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Non-Renewable Energy, Green Technological Innovation, and CO_2 Emissions in South Asia

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Abstract

Transitioning from fossil fuel usage to the adoption of green energy is crucial for mitigating the adverse impacts of greenhouse gas emissions. There is an urgent imperative to shift the economy away from reliance on non-renewable energy sources towards renewable alternatives to address environmental pollution effectively. This research aims to analyze the impact of non-renewable energy, green technological innovations, GDP, population, and industry on CO2 emissions across five South Asian countries, namely Pakistan, Bangladesh, India, Nepal, and Sri Lanka. Employing the Autoregressive Distributed Lag (ARDL) model and NARDL, the present study examined data spanning from 1985 to 2021. This study used STATA software to determine the association between variables. The findings indicate that an increase in non-renewable energy consumption leads to higher CO2 emissions across all five studied countries, while a decrease in non-renewable energy consumption helps reduce CO2 emissions. Population growth and GDP contribute to increase carbon emissions, whereas green technological innovations lead to a reduction in CO2 emissions in India, Sri Lanka and Nepal but boost CO2 levels in Pakistan and

Bangladesh. Industrialization also showed different impact in different countries as it mitigated CO_2 emissions in Pakistan, Bangladesh and Nepal but degrades the environment in India and Sri Lanka.

Keywords: Non-renewable energy, green technological innovation, CO_2 emissions, industrialization, South Asia.

1. Introduction

Climate change and the tremendous increase in carbon emissions over the last several decades have put a dark cloud over human existence and advancement, posing a new and unprecedented danger to the fate of our planet (Gan & Voda, 2023; Noor et al., 2024). Worldwide, environmental deterioration is speeding up as a result of people migrating developing areas for more developed ones as economies improve (Farooq et al., 2023). Forest fires, melting glaciers, increasing temperatures, droughts, floods, and deserts are just a few ways in which climate change is threatening Earth's biosphere and the survival of humans (Xia, 2023). Modern economic advancement has been impeded by the increased greenhouse gas emissions caused by the significant reliance on fossil fuels for energy production (Zhang et al., 2022). The creation of jobs, the improvement of transportation, the promotion of trade, the advancement of agriculture, the acceleration of economic growth, and the guarantee of human prosperity and the relief of poverty in the long run are all directly impacted by energy consumption. Nonetheless, it is still the single largest source of emissions of GHGs (Chien, 2022). Expansion of economic activities, urbanization, and industrial boom all contributed to a rise in energy demand, which is seen as a development indicator (Bulut, 2017).

Long-term growth is seriously threatened by unchecked environmental contamination, which has led to a rise in studies examining the connection between ecological degradation and GDP per capita. For any country, having a high GDP per capita is still the key goal. As a result, developed economies are focusing more on how their growth policies affect the environment (Awan &Azam, 2022; Onakpojeruo et al., 2025). An essential policy objective for all countries is now sustainable economic growth. SDGs for sustainable development are challenged by the need to reduce CO_2 emissions in order to achieve this aim. Due to its potential to balance the pursuit of economic expansion with the requirement to improve environmental quality, innovation is becoming a focal point in discussions about climate change policy (Dauda et al., 2019; Chontanawat, 2020). Effective energy production and sustainable development are now dependent on innovation in both developed and emerging countries. Economic growth can be promoted without contributing to environmental damage by changing energy sources. This fundamental shift toward sustainable economic prosperity is mostly being driven by technological advancements (Dauda et al., 2019). The world's economies must shift to low-carbon models if we are to combat climate change, eradicate pollution, and ensure steady energy supply. The level of pollution in our environment is high, which makes sustainable development quite difficult. Consequently, discussions around the world are focusing on the crucial connection between GDP and environmental sustainability (Farooq et al., 2023).

While artificial processes can also release significant amounts of carbon dioxide into the atmosphere, the most effective method for preventing such emissions is the development of new green technologies (Shao et al., 2021; Sharif et al., 2022). The primary goals of green technology include resource recycling, reducing carbon emissions, keeping tabs on green business practices, and using purifying techniques (Guo et al., 2020; Sharif et al., 2022). Green technological innovations play a crucial role in turning and advancing society from fossil fuel consumption to renewable energy utilization. For long-term sustainable development and carbon emission mitigation, it has been declared that developing countries must quickly adopt renewable energy and green technology to replace nonrenewable energy sources (Obobisa et al., 2022). By creating eco-friendly goods and services, decreasing energy intensity and refining manufacturing capacity, green technology innovation can be seen as the primary tool for enhancing environmental quality (Chang et al., 2023). For the planet's sake, every nation must adopt energy policies and implement technological advances that have the smallest possible negative effect on the natural world (Umar et al., 2020; Su et al., 2020; Shan et al., 2021).

One of the main causes of greenhouse gas emissions is the burning of fossil fuels, which releases a lot of CO2. Because of this, the energy industry is frequently deemed primarily responsible for greenhouse gas emissions. Environmental and energy policies are tightly entwined, with each dynamically affecting and developing the other (Ardakani et al., 2019). Countries must reduce their CO2 emissions in order to meet their obligations. Achieving this target requires a shift from non-renewable to renewable energy sources, underscoring the necessity of major CO2 reduction initiatives. With the goal of achieving socioeconomic and environmental sustainability through the effective use of renewable energy, global economies are progressively coordinating their transition from the conventional reliance on non-renewable energy to cleaner, sustainable alternatives (Zaidi et al., 2018). A plethora of academics have studied the correlation between rising economies and polluting energy consumption. Renewable energy sources improve environmental quality, but their high costs dampen economic activity. Policymakers aim to ensure the availability of affordable, reliable energy sources while decreasing carbon emissions, which contribute to environmental deterioration (Zhang et al., 2022).

Increasing population, residential housing size, and urbanization degree all have a negative impact on environmental quality, as does the size of the population (Wang et al., 2017). It is observed that a higher level of working-age people contributes highly to CO2 (Fan et al., 2006; Wang et al., 2017). Economic and population growth are the most significant drivers of CO2 emissions. Investigating the connection between population and carbon emissions is a formidable task. Furthermore, emissions and energy consumption will be impacted by a myriad of population dynamics that are beyond our control due to environmental changes in the next decades. Research on the effects of population dynamics on CO2 emissions is, thus, highly warranted and crucial (Wang et al., 2017). Changing environmental conditions are frequently associated with both natural and anthropogenic factors, including but not limited to continental drift, ocean currents, solar radiation, and volcanic activity. Environmental change, according to some scholars, is mostly caused by industrialization, global population rise, and the resulting increase in human activities (Pachiyappan et al., 2021).

