} \beta_2 GDPPC_{i,t-s} + \sum_{s=0}^{q} \beta_3 IND_{i,t-s} + \sum_{s=0}^{q} \beta_4 TR_{i,t-s} + \sum_{s=0}^{q} \beta_5 GCF_{i,t-s} + \sum_{s=0}^{q} \beta_6 FDI_{i,t-s} + \varepsilon_{it} \quad (5)$$

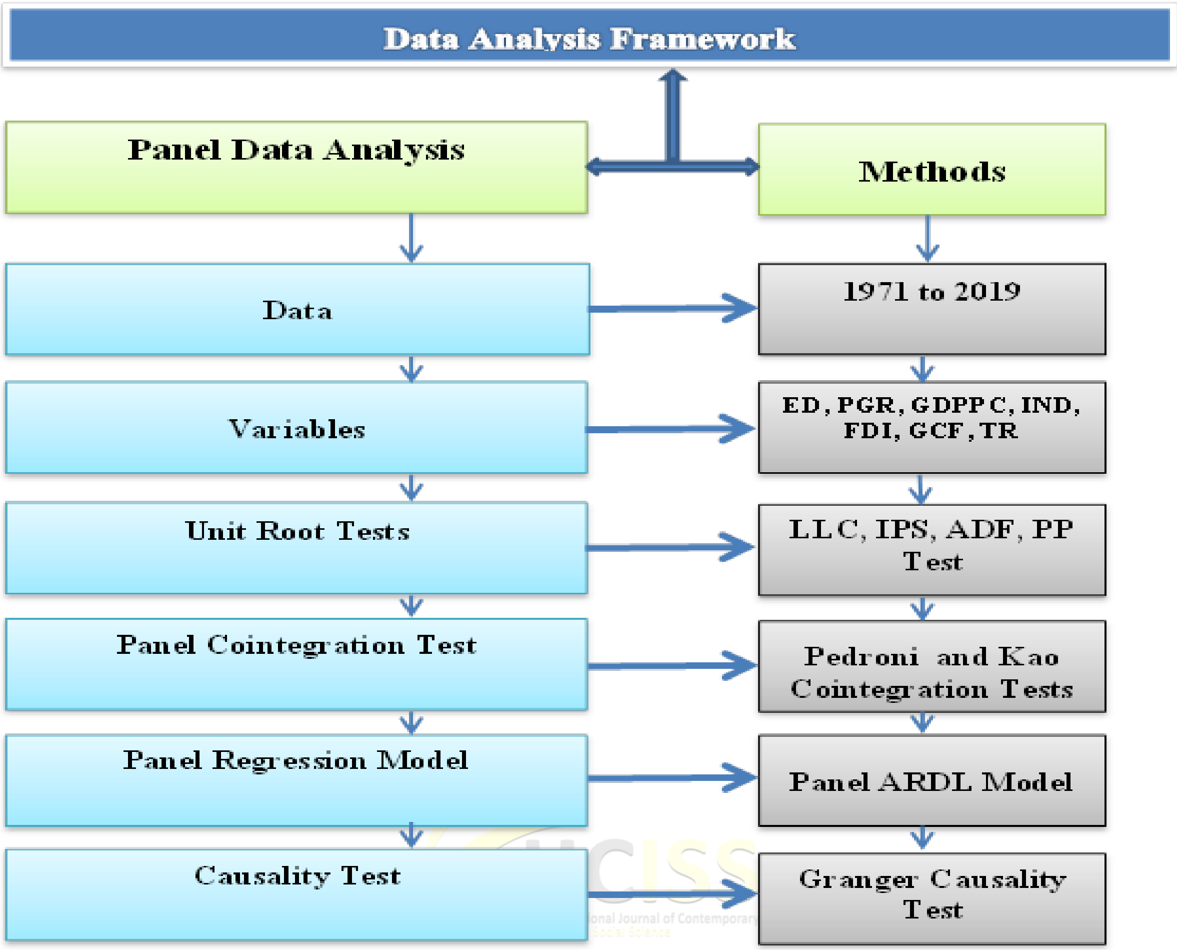
Where p denotes the lag of dependent variables, q denotes the lag of independent variables, ε_{it} denotes the error term, and βi's are independent variables' long-run coefficients. The short-run error correction form is likewise provided by the panel ARDL model, and the ECM model's equation is as follows:

$$\Delta ED_{it} = \partial_i \left(ECM_{i,t} \right) + \sum_{s=1}^{p-1} \chi_{i,t} ED_{i,t-s} + \sum_{s=0}^{q-1} \alpha_1 \Delta PGR_{i,t-s} + \sum_{s=0}^{q-1} \alpha_2 \Delta GDPPC_{i,t-s} + \sum_{s=0}^{q-1} \alpha_3 \Delta IND_{i,t-s} + \sum_{s=0}^{q-1} \alpha_4 \Delta TR_{i,t-s} +$$

$$+ \sum_{s=0}^{q-1} \alpha_5 \Delta GCF_{i,t-s} + \sum_{s=0}^{q-1} \alpha_6 \Delta FDI_{i,t-s} + \varepsilon_{it} \quad (6)$$

