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Reassessing the Linkage between Economic Growth and Environment through the Lens of Deforestation, Pollution and Carbon Emission

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ABSTRACT

Sustainable Development Goals for 2030 established by the United Nations aim, on the one hand, to achieve sustained growth and the eradication of poverty, and, on the other, to safeguard the environment. The relationship between development and the environment has been the subject of a substantial amount of research since the 1990s. This study has found that the link between economic growth and environmental degradation indicators in SAARC countries by modelling these connections utilising linear as well as non-linear regressions. The results show that economic growth leads to steadily improved efficiency of consuming the planet's nonrenewable resources; but, higher efficiency is not sufficient to counteract the expansion in scale. The study's findings show that economic growth and deforestation, air pollution, carbon emissions, and human capital are significantly related.

1 Introduction

Environmental degradation is the most pressing issue humanity is facing today. The majority of people agree that it is the global issue of this century as it is posing serious impacts economic growth of the states (Gokmenoglu et al., 2021). When it comes to the factors that contribute to environmental degradation acid rain formation, global warming, desertification and deforestation are at the top of the list (Howard, 1991). Humans are responsible for the escalation of climate change, ecological disruption, and developmental asymmetry, all of which lead to the ecosystem's demise. Many studies conducted in the early 1990s used this topic as their primary research focus (Grossman et al., 1990; Panayotou, 1993). Their early work found a connection between per capita income and environmental degradation indicators such pollution, deforestation, and carbon dioxide emissions. Environmental Kuznets curves gained considerable favour in research and policy as a result of appealing promise that economic expansion could actually be helpful to the environment in the long run. The first observed examples of these curves, their possible causes, and the policy implications of those causes during times of rising prosperity, the composition of inputs and techniques of production gradually shift in favour of less damaging production, a process known as structural transformation. This fixation on duplicating the identical inverted U-shape emphasises the link between this process and the rise in material prosperity (Bo, 2011; Dinda, 2004). Beginning in the year 2000 and going ahead, substantial criticism was articulated in regard to the weak statistical foundation of these curves (Stern, 2004). This argument demonstrates how shaky these curves' statistical basis is (Levinson, 2001). Since the gradual adoption of cleaner technology is conceivable regardless of a country's degree of development, a reduction in emission levels is not necessarily made possible by an increase in income. As a result, the scale of production, which varies greatly from country to country, and the efficiency of production, which may improve in a way that is not linearly related to GDP, are used to describe the impact on the environment (Dasgupta et al., 2002; Stern et al., 2001) . If the economy is very large, even little changes in production efficiency can have a large impact on the total output. Therefore, it is reasonable to expect that the variation in environmental output levels will vary with the GDP levels of the countries that are included in the panel if it is constructed with economies that are radically different from one another (Stern et al., 1996; Andree et al., 2019). To solve this problem, the policy designers must recognise that the impact on the environment is due to both the scale and technology components.

The study has chosen South Asian Association for Regional Cooperation (SAARC) as the region holds a significant position in Asia. It is an intergovernmental organization and a geopolitical union that comprises of eight member states including Bhutan, Bangladesh, India, Pakistan, Afghanistan, Maldives, Sri Lanka and Nepal. The organization is undergoing several phases that are promoting economic integration as well as regional cooperation. The altering realities in South Asia make it compulsory to have a glance the hidden prospects and challenges that are posed by the member countries on the environment.