There has been a notable and rising fluctuation in industrial CO_2 emissions, particularly in the manufacturing sector (Talbi et al., 2022). Industrial sectors contributed mainly to CO_2 emissions from the industrial sector, which was 21.4G tons. Economists had a positive outlook on the contribution of natural resources to local economic growth prior to the 1960s. Rich natural resources, especially an abundance of energy and resources, were seen as the cornerstone of industrialization and the engine of economic expansion (Xue et al., 2020). Coal and oil were the lifeblood of the industrial revolution and the driving forces behind its rapid development. While these fossil fuels sped up industrialization, they also dramatically increased carbon dioxide emissions. The expansion of industry has long been seen as essential to any society's economic progress, whatever the environmental costs involved (Zhang et al., 2022). The struggle between people, resources, and the environment has gotten more intense recently due to the acceleration of urbanization and industrialization. Although population increase used to spur economic growth, it is now seriously affecting the environment (Wang et al., 2017). Worldwide, 54% of all energy consumption occurs in industrial processes, making it the most energy-intensive sector, according to the International Energy Agency. There has been a noticeable increase of 1.6% in energy consumption within the sector in 2017, continuing an average yearly growth rate of 0.9% since 2010.

South Asia is the fastest-growing region in population, industry, and economic activities. Although some of these factors are significant for this region, they have also contributed to environmental challenges, particularly the rise in CO_2 emissions. To address this problem, green technological innovation and renewable energy can play a significant role, yet this region has ignored the contribution of these variables. Other variables, including GDP, industrialization, and population, are also key contributors to CO_2 and need in-depth investigation. This aims to explore the intricate relationship between these variables, providing policy implications for achieving sustainable development and a healthy environment in South Asia.

While many researchers have worked on the determinants of environmental degradation, yet the South Asia region has been overlooked. The region is most affected by climate change and is experiencing rapid population and economic growth. Most existing literature has focused on linear models and ignored the variations in these factors during growth and decline periods. This study filled this gap by employing the NARDL model to examine the asymmetric connection between these variables and offer insightful policy recommendations for sustainable development in South Asia.

This study significantly contributes to solving the problem of environmental degradation. South Asia is one of the most sensitive regions that are victims of climate change. Due to heavy reliance on fossil fuels along with rapid population expansion and industrialization, this faces significant environmental challenges. This study highlights the importance of technological innovations in reducing environmental risk in South Asian countries. Moreover, this study provides insightful energy policy reforms to achieve sustainable development. Additionally, it highlighted the dual role of industrialization and population on environmental quality; as both drive economic progress and participate in environmental degradation.

The five South Asian nations are the focus of this study, which examines the impact of industrialization, population, green technological innovation, non-renewable energy, and gross domestic product on environmental sustainability. This report analyses data from five different economies to provide new insights into the effects of CO2 emissions on Earth's health by illuminating the complex link between these variables. Secondly, the second issue is that it is unclear from the current literature whether the relationship between nonrenewable energy sources and environmental degradation is linear or nonlinear. Our study, which spans the years 1985–2021, seeks to clarify this uncertainty by examining the unequal effect of renewable energy on ecological sustainability in these five South Asian countries. Thirdly, we show how these variables really play a role by combining linear and nonlinear econometric estimations. Not only does this novel methodological approach provide more stable and reliable results than conventional estimating methods, but it also outperforms them. In the end, our study offers priceless information for these economies, helping policymakers and officials to create plans that promote environmental sustainability a crucial goal for a more sustainable future.

Here is how the article is structured: The literature review and theoretical linkage is covered in Section 2. Section 3 describes methodology and data; section 4 gives the findings and discussions and section 5 is about conclusions.

2. Literature Review and Hypotheses Development

2.1 Non-Renewable Energy Affects Environmental Sustainability

Apergis et al. (2023) for Uzbekistan, covering the period 1985 to 2020, conducted the interconnection between non-renewable energy, and CO_2 emanations. The observed results of the research report showed that non-renewable energy enhances CO_2 release, while RNE boosted the environmental quality. Similarly, the tie between NRE, GDP, and CO_2 was tested by Bulut (2017) by employing FMOLS for Turkey. The research findings revealed that GDP, NRE, and RNE impede environmental quality. From 1970 to 2016, using the ARDL approach, Zaidi et al. (2018) for Pakistan discovered the interconnection between NRE, GDP and CO_2 leakage. The research outcomes proved that RNE showed an insignificant impact on CO_2 discharge; in addition, non-renewable energy and GDP bulldozed the environmental quality. Adopting the FMOLS approach, Nunez et al. (2021) inspected the union between GDP, NRE, RNE, and CO_2 secretion in Mexico. The outcomes of the study uncovered that GDP positively influenced CO_2 emanations and GDP square reacted opposite it, while non-renewable energy enhanced CO_2outflow. For Tunisia, by utilizing the VECM technique, Ben Mbarek et al. (2018) demonstrated the linkage between NRE, RNE, GDP, and CO_2 discharge during the period 1990 to 2015. According to the outcomes of the study, GDP and non-renewable energy destroyed the environment; meanwhile, renewable energy consumption ameliorated environmental quality. The affiliation between GDP, NRE, RNE, and CO_2 ejection was discovered by Chien (2022) for N-11 countries by employing 1990 to 2020. The observed outcomes of the research disclosed that renewable energy and GDP square boost environment quality; meanwhile, non-renewable energy and GDP accelerated CO_2ejection. Noor et al. (2024) identified the connection between non-renewable energy and CO2 for South Asian countries employing PARDL and Onakpojeruo et al. (2025) for India adopting ARDL. They found the same results for different countries: non-renewable energy enhanced pollution. Nathaniel and Iheonu (2019) used the AMG approach to revisit the link between renewable energy, non-renewable energy, GDP, trade, FD and CO_2 exuding from 1990 to 2014 for 19 African countries. The empirical outcomes disseminated that RE, GDP and trade support the environmental quality; in contrast, non-renewable energy and FD acceleratedCO_2 emanations. The interconnection between GDP, NRE, RNE, trade, agriculture, industry, and CO_2 outflow was conducted by Omri and Saidi (2022) for African countries. The verifiable results of the research unfold that GDP, NRE, and trade shoot up CO_2 release; in addition, RE and GDP square mitigate CO_2 outflow.

- H_1: Non-renewable energy affects environmental sustainability.