When εit denotes the error term, αi's are the short-coefficients of the explanatory variables and ∂_i represent the coefficient of the error correction term. Finally, every pair of variables can have a causal relationship that is examined using pairwise Granger causality. The Granger causality test is used on data when determining if one variable causes the other, both variables cause the other, or neither causes the other. This test analyzes the causal relationships between the variables as one-way, two-way, and non-causal.

Figure 3: Methodological Framework



4. Analysis

The descriptive statistics, correlation analysis, unit root analysis, cointegration analysis, panel ARDL analysis and panel Granger causality analysis are presented in this section.

Descriptive Statistics

Descriptive statistics consists of the mean, maximum, minimum, standard deviation, and skewness of data. Table 1 demonstrates that ED's mean, maximum and minimum values are 1.286, 8.125 and 0.016, respectively. The skewness and kurtosis values specify the positively skewed and leptokurtic distribution. Similarly, the mean, maximum and minimum values of PGR are 1.886, 3.364 and -0.267, respectively. The skewness and kurtosis values specify the negatively skewed and platykurtic distribution. The normal box plots also shows the descriptive statistics summary of the variables in Figure 2.

Table 1: Descriptive Statistics

Variables	Mean	Maximum	Minimum	S.D.	Skewness	Kurtosis
ED	1.286	8.125	0.016	1.759	2.378	8.207
PGR	1.886	3.364	-0.267	0.746	-0.427	2.482
GDPPC	6.600	9.343	4.272	1.148	0.393	2.412
INDP	23.245	27.290	18.206	1.856	-0.284	2.713
TR	61.017	220.407	7.670	43.758	1.509	5.049
GCF	24.199	56.562	4.698	7.581	0.713	4.272
FDI	1.248	8.760	-0.327	1.458	1.830	7.020

Correlation Matrix

Correlation coefficient is used to investigate the association between two variables. Table 2 presents the correlation matrix. It is found that environmental degradation is positively correlated to the population growth rate (0.179) GDPPC (0.780), industrialization (0.508), trade openness (0.840), gross capital formation (0.226) and foreign direct investment (0.676).

Table 2: Correlation Matrix

Correlation	ED	PGR	GDPPC	INDP	TR	GCF	FDI
ED	1.000						
PGR	0.179	1.000					
GDPPC	0.780	-0.471	1.000				
IND	0.508	-0.290	0.706	1.000			
TR	0.840	-0.225	0.749	0.309	1.000		
GCF	0.226	-0.398	0.449	0.361	0.318	1.000	
FDI	0.676	-0.150	0.682	0.416	0.754	0.370	1.000

Unit Root Analysis

Unit root analysis is imperative in determining the data stationarity. The LLC, IPS, ADF fisher test, and Phillips Peron test (PP) are used to check the stationarity of variables. Table 3 presents the unit root analysis. The estimates show that the variables foreign direct investment and population growth rate are stationarity at level, while the variables environmental degradation, GDPP, industrialization, TR and gross capital formation are stationary at 1^{st} difference so that this analysis suggests that for long-run estimation of variables panel ARDL model is suitable approach.