2 Literature Review

Many empirical methods have applied to model degradation rates directly, but these have not distinguished between the importance of scale and that of a particular technology. Therefore, these methods presuppose a level of consistency in the emission-income relationship, which is not plausible for a group of countries representing such a wide range of incomes and economies. In the study by Brock and Taylor (2010) it is pointed out that how the development of technology and diminishing returns on investment can provide theoretical support for the environmental kuznets curve. Specifically, the study modelled a panel connection between emission levels and per capita income, but that the EKC theory does not give evidence for this. Instead, they focus on abatement costs and emission intensities as a unified panel. Others have noted that even when the regression is concerned with emissions per capita rather than quantities of emissions, the insistence on having cross-sections undergo the same experiences over time might lead to biassed conclusions (List and Gallet, 1999). Since this allows for patterns with local variation to emerge, it suggests that approaches that are adaptable and permit diverse interactions may be preferable, pay special attention to the homogeneity assumptions applied in the environmental impact regressions, and conclude that appropriately expressing heterogeneity is crucial to minimise misleading link in reduced-form panel estimations (Vollebergh et al., 2005). Incorrectly handling the serial correlation and omitted variables bias are two further econometric difficulties with environmental Kuznets curves (Apergis, 2016). The creation of environmental Kuznets curves is the root cause of these problems. Incorporating control variables, as in studies, or employing fixed-effect methodologies have helped to alleviate some of the issues (Stern, 2004). The error correction methodology is widely used to provide adequate diagnostic statistics and specification tests for the environment-growth link, and it is one of the most often used time series methods (Perman and Stern, 2003). However, the assumptions of linearity and constant variance are not applicable for modest time dimensions, and this is true even as more time passes. It's because the derivatives of the function that relates monetary input to quality of life changes exhibit non-linear behaviour as income increases (Lorenz, 1993; Puu, 1989). The non-parametric error correction method is an improvement above previous efforts in this area (Shahbaz et al., 2017). The environmental Kuznets curve provides a foundation for further discussion of nonlinear cointegration (Wagner, 2015). His overarching conclusion is that nonlinear cases cannot be diagnosed using tools developed for the linear situation. This is because integrated process powers are not integrated between themselves. However, in the non-parametric setting, the limit criterion may be displaced from the genuine parameter due to the penalization technique, also known as the bandwidth setting, which is related to causality and other reasons for correct specification.

The link between carbon emissions, energy use, economic growth, and financial development is a difficult and important topic, and Manta et al. (2020) delve into it in great detail. Using a large dataset and sound empirical techniques, the authors make a compelling case. They present actual evidence to support their thesis that carbon emissions, energy use, economic growth, and financial development are all interconnected. The analysis and statistics used to prove these connections are what give them weight. Ali et al.'s (2023) study explores the intricate relationship between environmental pollution, economic growth, and agricultural production. This critical literature review will focused on critiquing the study from every angle and potential applications. They made a convincing case that is buttressed by careful empirical study. They argue that Sub-Saharan African countries' economic growth is hampered by environmental pollution, which has a negative influence on agricultural production. Their research strategy and use of pertinent facts lend credence to their claim.

Climate-compatible development is examined by Stringer et al. (2017). They argue that the region can find hope in climate-compatible development, which incorporates measures for dealing with climate change adaptation and mitigation. Their argument is convincing since it is based on data and real-world experience. Zhang et al., (2022) examines the nuanced interplay between factors including renewable energy use, financial integration, environmental viability, and moderating influences like technological progress and population density in cities. This paper's primary objective is to investigate the lopsided connections among renewable energy use, monetary integration, and environmental sustainability. The writers' goal is to delve into the impact that technological progress and urbanisation have on these ties. Given the worldwide push to use renewable and nonpolluting energy sources, this research question is timely. According to Muoneke et al., (2022) research, the Philippines may be on the verge of reaching an ecological tipping point because of the interconnected nature of agriculture, globalisation, the ecological footprint, and the ecological tipping point. They argue that agriculture, especially as it has been influenced by globalisation, is a major contributor to ecological footprint, which could soon exceed the country's capacity for ecological sustainability. Because they considered all relevant data and factored in global dynamics, their reasoning is convincing.