2.2 Green Technological Innovation Affects Environmental Sustainability

Xia (2023) utilized the Cup-FM approach from 2005 to 2019 to discover the affinity between GDP, RNE, industry, urbanization, green technological information, and CO_2 excretions in China. The assessment of the study unveiled that urbanization and green technological innovation upgrade the environment; in contrast, renewable energy, GDP, and industry shoot up outpouring. Covering 1990 to 2018, employing BARDL to scrutinize the association between green technology, RNE, income, energy consumption, and CO_2 outflow by Shan et al. (2021) for Turkey. The interpretation of the outcomes of green technology and RNE reduced CO_2 exhalations; meanwhile, energy consumption, population, and income cause environmental pollution. Covering 2003 to 2019, Chang et al. (2023) for China 30 Provinces inspected the link between green technological innovation, FDI, population, education, environment regulation, and CO_2 exuding. The empirical results revealed that FDI and green technological innovation reduce CO_2emanations. The relatedness between GDP, green technological innovation, population, export, and CO_2 releases by Majekodunmi et al. (2023) over the period 1989 to 2019 for Malaysia. The evidence proved that green technological innovation and population reduce CO_2 ejection; conversely, GDP and exports raise CO_2 release. Obobisa et al. (2022), during the years 2000 to 2018, used the AMG technique to assert the attachment between green technological innovation, institutional quality, RNE, fossil fuel energy usage, GDP, and CO_2 discharge for African countries. According to empirical evidence, green technological innovation and renewable energy support environmental quality; in contrast, institutional quality and GDP destroy environmental quality. Using CS-ARDL for N-11 countries covering the years 1980 to 2018 by Shao et al. (2021) unfold the tie between green technological innovation, RNE, NRE, and CO_2 leakage. According to evidence, green technological innovation and RNE decrease CO_2 ejection; conversely, non-renewable energy proposed a favorable impact on CO_2 ejection. Employing CS-ARDL by Sharif et al. (2022) from 1995 to 2019 for G-7 countries underlined the relatedness between green technological innovation, green finance, GDP, globalization and CO_2emanation. The findings displayed that GDP and globalization leads to higher CO_2 outpouring, yet green finance and green technological innovation mitigates CO_2 outflow.

- H_2: Green technological innovation affects environmental sustainability.

2.3 Gross Domestic Product, Industry and Population Affects Environmental Sustainability

Pejovic et al. (2021) employed the GMM approach for 27 EU countries to probe the tie between GDP, RNE, energy utilization, and CO_2 outflow. The estimated results disclosed that GDP enhanced environmental pollution; conversely, renewable energy lessened CO_2outpouring. Utilizing FMOLS by Farooq et al. (2023) verified the nexus between GDP, financial inclusion, trade, tourism, electricity production, population density, and CO_2 discharge for 6 GCC countries. The author found that GDP, electricity production, financial inclusion, population, and tourism support CO_2 release; conversely, trade and banking development surge environmental quality. The attachment between trade, industry, GDP, population density, and CO_2 outflow were scrutinized by Aslam et al. (2021) employing the ARDL approach for the years 1962 to 2018. The results displayed that population density, trade, and industry diminished environment, while per capita GDP curbed CO_2release. The tie between FDI, GDP, energy consumption, income, and CO_2 leakage by Maroufi and Hajilary (2022) by adopting ARDL covering the period 1970 to 2016 for Iran. The assessed outcomes of research proposed that gas, GDP, and income shoot up CO_2 ejection; in addition, FDI and GDP square lessen CO_2 ejections.

- H_3: GDP affects environmental sustainability.

For China, covering the period 1997 to 2014, Li et al. (2017) probed the relationship between industry, GDP, technological progress and CO_2 emanations by adopting the STRIPAT approach. The verifiable outcomes of the study unfold that industry structure, rationalization, and industry structure upgrading reduced CO_2 ejection, while population and urbanization exacerbatedCO_2 emanations. Nwani et al. (2023) used the period 1995 to

2017 by using the MMQR model to document the affiliation between industry, ICT, population and CO_2 outflow. The empirical evidence showed that ICT and industry surge CO_2emanations.From 2004 to 2019, Siqin et al. (2022) analyzed the correlation between fossil fuel energy, GDP, industrial structure, urbanization, and CO_2 emanations from North China. The empirical evidence showed that GDP and urbanization diminish CO_2 outflow; meanwhile, industry and fossil fuel boost CO_2 excretion. Utilizing the ARDL approach for Vietnam, Ali et al. (2021) asserted the interconnection between fossil fuel consumption, GDP, industry, FD, and CO_2 ejections. The actual findings of the research unfold that fossil fuel and FD amplified CO_2 emanations. Industry lessened CO_2; meanwhile, industry square enhanced CO_2 emanations. For Tunisia over the period 2000 to 2018, Talbi et al. (2022) asserted the affinity between urbanization GDP energy consumption, industry, and CO_2 exhalation. The outcomes of the research disseminated that urbanization, energy from natural gas, and industry accelerated CO_2 emanations, while energy efficiency GDP impedes CO_2emanations.

- H_4: Industry affects the environmental sustainability.

Employing the CCEMG model observed the tie between GDP, renewable energy, industry service, and CO_2 discharge over the period 1996 to 2017 by Zhang and Wang (2019) for BRICS countries. The experimental results confessed that GDP square and renewable energy mitigated CO_2 secretion; in addition, GDP and industry ramped up CO_2ejection. Rahman and Alam (2021), for Bangladesh, by employing ARDL, demonstrated the relationship between clean energy, population density, urbanization, trade, economic development, and environmental pollution covering the period 1973 to 2014. The empirical evidence proved that clean energy diminished CO_2 ejection while trade, population, and urbanization lessened environmental quality. For OECD countries, by employing the GMM approach Hashmi and Alam (2019) examined the relationship between population, GDP, environmental tax revenue and CO_2 leakage covering the period 1999 to 2014. The observed results of the research announced that population and GDP expedited CO_2 emanation, while environmental tax revenue cleaned the environment. The union between energy consumption GDP, population, trade, and CO_2 secretion were investigated by Ohlan (2015) for India by employing the VECM approach over the period 1970 to 2013. The verifiable evidence displayed that population density, GDP and energy consumption stimulated CO_2 ejection, while the connection between trade and CO_2 was found insignificant.

- H_5: Population affects the environmental sustainability.

2.4 Theoretical Linkage

The study based on STIRPAT model, which stands for Stochastic Impacts by Regression on Population, Affluence, and Technology, is a sophisticated analytical tool used to study the environmental impacts of human activities. Building on the classic IPAT model (Impact

= Population x Affluence x Technology), STIRPAT introduces stochastic elements to account for variability and uncertainties in data. The model modifies the deterministic IPAT equation into a stochastic form, typically expressed as $I=aP^bA^cT^d$, where I represents the environmental impact, P is the population, A is affluence, and T is technology, with a being a constant and b, c, d being the elasticities of the respective variables. These elasticities capture the proportional impacts of population, affluence, and technology on the environment (Dietz and Rosa, 1994; York et al., 2003).The stochastic nature of STIRPAT, as opposed to the deterministic IPAT model, allows for the inclusion of random errors, making it more flexible and realistic in capturing the complexities of real-world data. By transforming the model into a logarithmic form, it can be analyzed using regression techniques, enabling hypothesis testing and inference of the significance of each variable. STIRPAT is particularly useful for policy analysis, helping to understand the relative contributions of different factors to environmental degradation and aiding in the formulation of targeted policies. Additionally, it is used in sustainability studies to assess the sustainability of economic growth by analyzing the trade-offs between population growth, economic development, and technological advancements. The model also facilitates comparative studies across different regions or time periods by examining how changes in population, affluence, and technology influence environmental impacts (Fan et al., 2006). The environmental Kuznets curve addresses the CO_2 GDP nexus. Griffin and Schiffel first developed this theory (1972); Grossman and Kruger updated it in 1991. This theory indicates an inverted U-shape relationship between income level and environment, which implies that at the initial stages of an economy's growth, Co_2 rises. Still, after reaching a certain level, the growth in income levels enhances the ability to overcome the problem of environmental degradation (Kaika & Zervas, 2013). CO_2 levels have increased by 50% higher than in the early stages of the large-scale burning of fossil fuels (Siegenthaler & Oeschger, 1978). Moreover, Chontanawat (2020) found a strong relationship between industrialization and CO_2 emissions in South Asian countries from 1995 to 2015. Salari et al. (2021) also asserted a positive, significant relationship between energy use and CO_2 emissions. However, renewable sources may be the best alternative energy source that may help to reduce CO_2.