Table 3: Unit Root Analysis

	Individual Intercept				Intercept and Trend				None			
Variable	**LLC Test**	**IPS Test**	**ADF-Fisher Chi-Square**	**PP-Fisher Chi-Square**	**LLC Test**	**IPS Test**	**ADF-Fisher Chi-Square**	**PP-Fisher Chi-Square**	**LLC**	**ADF-Fisher Chi-Square**	**PP-Fisher Chi-Square**	**Results**
ED	1.419 (0.922)	0.018 (0.507)	21.919 (0.345)	38.790 (0.007)	6.658 (1.000)	1.079 (0.860)	17.652 (0.610)	285.661 (0.000)	0.765 (0.778)	16.417 (0.691)	19.728 (0.475)	I(1)
GDPPC	-2.225 (0.013)	1.745 (0.960)	13.461 (0.857)	17.747 (0.604)	-1.475 (0.070)	-1.584 (0.057)	31.990 (0.043)	23.322 (0.273)	8.290 (1.000)	0.091 (1.000)	0.015 (1.000)	I(1)
PGR	-2.377 (0.009)	-1.403 (0.080)	32.505 (0.038)	16.581 (0.680)	-9.731 (0.000)	131.842 (0.000)	21.812 (0.351)	17.296 (0.634)	-4.910 (0.000)	53.796 (0.000)	95.728 (0.000)	I(0)
IND	-2.300 (0.011)	-1.585 (0.057)	31.814 (0.045)	27.924 (0.111)	0.236 (0.593)	0.727 (0.766)	27.363 (0.125)	20.809 (0.409)	0.304 (0.619)	8.424 (0.989)	7.502 (0.995)	I(1)
TR	-2.358 (0.009)	-2.288 (0.011)	40.140 (0.005)	31.606 (0.048)	-0.091 (0.464)	0.303 (0.619)	24.958 (0.203)	17.634 (0.612)	0.944 (0.827)	5.900 (0.999)	5.766 (0.999)	I(1)
FDI	-1.622 (0.052)	-2.946 (0.002)	41.321 (0.003)	59.887 (0.000)	-2.226 (0.013)	-4.576 (0.000)	58.115 (0.000)	96.186 (0.000)	-3.142 (0.000)	29.591 (0.077)	41.496 (0.003)	I(0)
GCF	-1.000 (0.159)	-0.839 (0.201)	25.896 (0.169)	19.409 (0.495)	0.623 (0.733)	-0.584 (0.280)	22.830 (0.297)	18.818 (0.534)	1.809 (0.965)	8.672 (0.986)	8.499 (0.988)	I(1)

Source: Author's Calculations by Using EViews
Note: *The values in the brackets are p-values*