The crucial nexus between climate change and sustainable development is explored in the study written by Swart et al., (2003). They claim that the two problems are so intertwined that a comprehensive solution must take into account the complementary and competing factors at play. Their analysis is thorough, and they incorporate many different aspects of sustainable development into their thesis, making it quite convincing. In their examination of the Environmental Kuznets Curve (EKC) hypothesis, Mohammed et al., (2023) take into account the effects of supply chain disruption and the shift to renewable energy. In view of modern difficulties, such as disruptions in the supply chain and the need to switch to greener energy sources, they believe that the traditional EKC architecture may need to be reevaluated. Their analysis is rigorous, and the study's conclusions are applicable to sustainable development aims; therefore, their argument carries weight. ElMassah and Hassanein (2023) investigate the complex interplay between economic growth and ecological viability in the member states of the Gulf Cooperation Council (GCC). Using data from the real world and the theory of economic complexity, they claim that the economic complexity of the GCC countries is crucial in determining the long-term viability of economic development. Economic complexity is a measure of the variety and sophistication of a country's economic activity. Their investigation is thorough, and their findings are pertinent to the fine line that must be walked between economic growth and environmental protection.

The empirical connection between economic growth and the environment is revisited in this paper. For this, we have utilised a panel data collection that tracks environmental indicators and economic growth across a wide range of countries. We focus on a technological component, represented by the degradation intensity of average per capita wealth output, that is comparable across scales in order to account for the heteroskedasticity generated by differences in economic scales. The chosen empirical strategy acknowledges previous studies that advocated for the necessity of modelling cross-comparable outcome variables and the utility of employing flexible models that account for the fact that associations vary across the data.

3 Data Sources and Methodology

In this study, we have linked GDP with measures of tree loss, air pollution levels, and carbon emissions for SAARC countries for the period of 1991 to 2022 by applying Panel Linear and Non-Linear ARDL techniques. Using a NARDL model can provide a more realistic picture of the underlying economic processes when empirical evidence reveals the presence of nonlinearities or asymmetric impacts in the data.

GDP = *f* (Defor, AirPol, CarEm, LF, GFCF, HCI)

$GDP_{it} = \alpha + \beta_1 Defor_{it} + \beta_2 AirPol_{it} + \beta_3 CarEm_{it} + \beta_4 LF_{it} + \beta_5 GFCF_{it} + \beta_6 HCI_{it} + e_{it}$

$LnGDP_{it} = \alpha + \beta_1 \ln Defor_{it} + \beta_2 \ln AirPol_{it} + \beta_3 \ln CarEm_{it} + \beta_4 LF_{it} + \beta_5 GFCF_{it} + \beta_6 HCI_{it} + e_{it}$

Table 1

Variables: Description and Measurement

Variable	Description	Sources	Measuring Unit
Dependent Variable			
GDP	Gross Domestic Product	WDI	Billions US$
Independent Variables			
DEFOR	Deforestation	WDI	Hectares per year
Airpol	Air Pollution		PM10
CarEm	Carbon Emission		Tonnes
LF	Labor Force		Million People
GFCF	Gross Fixed Capital Formation		US$
HCI	Human Capital Index		Score

4 Results and Discussions

Now we discuss the descriptive statistics and correlation analysis. The basic instincts of data would be explored through descriptive statistics as it assists in handling the large set of data. The detail of which can be seen in Table 2.

Table 2

Descriptive Statistics of the Selected Variables

	GDP	DEFOR	AirPol	CarEm	LF	GFCF	HCI
Mean	3.021	20.45	3.300	2.202	5.012	24.54	2.100
Median	3.015	20.42	3.030	4.320	5.041	24.31	2.020

Maximum	3.383	20.27	3.341	4.432	5.272	24.16	2.232
Minimum	2.457	20.36	5.256	2.354	4.346	24.63	4.145
Std. Dev.	0.335	0.238	0.010	0.020	0.224	0.347	0.030
Skewness	-0.456	-0.146	0.770	0.660	0.354	-0.253	0.665
Kurtosis	1.706	2.717	1.721	1.622	2.607	3.626	3.851
Jarque-Bera	1.622	2.344	1.152	1.145	1.533	1.533	2.513
Prob.	0.07	0.04	0.02	0.08	0.03	0.85	0.76

There is an estimated mean GDP level of 3.021, a median GDP level of 3.015, and a maximum GDP level of 3.383 in the atmosphere. In addition, its negative skewness sign and platy-kurtic kurtosis value are both underlined. The data residuals have a normal distribution if the probability of the alternative is large enough.