3. Methodology

This section demonstrates the variables used in this study, the measurement of variables, and data sources. CO2 is measured as CO2 emission (kt), non-renewable energy (NRE) as energy use (kg of oil equivalent per capita), GDP as GDP growth (annual %), green technological innovation as patent applications, resident, the industry as the industry (including construction value added annual % growth), population is measured as Population. Data is utilized from 1985 to 2021. All data is taken from world development indicators.

Table 1: Variables Description

Variables	**Symbol**	**Measurement**	**Data Source**
Carbon emission	CO_2	CO_2 emissions (kt)	WDI
Non-renewable energy	NRE	Energy use (kg of oil equivalent per capita)	WDI
Gross domestic product	GDP	GDP growth (annual %)	WDI
Green technological innovation	GTIN	patent applications, resident,	WDI
Industry	INDS	industry (including construction value added annual % growth)	WDI
Population	POP	Population, total	WDI

In this study, we have taken CO_2 emission as dependent variable while NRE, green technological innovation, GDP, population, and industry are explanatory variables. All data is transformed into logarithmic form to achieve efficient, consistent, and better results and to avoid the problem of heteroskedasticity. The study based on STIRPAT model, which stands for Stochastic Impacts by Regression on Population, Affluence, and Technology, is a sophisticated analytical tool used to study the environmental impacts of human activities. Building on the classic IPAT model (Impact = Population x Affluence x Technology), STIRPAT introduces stochastic elements to account for variability and uncertainties in data.

The model of study is as under with control variables:

$$CO_2 = f\ (NRE, GTIN, GDP, POP, INDS) \qquad (i)$$

Here CO_2 is carbon emissions, non-renewable energy represents non-renewable energy, GTIN stands for green technological innovation, GDP is gross domestic product, POP shows population growth, INDS is a symbolic representation of industrialization.
In this analysis, we will use the following econometric equation;

$$CO_{2t} = \xi_5 + \xi_6 NRE_t + \xi_7 GTIN_t + \xi_8 GDP_t + \xi_9 POP_t + \xi_{10} INDS_t + \mu_t \quad (ii)$$

The Auto Regressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) models are widely used for analyzing time-series data with mixed levels of integration (I(0) and I(1)). ARDL is ideal for examining long-run relationships and short-run dynamics between variables, even with small sample sizes. NARDL extends this by capturing asymmetries, allowing for the analysis of the differential effects of positive and negative changes in explanatory variables (Faheem et al., 2020).

Here is how the estimation equations for the ARDL are written down:

$$\Delta CO_{2_t} = \xi_4 + \sum_{c=1}^{w} \xi_{5_i} \Delta CO_{2_{t-1}} + \sum_{c=0}^{w1} \xi_{6_i} \Delta NRE_{t-i} + \sum_{c=0}^{w2} \xi_{7_i} \Delta GTIN_{t-i} + \sum_{c=0}^{w3} \xi_{8i} GDP_{t-i} + \sum_{c=0}^{w4} \xi_{9i} \Delta POP_{t-i} + \sum_{c=0}^{w5} \xi_{10i} \Delta INDS_{t-i}$$
$$+ \vartheta_5 CO_{2_{t-1}} + \vartheta_6 NRE_{t-1} + \vartheta_7 GTIN_{t-1} + \vartheta_8 GDP_{t-1} + \vartheta_9 POP_{t-1} + \vartheta_{10} INDS_{t-1} + \mu_t$$

NARDL equation:

$$\Delta CO_{2_t} = \xi_4 + \sum_{c=1}^{w} \xi_{5_i} \Delta CO_{2_{t-1}} + \sum_{c=0}^{w1} \xi_{6_i} \Delta NRE^{+}{}_{t-i} + \sum_{c=0}^{w1} \xi_{6_i} \Delta NRE^{-}{}_{t-i} + \sum_{c=0}^{w2} \xi_{7_i} \Delta GTIN_{t-i} + \sum_{c=0}^{w3} \xi_{8i} GDP_{t-i} + \sum_{c=0}^{w4} \xi_{9i} \Delta POP_{t-i} + \sum_{c=0}^{w5} \xi_{10i} \Delta INDS_{t-i}$$
$$+ \vartheta_5 CO_{2_{t-1}} + \vartheta_6 NRE_{t-1} + \vartheta_7 GTIN_{t-1} + \vartheta_8 GDP_{t-1} + \vartheta_9 POP_{t-1} + \vartheta_{10} INDS_{t-1} + \mu_t$$

4. Results and Discussion

Using data collected from 1985 to 2021, this study examines the impact of non-renewable energy sources, green technological innovation, gross domestic product (GDP), population, and industrialization on environmental sustainability in five South Asian nations.

Table (see appendix) shows the descriptive statistics of the variables. Descriptive statistics shows the mean, median, St. deviation, etc. The table shows that for Pakistan, CO_2 has the highest mean value of 124358.2, while POP has the lowest mean value (1.74). In the case of Bangladesh, CO_2 has the minimum mean value (0.286), while green technological innovation (GTIN) reported the highest mean value (49.53). India shows CO_2 has the highest mean value (1380), while POP has the lowest minimum means value (1.15). The Nepal table shows that the population has the highest mean value (255300), and GTIN has the lowest mean value (3.104). Finally, Sri Lanka shows the population reported the highest mean value (1967), and GDP reported the lowest mean value (4.718).

4.1 Unit Root Test

Testing the series for their order of integration is an important first step before conducting econometric analysis on time series data. The augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests for stationarity are used for this purpose. A mixed order of integration is revealed by the results, which are presented in Table 2.

The co-integration results lead to the decision of applying autoregressive distributed lag model (ARDL) due to mixed order of integration of stationarity results. The results reported in the following table explain existence of co integration in the case of all countries results in both cases.