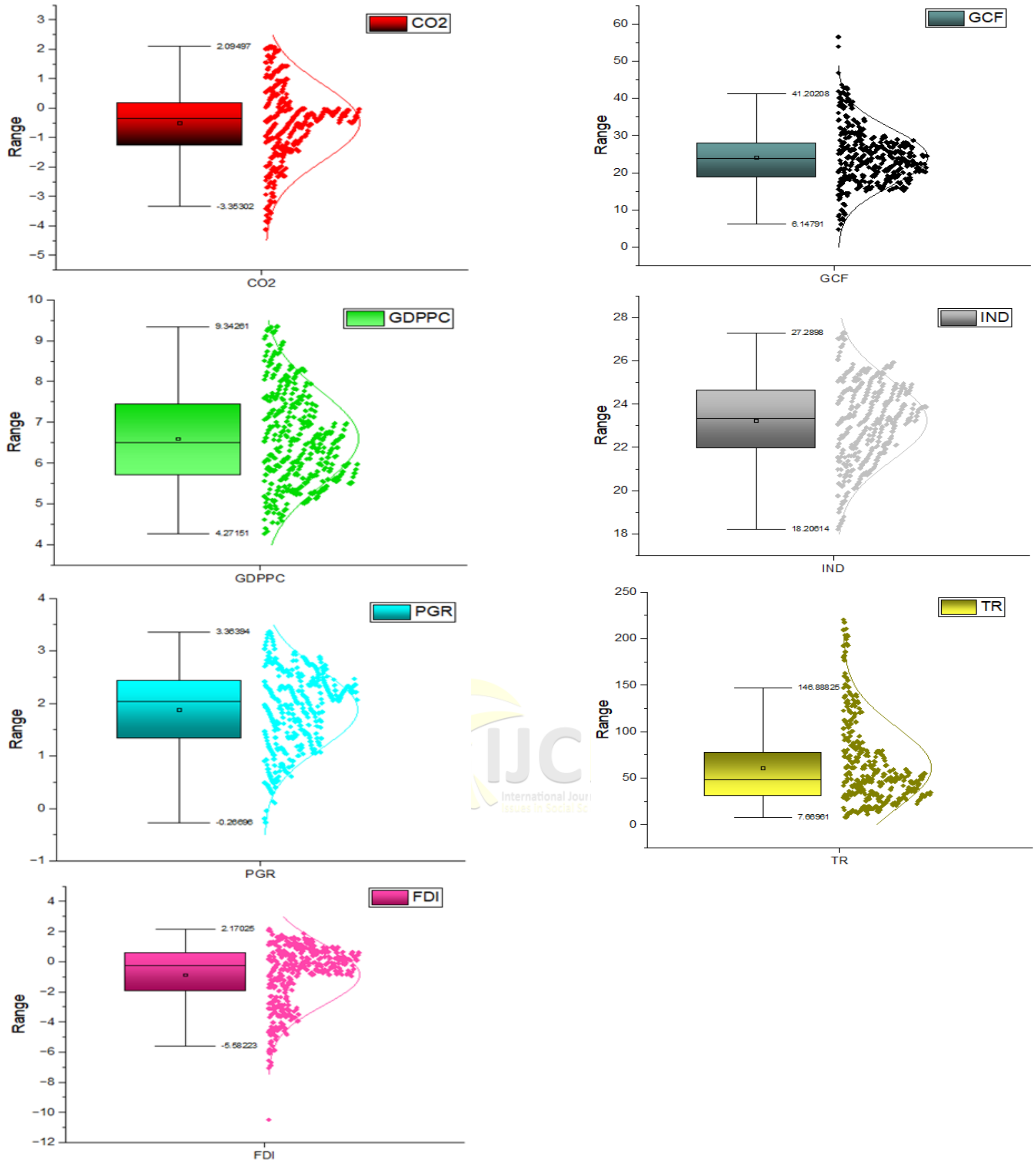


Figure 4: Normal Box Plots of Variables

Cointegration Test

Table 4 presents the Pedroni and Kao test of cointegration estimates. The outcomes show that Panel PP-Statistic and Panel ADF-Statistic within dimensions and Group PP-statistic and Group ADF-Statistic between dimensions have probability values less than 5 percent; it suggests that the null hypothesis is rejected and the alternative hypothesis is accepted that there is a long-run cointegration-among-variables. The Kao Residual cointegration test also has a p-value of less than 5 percent, suggesting the long-run cointegration between variables.

Table 4: Pedroni Test of Cointegration

Within Dimensions		
Panel	**Statistic**	**P-value**
v-Statistic	-0.0597	0.5238
rho-Statistic	1.1100	0.8665
PP-Statistic	-2.9220	0.0178
ADF-Statistic	-3.0687	0.0142
Group	**Between Dimensions**	
rho-Statistic	0.5675	0.7148
PP-Statistic	-2.4027	0.0081
ADF-Statistic	-3.6229	0.0477
Kao Residual Cointegration Test		
ADF	-3.2462	0.0000

Panel ARDL Analysis

Table 5 displays the panel ARDL long-run estimates of the impact of population growth, FDI and trade openness on environmental degradation. Considering the population growth rate first, it is found that the PGR and environmental degradation are positively and significantly connected. The coefficient of the population growth rate exhibits that as it increases by one unit, ED increases by 0.4611 units. It implies that the population affects the environment through the use of natural resources, which leads to water and air pollution. Due to increased population production, waste also increases (Ray & Ray, 2011). These results were also established in the studies of Ali et al., (2020); Wang et al., (2017); Zaman et al., (2011). The variable affluence, measured by GDP per capita, shows a positive and significant relationship with ED. The GDPPC's coefficient exhibits that environmental degradation increases by 2.4017 units as GDPPC increases by a unit. It suggests that an increase in GDP per capita enhances a country's economic activities (Shah et al., 2020), which raises energy demand and, in turn, raises CO_2 emissions. Similarly, industrialization shows a positive and significant relationship with ED. The IND's coefficient displays that as it upsurges by a unit, the ED rises by 1.4240 units. These results suggest that increased industrial production leads to more energy use and affects the environment by increasing pollutants and causing the loss of natural resources. In contrast, TR turns out to be directly but insignificantly related to the ED in SAARC and ASEAN countries. In addition, GCF is essential to improve the country's economic progress (Asghar et al., 2024, Asghar et al., 2023) however; the study found a positive and significant relationship between GCF environmental degradation. The coefficient value of GCF exhibits that ED increase by 0.0600 units as GCF increases by a unit. Rahman & Ahmad (2019) and Baek (2016) also found a positive relationship between GCF and ED. Lastly, FDI shows a positive and significant relationship with ED. The FDI's coefficient exhibits that as it increases by one, the ED leads to an increase of 0.3892 units. It implies that SAARC and ASEAN countries need to build strict policies to stop polluted technologies in the form of capital inflows in their countries.