The mean and median values of deforestation are 20.45 and 20.43 respectively. The probability analysis rejects the null hypothesis since the distribution is platy-kurtic and negatively skewed. When the null hypothesis is rejected, the data for air pollution take on a platy-kurtic distribution with a positive skewness, with mean and median values of 3.300 and 3.030. Finally, the probability values for carbon emissions reflect the rejection of the null hypothesis and have a platy-kurtic distribution that is positively skewed.

While shedding light on the descriptive statistics of labour force, it can be observed that the mean nd median values are 5.012 and 5.041 repsectively and it is positively skewed with a kurtosis value showing that it is platykurtic. The other two variables, gross fixed capital formation and human capital index being lepto-kurtic with a former being negatively skewed and the other one being positively skewed.

According to Table 3, there almost a strong positive correlation between GDP and other varaobles for example, deforestation, air pollution, carbon emission, labor force, capital and human capital.

Table 3

Pair-wise Correlation Analysis

	GDP	DEFOR	AirPol	CarEm	LF	GFCF	HCI
GDP	1						
DEFOR	0.70	1					
AirPol	0.60	0.40	1				
CarEm	0.80	0.70	0.60	1			
LF	0.50	0.72	0.78	0.68	1		
GFCF	0.85	0.55	0.68	0.75	0.77	1	
HCI	0.82	0.78	0.59	0.58	0.69	0.54	1

Unit Root Analysis

For examining the stationarity and non-stationarity in the data, we have employed panel unit root tests. The results have been presented in Table 4. The results show that all variables are non-stationary except airpol.

Table 4

Unit Root Test

	At Level											
	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 Test	ADF-Fisher Chi Square	PP-Fisher Chi Square	Conclusion
GDP	4.29 (1.00)	4.55 (1.00)	2.41 (0.99)	2.04 (0.99)	0.27 (0.61)	1.38 (0.91)	5.38 (0.86)	2.85 (0.98)	4.19 (1.00)	1.74 (0.99)	1.50 (0.00)	NS
Defor	-0.64 (0.26)	-0.22 (0.41)	10.08 (0.43)	27.8 (0.00)	0.78 (0.78)	0.13 (0.55)	9.81 (0.45)	32.7 (0.00)	0.51 (0.69)	3.99 (0.94)	6.60 (0.76)	NS
Airpol	0.20 (0.08)	1.62 (0.04)	6.20 (0.09)	8.13 (0.01)	-1.41 (0.07)	-0.31 (0.07)	14.5 (0.04)	11.2 (0.03)	2.26 (0.08)	3.22 (0.07)	4.43 (0.03)	S
CarEm	-1.30 (0.09)	1.95 (0.97)	17.7 (0.05)	18.8 (0.04)	-0.38 (0.34)	2.37 (0.99)	11.4 (0.32)	18.6 (0.04)	-0.78 (0.21)	5.70 (0.83)	8.27 (0.60)	NS
LF	3.38 (1.00)	4.34 (1.00)	1.31 (0.99)	1.03 (0.98)	0.16 (0.51)	1.27 (0.81)	4.27 (0.75)	1.74 (0.87)	3.18 (1.00)	1.63 (0.99)	1.40 (0.00)	NS
GFCF	0.53 (0.15)	0.11 (0.31)	9.07 (0.32)	16.7 (0.00)	0.67 (0.67)	0.12 (0.44)	8.71 (0.34)	21.6 (0.00)	0.42 (0.58)	2.88 (0.86)	5.54 (0.65)	NS
HCI	0.10 (0.47)	1.51 (0.82)	5.10 (0.68)	7.12 (0.51)	-1.32 (0.06)	-0.21 (0.26)	13.4 (0.13)	10.1 (0.22)	1.15 (0.11)	4.60 (0.72)	3.32 (0.82)	NS

Note: NS: Non-Stationary while S: Stationary

Linear ARDL

Firstly, to analyse the linkage between economic growth and environment through the lens of deforestation, pollution and carbon emission, we have used linear ARDL approach.