Table 2: Unit Root Test

Pakistan				
Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO_2	0.739	-4.514***	-1.001	-4.644***
NRE	-3.072**	-4.657***	-2.983**	-4.688***
GDP	-4.020***	-6.148***	-4.032***	-8.150***
GTIN	4.928	-7.452***	-0.575	-21.53***
POP	0.811	-3.853**	-0.646	-3.853**
INDS	-5.491***	-7.664***	-5.458***	-11.22***
Bangladesh				
Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO_2	-1.186	-1.707**	-1.186	-1.707**
NRE	1.903	-12.421***	1.903	-12.421***
GDP	-4.223***	-8.697***	-4.223***	-8.697***
GTIN	-3.190**	-9.668***	-3.190**	-9.668***
POP	-1.896	-9.202**	-1.896	-9.202**
INDS	-5.082***	-8.300***	-5.082***	-8.300***
India				
Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO_2	-0.159	-0.905**	-0.159	-0.905**
NRE	3.713	-5.570***	3.713	-5.570***
GDP	8.527	0.348***	8.527	0.348***
GTIN	-5.646***	-7.989***	-5.646***	-7.989***
POP	-3.013**	-2.361	-3.013**	-2.361
INDS	-4.079***	-5.162***	-4.079***	-5.162***
Nepal				
Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO_2	3.657	-3.633***	3.657	-3.633***
NRE	2.640	-8.187***	2.640	-8.187***
GDP	0.839	-6.460***	0.839	-6.460***
GTIN	-7.019***	-9.507***	-7.019***	-9.507***
POP	-1.084	-7.960***	-1.084	-7.960***
INDS	-1.246	-10.220***	-1.246	-10.220***

Sri Lanks				
Variable	ADF		PP	
	Level	First Difference	Level	First Difference
CO_2	-0.800	-6.353***	-0.800	-6.353***
NRE	-0.543	-7.173***	-0.543	-7.173***
GDP	2.348	-10.453***	2.348	-10.453***
GTIN	-3.822***	-8.023***	-3.822***	-8.023***
POP	-1.541	-3.123**	-1.541	-3.123**
INDS	-4.457	-6.048***	-4.457	-6.048***

Note:*,**,*** represents significance level at 10, 5, and 1%.

4.2 Bound Test for Co-integration

Both the ARDL and NARDL models' bounds test results are displayed in Table 3. The NARDL model and the ARDL model both statistics surpass the critical values for the upper and lower bounds. We may proceed with our analysis with confidence thanks to this strong evidence of co-integration.

Table 3: F-Bound Test

ARDL				
Pakistan	**India**	**Bangladesh**	**Sri Lanka**	**Nepal**
6.705	3.769	8.989	5.016	8.322
I(0)	I(1)			
2.45	3.52			
2.86	4.01			
3.74	5.06			
NARDL				
Pakistan	**India**	**Bangladesh**	**Sri Lanka**	**Nepal**
5.97	6.162	8.524	6.059	10.87
I(0)	I(1)			
2.26	3.35			
2.62	3.79			
3.41	4.68			

4.3 Long Run Estimations

The ARDL results showed that non-renewable energy and CO_2 are positively associated in Pakistan, Bangladesh, India, Sri Lanka and Nepal. The positive coefficient of non-renewable energy implies that one unit rise in NRE will boost the carbon emissions in Pakistan by 1.74%, in Bangladesh by 16.73% in India by 7.20%, in Nepal by4.00% and in Sri Lanka by 1.88%. The level of significance is found different for different countries, Pakistan and Bangladesh are showing the 1% level of significance while, India, Sri Lanka and Nepal showed significance at

5% level. The positive correlation between NRE and CO2 shows damaging role of NRE on environmental sustainability. These results align with studies by Apergis et al. (2023) for Uzbekistan which also report the damaging effects of NRE on environmental sustainability. The varying significance levels in our study (1% for Pakistan and Bangladesh, 5% for India, Nepal, and Sri Lanka) and similar global trends underscore the urgent need for energy diversification, enhanced efficiency, and the promotion of renewable energy worldwide.

Table 4: ARDL Long Run Estimates

	ARDL Model				
	Pakistan	**Bangladesh**	**India**	**Sri Lanka**	**Nepal**
NRE	1.74*** [0.51]	16.73*** [3.83]	7.20** [2.56]	1.88** [0.62]	4.00** [0.21]
NRE^{Pos}	-	-	-	-	-
NRE^{Neg}	-	-	-	-	-
GTIN	0.09** [0.04]	0.13*** [0.06]	-2.04** [0.88]	-0.20** [0.01]	0.67** [0.06]
GDP	0.51** [0.15]	0.93*** [0.18]	1.61** [0.60]	0.36** [0.02]	0.62** [0.01]
POP	2.02*** [0.29]	8.19*** [0.93]	8.43** [2.71]	14.36*** [0.18]	0.45* [0.05]
INDS	0.51** [0.25]	-1.16*** [0.18]	0.13** [0.06]	-1.88** [0.07]	0.38** [0.01]
C	-17.22*** [4.37]	-66.79*** [6.75]	-125.09** [43.15]	-225.25*** [3.13]	-23.74** [1.99]
	NARDL Model				
	Pakistan	**Bangladesh**	**India**	**Sri Lanka**	**Nepal**
NRE	-	-	-	-	-
NRE^{Pos}	0.33** [0.08]	2.62*** [0.55]	7.20** [2.56]	0.63*** [0.15]	10.10** [0.18]
NRE^{Neg}	-0.30** [0.14]	-0.73*** [0.18]	-0.13** [0.04]	-1.70*** [0.48]	-0.03* [0.01]
GTIN	0.35*** [0.05]	0.37*** [0.06]	-2.04*** [0.88]	-0.06*** [0.02]	-2.49*** [0.04]
GDP	0.13** [0.03]	0.77*** [0.04]	0.60** [0.06]	0.04** [0.02]	0.42** [0.01]
POP	3.00*** [0.32]	0.08*** [0.25]	8.43** [0.65]	2.95*** [0.05]	3.96*** [0.13]
INDS	-0.10*** [0.07]	-0.63*** [0.12]	0.23** [0.06]	2.70*** [0.58]	-0.33* [0.09]
C	-55.41*** [5.38]	-18.60*** [4.80]	-125.09** [43.15]	-58.51*** [10.45]	-128.00*** [1.66]

Note: *,**,*** represents 10%, 5%, & 1% significance level

Evaluating the association between green technological innovation and CO_2 emissions, it is found that there is a positive relationship between GTIN and CO_2 emissions in Pakistan, Bangladesh and Nepal.

The positive sign of green technological innovation implies that one unit hike in GTIN will enhance carbon emissions in Pakistan by 0.09% in Bangladesh by 0.13%, and in Nepal by 0.67; in contrast, the negative sign of GTIN means one unit growth in GTIN will lessen CO_2 emanations in India by -2.04%, and in Sri Lanka -0.20 in the long run. The negative impact of GTIN shows the complementing role of green technological innovations on environmental quality by reducing CO_2 emissions. Our results are matching with Xia (2023) for China and Shan et al. (2021) for Turkey.

GDP with a positive sign shows a positive association between GDP and CO_2 emissions across these five countries. The positive coefficient implies that one unit expansion in GDP will exacerbate the carbon emissions in India by 1.61% and in Nepal by 0.62%, in Pakistan by 0.51%, in Bangladesh by 0.93%, in Sri Lanka by 0.36%. The positive association claims that GDP works as catalyst for CO_2 emissions as it deteriorates the environmental quality in these countries. Our results are similar with Farooq et al. (2023) for 6 GCC countries and Maroufi and Hajilary (2022) for Iran. The governments of these countries should focus on the green technologies to overcome the harmful impact of GDP.