Table 5: Panel ARDL Long-Run Estimates

Variables	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.***
PGR	0.4611	0.1222	3.7727	0.0002
GDPPC	2.4017	0.3885	6.1810	0.0000
IND	1.4240	0.2581	5.5168	0.0000
TR	0.0142	0.0133	1.0676	0.1642
GCF	0.0600	0.0134	4.4820	0.0000
FDI	0.3892	0.0767	5.0702	0.0000

Table 6 presents the panel ARDL short-run error correction model. The ECM term shows the speed of adjustment and lies between 0 and -1. The value of the ECM term was found to be negative (-0.0758) and statistically significant. The ECM value suggests that 7.58 percent of errors become corrected if there is any disturbance in the short-run.

Table 6: Panel ARDL Short-Run Estimates

Variables	Coefficient	Std. Error	t-Statistic	Prob.*
ECM(-1)	-0.0758	0.0141	-5.3641	0.0000
D(ENV(-1))	-0.4194	0.1717	-2.4426	0.0157
D(PGR)	0.0167	1.1792	0.0142	0.9887
D(GDPPC)	-0.5680	0.4721	-1.2030	0.2308
D(IND)	0.5826	0.4730	1.2316	0.2200
D(TR)	-0.0029	0.0014	-2.1024	0.0371
D(GCF)	0.0076	0.0051	1.4836	0.1399
D(FDI)	-0.0187	0.0136	-1.3794	0.1698
C	1.1658	0.2131	5.4693	0.0000

Panel Granger Causality Test Analysis

Table 7 shows that no causality originates between PGR and ED, GDPPC and ED, and IND and ED. In contrast, bidirectional causality is observed between TR and ED, and FDI and ED. Lastly, unidirectional causality is observed between GCF and ED.

Table 7: Granger Causality Estimates

Null Hypothesis	F-Statistic	P-value	Results
PGR ≠ ED	0.7701	0.5452	No-Causality
ED ≠ PGR	0.6558	0.6231	
GDPPC ≠ ED	1.4492	0.2173	No-Causality
ED ≠ GDPPC	0.7677	0.5468	
IND ≠ ED	0.6399	0.6343	No-Causality
ED ≠ IND	0.1868	0.9452	
TR ≠ ED	5.7669	0.0002	Bidirectional
ED ≠ TR	4.2206	0.0024	
GCF ≠ ED	1.6665	0.1572	Unidirectional
ED ≠ GCF	2.8561	0.0236	
FDI ≠ ED	4.9289	0.0007	Bidirectional
ED ≠ FDI	10.1327	0.0000	

5. Conclusions

The environmental implications of population growth, FDI, and trade openness in SAARC and ASEAN countries are examined in a study using an extended form of the STRIPAT model. Unit root analysis found that the variables FDI and population growth rate are stationary at level, while environmental degradation, gross domestic per capita, industrial production, trade openness and GCF are stationary at 1st difference. Similarly, Pedroni and Kao's cointegration analysis shows a long-run cointegration among variables. Panel ARDL outcomes revealed that population growth rate, gross domestic per capita, FDI, GCF and industrialization positively influence the environmental degradation in SAARC and ASEAN countries. Lastly, no causality is established between PGR and ED, GDPPC and ED, and IND and ED. In contrast, bidirectional causality is observed between TR and ED, and

FDI and ED. Lastly, unidirectional causality is observed between GCF and ED.

These findings suggest several implications for policymakers in SAARC and ASEAN countries in controlling environmental degradation. First, special efforts should be made to inform and educate the people and local leaders by using mass media about the adverse effects of a large population and how a large population degrades our environment. Second, to promote new growth regions and firmly remove outdated manufacturing facilities, the government should support the development of green industries and environmentally friendly technologies. Third, SAARC and ASEAN countries should strive to establish stronger environmental regulations about foreign direct investment and trade. Trade and FDI entry regulations may also be designed to boost productivity and enhance environmental quality rather than allowing FDI to come at the expense of the environment since this will help them improve their economic progress. Lastly, CO_2 emissions can be reduced by speeding up the transformation and improvement of the industrial structure. The transformation and improvement of the industrial structure include the transition from low to high value-added and the transition from high to low energy consumption.

The study has also some limitations. First, the study incorporates FDI, trade openness and population growth as core factors of environmental degradation; however, in addition to these factors such as globalization, digitalization and green finance can be integrated in a model. Secondly, although the data from SAARC and ASEAN countries from 1971 to 2019 are included in the study, future research might use data from underdeveloped countries, Asian countries, and other regions. Lastly, the advanced econometric techniques, including second-generation unit root tests, cross-sectional dependence tests and dynamic correlated common effects model can be used for panel data analysis.

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