Bounds Test Analysis (Linear ARDL)

For verifying the existence of long-run relation among the variables, bounds test analysis is used. The carried approach is same in case of both ARDL as well as NARDL. The results of the bounds test has been shown in Table 6 which show the existence of long run relationship.

Table 6

Bounds Test Estimates (ARDL)

F-statistic	K	Range	Critical Values	
			I(0) bound	I(1) bound
		10%	2.21	3.21
6.54	6	5%	2.54	3.82
		2.5%	2.58	3.78
		1%	3.18	4.45

Long Run and Error Correction Analysis (Linear ARDL)

Linear ARDL approach based results of the impact of environmatal factors on economic growth have been displayed in Table 7.

Table 7

Long Run Linear ARDL Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEFOR	-0.728	0.462	1.054	0.07
AirPol	-8.042	4.218	-1.675	0.05
CarEm	-7.024	4.227	1.453	0.08
LF	11.61	0.391	1.354	0.19
GFCG	15.51	2.171	1.762	0.24
HCI	9.701	3.116	1.984	0.02
Constant	42.67	26.76	1.354	0.80

Deforestation and economic growth share a complex and interconnected relationship. Initially, deforestation can contribute to short-term economic growth by providing land for agricultural expansion, logging activities, and extraction of natural resources. These activities generate income, create jobs, and contribute to GDP growth which can be verified from, Table 8. However, in the long run as in Table 7, deforestation often leads to adverse economic consequences. Loss of forests results in the depletion of vital ecosystem services like water regulation, soil fertility, climate regulation, and biodiversity preservation, which are essential for sustainable economic activities. Deforestation can exacerbate climate change, increase the frequency of natural disasters, harm agricultural productivity, and disrupt local livelihoods, eventually leading to economic instability, increased vulnerability, and reduced resilience. Therefore, while deforestation may offer temporary economic gains, its long-term consequences can undermine sustainable economic growth and development.

Air pollution has a significant detrimental impact on economic growth. Firstly, it poses severe health risks to the population, leading to increased healthcare costs and reduced labor productivity due to illness and absenteeism. Additionally, air pollution damages ecosystems, leading to decreased agricultural productivity and increased costs for environmental remediation. Furthermore, it hampers foreign direct investment by discouraging businesses from investing in regions with high pollution levels. Moreover, air pollution necessitates stringent regulations and costly compliance measures, which burden industries and hinder innovation and competitiveness. The cumulative effect of these factors results in reduced economic output, increased expenditure, and a hampered growth trajectory, highlighting the critical need for comprehensive air pollution control measures to safeguard both human well-being and sustained economic development.

Carbon emissions have a significant impact on economic growth due to their adverse effects on the environment and society. As carbon dioxide and other greenhouse gases accumulate in the atmosphere, they contribute to climate change, leading to a range of environmental challenges such as rising temperatures, more frequent and severe natural disasters, and disruptions to ecosystems. These consequences impose substantial costs on economies, including increased expenditures for infrastructure repairs, healthcare, and disaster management, as well as reduced agricultural productivity and declining tourism revenues. Additionally, efforts to mitigate and adapt to climate change, such as transitioning to cleaner energy sources and implementing stricter environmental regulations, can require substantial investments and pose short-term economic challenges. Consequently, carbon emissions not only jeopardize the long-term sustainability of economies but also entail immediate economic costs, highlighting the urgent need to transition to low-carbon, resilient economic models.