Examining the relationship between POP and CO_2 emissions it is found that population and CO_2 emissions are positively associated in all five countries. The positive coefficients imply that a unit increase in population will boost carbon emissions in Pakistan by 2.02%, in India by 8.43%, in Bangladesh by 8.19%, Sri Lanka by 14.36% and Nepal by 0.45%, in the long run. The positive association demonstrates the devastating role of population on environmental sustainability as it enhances CO_2 emissions. Our results align with Rahman and Alam's (2021) for Bangladesh and Hashmi and Alam's (2019) for OECD countries.

Moreover, industry with positive coefficients displays a positive association between industry and carbon ejection in Pakistan, Nepal and India. The positive sign indicates that a unit rise in industry will boost carbon outflow in Pakistan by 0.51%, in Nepal by 0.38% and in India by 0.13%; our findings are parallel to Nwani et al. (2023) for Africa and Siqin et al. (2022) for North China. Conversely, in Bangladesh and Sri Lanka, the negative sign of industry shows the negative connection between industry and carbon emissions. The results imply that a unit rise in industry will minimize carbon release in Bangladesh by -1.16%, in Sri Lanka by -1.88%. In Bangladesh and Sri Lanka industry plays constructive role in improving environmental health. Our results are analogous with Li et al. (2017) for China and Ali et al. (2021) for Vietnam.

4.4 Nonlinear Auto Regressive Distributed Lag (NARDL) Results

In our examination of the asymmetrical impacts of non-renewable energy sources on ecological sustainability, we have discovered an intriguing contradiction. Non-renewable energy sources have a major influence on environmental health and affect it greatly in both positive and negative shocks. This highlights the crucial significance of non-renewable energy in determining our environmental future, since an increase in its usage would inevitably lead to higher CO_2 emissions. The long run NARDL results showed that in positive shocks one unit rise in NRE will be accountable for 0.33 % rise in CO_2 emissions in Pakistan, 2.62% increase in Bangladesh, 7.20% surge in India, 0.63% rise in Sri Lanka, 10.10 % hike in Nepal, while in negative shocks NRE negatively affect the CO_2 emissions. The negative linkage displays the favorable role of NRE in mitigating CO2 emissions in negative shocks. The results imply that one unit decrease in NRE will improve environmental quality by 0.30% in Pakistan, by 0.73% in Bangladesh, by 0.13% in India, by 1.70 % in Sri Lanka, by 0.03% in Nepal.

Examining the impact of green technological innovation (GTIN) on environmental quality, the coefficient of GTIN is found to be positive in Pakistan and Bangladesh. The level of significance is found at 5% in Pakistan and at 1% level in Bangladesh. The positive association between GTIN and CO_2 emissions displays unfavorable impact of GTIN on environmental sustainability as it enhances the environmental degradation in Pakistan and Bangladesh, while the same relationship is found negative and significant in case of India, Sri Lanka and Nepal. The level of significance is found at 1% level in these three countries. These results imply that one unit rise in GTIN is responsible for 0.35% rise in CO_2 in Pakistan and 0.37% in Bangladesh, while one unit rise in GTIN is responsible for 2.04% reduction in CO_2 in India, 0.06% in Sri Lanka and 2.49% in Nepal. The coefficient of GDP is found positive and significant at 5% level in Pakistan, India, Sri Lanka and Nepal, while at 1% level in Bangladesh. The positive coefficient of GDP denotes dangerous impact of GDP on environmental quality. Examining the causal linkage between population and environment we have found that both variables are positively connected. The positive association shows the harmful impact of population on environment in all five studied countries. The results show that one unit surge in population will lead to 3.00 % rise in CO_2 emissions in Pakistan, 0.08% in Bangladesh, 8.43% in India, 2.95% in Sri Lanka, 3.96% in Nepal. The findings revealed a positive impact of population on environmental degradation as it enhances CO_2 emissions in all five studied countries. The significance levels of population are found different in different countries. It is found significant at 1% level in Pakistan, Bangladesh, Sri Lanka and Nepal, while at 5% level in India. The coefficient of Industrialization is found negative and significant in Pakistan, Bangladesh and Nepal, while positive in India and Sri Lanka. The positive coefficient indicates that industry has a devastating impact on environmental quality in India and Sri Lanka, while favorable impact on environment in Bangladesh, Pakistan and Nepal. The results imply that one unit rise in industrialization will cause 0.10% reduction in CO_2 emissions in Pakistan, 0.63% in Bangladesh, 0.33% in Nepal, while one unit rise in industrialization will damage the environment by 0.23% in India and by 2.70% in Sri Lanka.

Table 5: Short Run Estimates

	ARDL Model				
	Pakistan	**India**	**Bangladesh**	**Sri Lanka**	**Nepal**
D(CO_2(-1))	-	-	-	-7.32** [0.38]	-
D(CO_2(-2))	-	-	-	-4.89** [0.27]	-
D(CO_2(-3))	-	-	-	-0.29 [0.10]	-
D(NRE)	0.08 [0.04]	-0.05** [0.01]	4.16*** [0.79]	0.44*** [0.12]	5.20*** [0.01]
D(NRE (-1))	-	-	-4.36*** [0.59]	-	0.12* [0.01]
D(NRE(-2))	-	-	-	-	3.10*** [0.03]
D(NRE)^{neg}	-	-	-	-	-
D(NRE ^{neg} (-1))	-	-	-	-	-
D(LNRE^{neg} (-2))	-	-	-	-	-
D(LNRE)^{pos}	-	-	-	-	-
D(LNRE(-1))^{pos}	-	-	-	-	-
D(LNRE(-2))^{pos}	-	-	-	-	-
D(LGDP)	-0.06*** [0.03]	-0.14** [0.14]	0.23 [0.13]	1.22* [0.19]	-0.13** [0.00]
D(LGDP(-1))	0.09 [0.04]	-0.30 [0.21]	-0.20* [0.10]	1.05 [0.24]	-0.14*** [0.04]
D(LGDP(-2))	-	-	-0.19 [0.11]	-	-0.18** [0.07]
D(LPOP)	6.03*** [1.51]	3.64*** [0.99]	-3.11 [3.70]	-47.63** [3.53]	18.18** [0.35]
D(LPOP(-1))	-4.15** [1.79]	0.03 [0.05]	-5.15 [4.23]	4.15** [1.73]	-16.69** [5.01]
D(LPOP(-2))	-	-	14.06* [5.45]	-	12.96** [3.55]
D(LINDS)	-0.17* [0.09]	0.03** [0.01]	-0.36** [0.14]	8.49** [0.39]	0.11 [0.04]
D(LINDS(-1))	-0.22** [0.09]	-	0.36*** [0.07]	2.53 [0.44]	3.65 [1.01]
D(LINDS(-2))	-	-	-	-	0.15** [0.01]
D(LGTIN)	-0.04* [0.02]	0.08 [0.12]	-0.02 [0.02]	0.37* [0.05]	1.36** [0.05]