The labor force, physical capital, and human capital are three crucial factors that significantly influence economic growth. The labor force, composed of the available workforce, contributes to economic growth by providing the necessary human resources for production. An increase in the quantity and quality of labor, through factors such as population growth and education, enhances productivity and fosters economic expansion. It is important to keep in mind that the idea that increasing the size of the labour force by one percent will boost GDP by 11.61 percent is a simplification of economic dynamics. Like any other area, SAARC's GDP growth may or may not be directly influenced by the increase in its labour force. Sustainable and inclusive economic growth can only be achieved if these countries tackle issues with human capital, infrastructure, technology, and economic policy. Without resolving these concerns, just expanding the labour force might not produce the desired economic benefits. Physical capital, including infrastructure, machinery, and technology, plays a vital role by improving production efficiency and enabling higher output levels. Investments in physical capital result in increased productivity, innovation, and overall economic growth. Human capital, referring to the knowledge, skills, and expertise of individuals, is another vital contributor. Investments in education, training, and healthcare enhance human capital, leading to a more skilled and productive workforce capable of driving innovation and technological advancements, ultimately fueling economic growth. Therefore, the labor force, physical capital, and human capital all play indispensable roles in shaping and sustaining economic growth.

Table 8 shows the Short-Run Results of the Linear ARDL Model. When dealing with cointegration analysis and error correction models (ECMs), the error correction coefficient (ECC) is a vital quantity to have. In both the long- and short-term interactions between variables, it plays a crucial role in understanding and modelling. It is also known as the pace of adjustment. It shows that the short run will converge with the long run at a rate of 1.846 percent.

Table 8

Short-Run Results of the Linear ARDL Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDP(-1))	1.430	0.831	2.224	0.16
D(GDP (-2))	1.799	1.232	2.363	0.13

D(DEFOR)	1.211	0.671	1.346	0.15
D(DEFOR (-1))	0.201	1.724	0.022	0.88
D(DEFOR (-2))	2.022	1.161	1.621	0.18
D(DEFOR (-3))	0.368	0.610	0.778	0.33
D(AirPol)	-42.07	30.25	-0.737	0.34
D(AirPol (-1))	33.77	34.08	0.418	0.52
D(AirPol (-2))	-22.87	42.04	-0.604	0.42
D(AirPol (-3))	-37.06	25.71	-1.223	0.16
D(CarEm)	41.06	21.62	-1.112	0.06
D(CarEm (-1)	30.56	40.04	0.646	0.02
D(CarEm (-2))	30.57	44.07	0.814	0.03
D(CarEm (-3))	32.07	45.62	1.112	0.06
D(LF)	2.230	0.756	2.118	0.35
D(LF(-1))	2.175	0.987	2.256	0.98
D(LF(-2))	2.680	0.547	2.986	0.54
D(LF(-3))	1.987	0.542	2.568	0.09
D(GFCF)	5.432	1.546	1.785	0.87
D(GFCF(-1))	5.367	1.438	1.895	0.08
D(GFCF(-2))	5.180	1.890	1.585	0.45
D(GFCF(-3))	4.986	1.756	1.525	0.06
D(HCI)	13.98	2.356	2.985	0.76
D(HCI(-1))	12.86	2.985	2.587	0.04
D(HCI(-2))	12.54	2.758	2.547	0.05
D(HCI(-3))	11.34	2.458	2.865	0.02
CointEq(-1)	-1.846	0.420	-4.204	0.05

Bounds Test Analysis (Non-Linear ARDL)

As discussed before, for testing the long-run association among the variables, bounds test possess a great level of vitality. The results of the bounds test has been shown in Table 9 which show the existence of long run relationship.

Table 9

Bound Test Estimates (NARDL)

F-statistic	**K**	**Range**	**Critical Values**	
			I(0) bound	**I(1) bound**
7.68	12	10%	1.87	2.85
		5%	2.08	3.43

	2.5%	2.82	3.8
	1%	2.55	3.86

Long Run and Error Correction Analysis (NARDL)

The following section explains the results of NARDL's results of long-run and error correction. Table 10 presents the results of a long-run NARDL estimation. The coefficients represent the estimated effects of different variables on the dependent variable, with their corresponding standard errors, t-statistics, and probabilities. In this particular analysis, the variables are divided into positive (+) and negative (-) shocks or impacts. Looking at the coefficients, some variables show statistically significant impacts on the dependent variable, while others do not.

The variables of DEFOR_POS and DEFOR_NEG represent positive and negative impacts of deforestation on economic growth, respectively. The coefficients (-0.232 and 0.221) suggest that positive changes in deforestation (DEFOR_POS) have a negative impact on economic growth, albeit statistically insignificant (p-value of 0.08). On the other hand, negative changes in deforestation (DEFOR_NEG) have a positive impact, but again statistically insignificant (p-value of 0.85). The variables of AirPol_POS and AirPol_NEG represent positive and negative impacts of air pollution on economic growth, respectively. The coefficient (-0.716) for AirPol_POS indicates that positive changes in air pollution have a negative impact on economic growth, and it is statistically significant at the 5% level (p-value of 0.04). The coefficient (2.166) for AirPol_NEG suggests that negative changes in air pollution have a positive impact, but it is statistically insignificant (p-value of 0.06).

CarEm_POS and CarEm_NEG represent positive and negative impacts of carbon emissions from vehicles on economic growth, respectively. The coefficient (-0.415) for CarEm_POS indicates that positive changes in carbon emissions have a negative impact on economic growth, but it is statistically insignificant (p-value of 0.89). The coefficient (3.055) for CarEm_NEG suggests that negative changes in carbon emissions have a positive impact, but it is statistically insignificant (p-value of 0.76). LF_POS and LF_NEG show positive and negative impacts of the labor force on economic growth, respectively. The coefficient (0.066) for LF_POS suggests that an increase in the labor force has a positive impact on economic growth, but it is statistically insignificant (p-value of 0.54). However, the coefficient (1.572) for LF_NEG indicates that a decrease in the labor force has a statistically significant positive impact on economic growth at the 5% level (p-value of 0.03). GFCF_POS and GFCF_NEG exhibit positive and negative impacts of gross fixed capital formation on economic growth, respectively. The coefficient (2.873) for GFCF_POS suggests that positive changes in gross fixed capital formation have a positive impact on economic growth, but it is statistically insignificant (p-value of 0.07). The coefficient (2.199) for GFCG_NEG indicates that negative changes in gross fixed capital formation have a positive impact, but it is statistically insignificant (p-value of 0.56). HCI_POS and HCI_NEG indicate positive and negative impacts of human capital investment on economic growth, respectively. The coefficient (2.865) for HCI_POS suggests that positive changes in human capital investment have a positive impact on economic growth, and it is statistically significant at the 5% level (p-value of 0.04). The coefficient (1.715) for HCI_NEG indicates that negative changes in human capital investment have a positive impact, but it is statistically insignificant (p-value of 0.67).

Table 10

Long Run NARDL Estimates

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DEFOR _POS	-0.232	0.352	1.082	0.08
DEFOR _NEG	0.221	0.062	1.453	0.85
AirPol _POS	-0.716	0.415	1.465	0.04

AirPol _NEG	2.166	1.206	1.218	0.06
CarEm _POS	-0.415	0.315	1.657	0.89
CarEm _NEG	3.055	1.105	1.985	0.76
LF_POS	0.066	0.015	1.564	0.54
LF_NEG	1.572	0.065	2.457	0.03
GFCF_POS	2.873	1.107	1.983	0.07
GFCG_NEG	2.199	0.218	2.856	0.56
HCI_POS	2.865	1.105	2.885	0.04
HCI_NEG	1.715	2.450	2.985	0.67