D(LGTIN(-1))	-	0.40** [0.17]	0.03 [0.02]	-0.24* [0.034]	0.25* [0.03]
D(LGTIN(-2))	-	0.34* [0.17]	-0.05** [0.02]	-	0.68** [0.04]
CointEq(-1)	-0.49*** [0.11]	-0.43** [0.19]	0.82** [0.35]	1.01** [0.34]	-1.21** [0.02]
	NARDL Model				
	Pakistan	**India**	**Bangladesh**	**Sri Lanka**	**Nepal**
D(CO_2(-1))	-	-	-	-	-
D(CO_2(-2))	-	-	-	-	-
D(CO_2(-3))	-	-	-	-	-
D(NRE)	-	-	-	-	-
D(NRE (-1))	-	-	-	-	-
D(NRE(-2))	-	-	-	-	-
D(NRE)^{neg}	0.82** [0.36]	0.24 [0.33]	8.49*** [2.20]	3.34** [0.29]	7.22** [0.21]
D(NRE ^{neg} (-1))	0.81 [0.46]	1.34** [0.44]	-1.48** [0.49]	6.13** [0.36]	-14.84** [0.79]
D(LNRE^{neg} (-2))	-	0.92 [0.55]	-1.22 [0.63]	-	3.30* [0.48]
D(LNRE)^{pos}	-0.04*** [0.01]	0.18*** [0.02]	0.06 [0.05]	-0.04 [0.06]	0.40* [0.20]
D(LNRE(-1))^{pos}	-	-	-0.10** [0.04]	0.74** [0.26]	0.18*** [0.02]
D(LNRE(-2))^{pos}	-	-	-	-	-0.15*** [0.03]
D(LGDP)	-1.98*** [0.32]	-0.13 [0.09]	0.42** [0.16]	-0.04 [0.02]	0.07*** [0.03]
D(LGDP(-1))	0.47 [0.67]	-	-1.53*** [0.25]	-	-0.06*** [0.02]
D(LGDP(-2))	-	-	-	-	0.25 [0.09]
D(LPOP)	33.14** [3.91]	1.64 [1.86]	-10.41*** [2.56]	2.06*** [0.57]	4.88*** [0.06]

D(LPOP(-1))	0.18 [0.10]	-4.70** [1.68]	-	-	-9.70*** [0.05]
D(LPOP(-2))	-	-	-	-	4.36*** [0.04]
D(LINDS)	-0.25 [0.12]	0.05 [0.02]	-0.92** [0.40]	1.18*** [0.40]	0.22 [0.07]
D(LINDS(-1))	-	0.05*** [0.01]	1.35** [0.54]		-3.50* [0.99]
D(LINDS(-2))	-	-	-	-	0.12** [0.03]
D(LGTIN)	-0.13*** [0.02]	-	0.92*** [0.24]	-0.01 [0.04]	0.35** [0.09]
D(LGTIN(-1))	-	-0.32*** [0.06]	-	-	-0.16** [0.04]
D(LGTIN(-2))	-	-	-	-	0.84*** [0.37]
CointEq(-1)	-0.82** [0.18]	-1.04*** [0.13]	-0.49*** [0.20]	-0.69*** [0.13]	-0.45*** [0.19]

Note: *,**,*** represents 10%, 5%, & 1% significance level.

4.5 Diagnostic Test Results

The following results (see table 5) reports the diagnostic testing and results shows the models (ARDL & NARDL) are free from heteroscedasticity problem, serial correlation, normality issue and models are stable throughout time period.

Table 5: Diagnostic test (ARDL / NARDL)

	ARDL Model				
	Pakistan	**India**	**Bangladesh**	**Sri Lanka**	**Nepal**
R^2	0.997	0.998	0.999	0.999	0.999
Adj R^2	0.993	0.996	0.998	0.998	0.999
D.W	2.018	2.165	1.995	2.792	2.48
LM test	0.245 (1.000)	0.148 (0.864)	0.831 (0.499)	1.016 (0.391)	0.456 (0.846)
Hetero	2.329 (0.074)	0.588 (0.832)	0.762 (0.702)	0.673 (0.761)	0.833 (0.639)
J.B	2.465 (0.291)	0.1239 (0.9399)	0.7163 (0.6989)	0.650 (0.722)	1.024 (0.599)
Ramsey reset	2.124 (0.170)	1.179 (0.265)	0.425 (0.687)	2.123 (0.162)	1.897 (0.217)
CUSUM	S	S	S	S	S
CUSUMQ	S	S	S	S	S
	NARDL Model				
	Pakistan	**India**	**Bangladesh**	**Sri Lanka**	**Nepal**
R^2	0.999	0.998	0.999	0.990	1.000
Adj R^2	0.997	0.997	0.998	0.988	0.999
D.W	3.20	2.085	2.625	2.159	2.601
LM test	2.2299 (0.309)	1.205 (0.333)	1.955 (0.203)	0.189 (0.829)	3.574 (0.117)
Hetero	3.312(0.129)	0.551 (0.854)	0.743 (0.712)	0.953 (0.477)	0.171 (0.975)
J.B	0.8129(0.6659)	1.3446(0.5105)	0.244 (0.884)	0.246(0.884)	0.6126 (0.7361)
Ramsey reset	1.133(0.339)	0.666 (0.516)	0.776 (0.457)	1.477 (0.248)	2.363 (0.210)
CUSUM	S	S	S	S	S
CUSUMQ	S	S	S	S	S

5. Conclusion

The concept of sustainability has emerged as a central theme in global discussions during the past three decades. Because of this tidal change, researchers, environmentalists, and lawmakers are now focusing on the novel idea of green growth. This strategy lays the groundwork for long-term economic growth by demanding the complete elimination of CO_2 emissions from manufacturing operations. Previous studies have mostly concentrated on factors that impact environmental quality, but very few have delved into the complex aspects of green development.

Progress towards clean energy transition in five South Asian countries from 1985 to 2021 is the focus of the current study. The current study evaluated the causal linkage between non-renewable energy, green technological innovation, GDP, population, industry, and CO_2 emissions. Reliable and robust results are produced by this study by means of rigorous econometric methodologies. A few of the examined variables show mixed-order integration; some are level-stationary while others necessitate first differencing. All of the variables that have been studied also show signs of long-run co integration. The ARDL findings show a positive impact of NRE, GDP, and population on CO_2 emissions; conversely, green technological innovation minimizes CO_2 emissions in India and Sri Lanka and enhance CO_2 emissions in Pakistan, Bangladesh and Nepal. GDP and POP boost environmental degradation in all five studied countries. Our study provides the basis for the following detailed suggestions for policy. The first and most obvious way green technological innovation and renewable energy contribute to sustainable development is by reducing carbon dioxide emissions. As a result, lowering CO_2 emissions can be facilitated by considerable investment in green technological innovations and renewable energy sources, as well as wise management of economic activities. Governments around the world would do well to expand funding for environmentally friendly technical advances. To establish uniform standards in green finance and increase global investment in sustainable projects, cooperation with countries in South Asia and beyond is essential. For this partnership to work, all parties involved must take part in international climate accords and programs that seek to harmonize national policies with sustainability targets set by other nations. Participating in these global initiatives allows nations to harmonize their green finance policies, which in turn facilitates foreign investments in ecologically sound projects by standardizing and regulating them uniformly. More money will go towards environmentally friendly projects, and countries will stand together to combat climate change, which will promote green growth worldwide. It is also important to provide incentives, such as price subsidies for renewable energy sources to encourage their use in commercial and residential sectors to combat environmental degradation. Furthermore, businesses should use renewable energy and boost the development of technical advances that support a sustainable environment to reduce their detrimental effects on the environment. Further, legislators should push for green innovation by funding and supporting cutting-edge projects and studies.

This study focused on the South Asia region. Future research can enhance the generalization ability of these findings by including a broader range of countries. Institutional quality is a main pillar in enforcing environmental laws, so future research could add variables such as institutional quality, governance, environmental regulations, and technological innovations to improve environmental quality. Moreover, this study employed NARDL to estimate the nonlinear relationship among variables, yet future research could utilize other econometric techniques, such as threshold regression, panel quantile, and DCCE. Future research could also focus on the impact of FD on green technological innovations to offer insightful policies for environmental health.

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APPENDIX

Pakistan						
	CO_2	NRE	GTIN	GDP	INDS	POP
Mean	124358.2	6.033531	110.7586	3.918864	4.619651	1.74E+08
Median	121608.7	6.052067	91	4.396457	4.723542	1.74E+08
Maximum	198738.8	6.134701	338	7.54686	17.37416	2.27E+08
Minimum	59026	5.910881	16	-1.27409	-5.74514	1.15E+08
Std. Dev.	40592.69	0.052703	92.91842	1.881106	3.879407	34503174
Skewness	0.182137	-0.61357	1.08269	-0.58692	0.516114	-0.10202
Kurtosis	1.941135	3.073286	3.243478	3.45486	6.575844	1.741814
Jarque-Bera	1.515119	1.826062	5.737348	1.914949	16.73802	1.963139
Probability	0.468809	0.401306	0.056774	0.383861	0.000232	0.374722
Sum	3606388	174.9724	3212	113.647	133.9699	5.05E+09
Sum Sq. Dev.	4.61E+10	0.077774	241747.3	99.07969	421.3943	3.33E+16

Bangladesh						
	CO2	NRE	GDP	GTIN	INDS	POP
Mean	0.286797	5.129515	5.557888	49.53333	7.863754	1.39E+08
Median	0.241929	5.074867	5.432541	48.5	8.013279	1.42E+08
Maximum	0.586158	5.530545	7.881907	77	11.63331	1.67E+08
Minimum	0.099144	4.744345	3.448026	22	3.61109	1.07E+08
Std. Dev.	0.153127	0.252699	1.170655	15.39085	1.918241	17822914
Skewness	0.559945	0.140431	-0.02535	-0.04335	-0.12806	-0.18753
Kurtosis	1.991944	1.648992	2.185575	1.931766	2.5417	1.900573
Jarque-Bera	2.837911	2.380133	0.832325	1.4358	0.34454	1.68677
Probability	0.241967	0.304201	0.659573	0.487776	0.841752	0.430252
Sum	8.603901	153.8855	166.7366	1486	235.9126	4.18E+09
Sum Sq. Dev.	0.679992	1.851846	39.74257	6869.467	106.7098	9.21E+15
India						
	CO2	NRE	GTIN	GDP	INDS	POP
Mean	1380652	6.033531	110.7586	3.918864	4.619651	1.74E+08
Median	1175836	6.052067	91	4.396457	4.723542	1.74E+08
Maximum	2458176	6.134701	338	7.54686	17.37416	2.27E+08
Minimum	563575.4	5.910881	16	-1.27409	-5.74514	1.15E+08
Std. Dev.	623494.3	0.052703	92.91842	1.881106	3.879407	34503174
Skewness	0.382722	-0.61357	1.08269	-0.58692	0.516114	-0.10202
Kurtosis	1.675481	3.073286	3.243478	3.45486	6.575844	1.741814
Jarque-Bera	2.925321	1.826062	5.737348	1.914949	16.73802	1.963139
Probability	0.231619	0.401306	0.056774	0.383861	0.000232	0.374722
Sum	41419549	174.9724	3212	113.647	133.9699	5.05E+09
Sum Sq. Dev.	1.13E+13	0.077774	241747.3	99.07969	421.3943	3.33E+16
Nepal						
	CO2	NRE	GTIN	GDP	INDS	POP
Mean	5054.494	356.7418	3.104721	4.424179	4.632844	25530027
Median	3156.15	341.9885	2.34838	4.584058	3.981844	26402041
Maximum	15139.4	479.2864	8.637289	8.977279	17.1374	29348627
Minimum	938.8	295.1168	0.940806	-2.36962	-4.13316	19616530
Std. Dev.	4250.107	56.45306	2.285892	2.299952	4.384967	2629080
Skewness	1.381414	0.754083	1.121447	-0.72112	0.516425	-0.72053
Kurtosis	3.596061	2.403522	3.027269	4.515884	4.152129	2.521628
Jarque-Bera	9.985632	3.287938	6.289143	5.472473	2.992729	2.881859
Probability	0.006787	0.193212	0.043085	0.064814	0.223943	0.236708
Sum	151634.8	10702.26	93.14162	132.7254	138.9853	7.66E+08
Sum Sq. Dev.	5.24E+08	0.128929	92421.5	151.5338	153.4036	557.61
Sri Lanka						
	CO2	NRE	GTIN	GDP	INDS	POP
Mean	12795.33	430.5215	160	4.718836	5.081555	19676851
Median	12408.6	446.3837	136	5.472573	5.806033	19582149
Maximum	23427.9	535.496	356	8.669483	12.96167	21919000
Minimum	3839.2	320.6319	23	-4.62452	-5.31714	17204094
Std. Dev.	5884.756	70.53208	104.6214	2.869986	4.3668	1434356
Skewness	0.428263	-0.24622	0.554613	-1.64504	-0.75671	0.028557
Kurtosis	2.324989	1.837781	2.136745	5.837215	3.165488	1.768817
Jarque-Bera	1.387488	1.858794	2.304856	22.0201	2.704139	1.772253
Probability	0.499702	0.394792	0.315869	0.000017	0.258704	0.41225
Sum	358269.1	12054.6	4480	132.1274	142.2835	5.51E+08
Sum Sq. Dev.	9.35E+08	134318.9	295532	222.3942	514.8614	5.55E+13