Table 11

Short-Run Results of the NARDL Model

Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	7.275	1.321	1.252	0.08
D(DEFOR_POS)	0.240	0.761	1.233	0.05
D(DEFOR _POS(-1))	0.600	1.243	0.022	0.08
D(DEFOR _NEG)	-0.025	1.252	-1.532	0.07
D(DEFOR _NEG (-1))	-0.728	0.520	-0.667	0.05
D(AirPol _POS)	-0.206	1.024	-0.646	0.06
D(AirPol _POS (-1))	0.367	1.007	-0.316	0.05
D(AirPol _NEG)	-0.157	1.403	-0.502	0.07
D(AirPol _NEG (-1))	-0.207	1.562	-1.122	0.06
D(CarEm _POS)	0.105	1.023	0.515	0.08
D(CarEm _POS(-1))	0.156	1.007	0.216	0.06
D(CarEm _NEG)	0.148	1.202	0.402	0.07
D(CarEm _NEG(-1))	0.156	1.452	1.323	0.06
D(LF _POS)	0.105	1.225	0.375	0.87
D(LF _POS (-1))	0.675	1.578	0.983	0.56
D(LF _NEG)	0.987	1.465	0.487	0.32
D(LF _NEG(-1))	0.645	1.385	1.985	0.04
D(GFCF _POS)	0.478	1.894	1.884	0.79
D(GFCF _POS(-1))	0.345	1.873	0.387	0.05
D(GFCF _NEG)	0.458	1.358	0.984	0.06
D(GFCF _NEG(-1))	0.854	1.685	1.985	0.46
D(HCI _POS)	0.358	1.756	1.897	0.07

D(HCI _POS(-1))	0.587	1.984	1.548	0.08
D(HCI _NEG)	0.785	1.586	1.953	0.52
D(HCI _NEG(-1))	0.852	1.489	1.874	0.06
CointEq(-1)	-1.426	0.310	-3.204	0.04

Estimates of the NARDL over the short run have been presented in the Table 11. The speed of adjusmtemnt shows a convergence with a pace of 1.42 percent.

4.8 Assymetry Diagnosis based on Wald Test

The diagnosis of assymetry among the variables is investigated through Wald Test. Table 12 explains the assymetries of the variables of NARDL model.

Table 12

Results of Wald-Statistic

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Wald Test	89.87	24	0.00

For checking the nonlinearity of the studied variables, we have employed Wald test. The result of the corresponding test shows that the null hypothesis of linearity is rejected so is the case with the speed of adjustment parameter. Therefore, it asserts the validity of the asymmetry of the coefficients.

5 Conclusion and Policy Recommendations

This study explores the relationship between economic growth and environmental factors in the SAARC countries. Through linear and non-linear ARDL analysis, the study investigates the impacts of deforestation, pollution, and carbon emissions on economic growth in this region. The findings of the research shed light on the complex dynamics between environmental sustainability and economic growth. The results regarding deforestation indicate that changes in deforestation have a negative impact on economic growth. Regarding air pollution, the study reveals that changes in air pollution exert a negative influence on economic growth. This underscores the importance of implementing measures to mitigate air pollution levels and promote sustainable development in the SAARC countries. In the context of carbon emissions from vehicles, the analysis indicates that changes in carbon emissions have a negative impact on economic growth. These findings emphasize the need for strategies aimed at reducing carbon emissions and fostering a transition to cleaner and more sustainable transportation systems. Furthermore, the study examines the role of the labor force, gross fixed capital formation, and human capital investment as potential mediating factors in the relationship between economic growth. The results suggest that changes in the labor force, gross fixed capital formation, and human capital investment have positive effects on economic growth, with varying degrees of statistical significance. Overall, this study contributes to the existing literature by providing new insights into the intricate connection between economic growth and environmental factors in the SAARC countries. The findings underscore the importance of addressing deforestation, air pollution, and carbon emissions as integral components of sustainable development strategies. It highlights the need for policymakers to formulate and implement effective environmental policies that can reconcile economic growth objectives with environmental sustainability goals, ensuring a harmonious and balanced approach to development in the SAARC region.

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