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Research Article

Natural Resources Depletion, Energy Crises, Industrial Output, and Environmental Degradation: A Panel Data Analysis

Sadia Kanwal[1], Prof. Dr. Abdul Ghafoor Awan[2]

1. Research Scholar, Department of Economics, Institute of Southern Punjab, Multan, Pakistan. Sadiakanwal329@gmail.com
2. Dean, Faculty of Management Sciences, Institute of Southern Punjab, Multan, Pakistan. drabdulghafoorawan@gmail.com OICD ID: https://orcid.org/0000-0001-5767-6229

Abstract:

This study aims at investigating into the complex interplay between natural resources depletion, energy crises, industrial output, and environmental degradation in Pakistan, Bangladesh, and India using 30 years of secondary data spanning from 1992 to 2022 and employing statistical techniques, such as Correlation analysis and Pooled Mean Group method to identify short and long-term relationship between variables. The environmental degradation is dependent variable and it is proxied for CO_2 emissions, while natural resources depletion, industrial output and energy crisis are independent variables. The electricity consumption is proxied for energy crisis. According to the findings, natural resources depletion negatively influences environmental degradation. Conversely, energy consumption, transmission and distribution losses, urbanization, and industrial output exhibit positive correlations with environmental degradation, underscoring the urgent need for intervention.

Key words: Natural resources depletion; Electricity consumption; Electric power transmission and distribution losses; urbanization; Environmental degradation

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1.Introduction

Environmental degradation is now a days, a serious issue. The phrase "environmental degradation" refers to how various human activities have deteriorated the environment. Just a handful of many issues it addresses include pollution, deforestation, habitat loss, climate change, and the decrease of natural resources. Environmental deterioration has drawn a lot of attention as the impacts of human activities on the environment have become more and more visible. Industrial development and economic growth have increased demand for energy consumption and extraction of natural resources which negatively affect environmental quality. When fossil fuel is used in power generation and transport sector it discharges greenhouse gases, which in turn, cause global warming and climate change. It also increases emissions discharged by industry, vehicles and other human activities. The high level of emissions in the air causes respiratory disorders and other serious health issues among human. The main causes of environmental degradation and depletion of natural resources are industrialization and consumption of fossil fuel in industry, transport and other sector. The deforestation has caused climate change, resulting heavy rains, devastating floods and earthquakes all over the world. Ayres & Ayres (2002) disclosed that the depletion of natural resources, rising energy demand and industrialization have close association with environmental degradation, which is has become a global issue. Forests, minerals, and renewable or non-renewable resources are considered necessary for the economic activities and growth of economies. But their overexploitation has made doubtful for their availability for future generation. The UNs Sustainable Development Goals (SDGs) has emphasized prudent use of natural resources in order to stained growth for a longer period of time. Under Kyoto protocol (1987), greenhouse gas emission in 37 European

countries was suggested to cut substantially to achieve sustainable development. While European Commission on Environmental Development Report, (1987) titled (Our common future" defines sustainable development as "Development which meets the requirement of present, without compromising the need of future generation". It implies that natural resources should be used in such a way that they meet the needs of current and future generation equally. Moreover, the Paris Agreement (2015) signed by 195 nations had set the goal for all member countries to cap temperature below 2 degree C and strive for bring it down to 1.5 C, and provide climate finance by developed countries up to $100 billion to poor nations till 2020 to enable them to manage climate-related challenges. The summit convened in the New York in September, 2015 approved the UN's 2030 17-points Agenda for Sustainable Development Goals (SDGs). In this agenda, 7^{th} and 13^{th} components are very important because they are related to provision of affordable, reliable and sustainable energy and combating the menace of climate change. All members countries were assigned the task of implementing these goals by 2030. Further, a three days conference was held in Dubai in December, 2023 to make the assessment of UN's Sustainable Development goals and a declaration was signed by 120 countries, pledging to accelerate actions to protect people's health from growing climate impacts as the focus of this conference was climate change and people's health. These global efforts highlight the seriousness of environmental issues around the world and demanded collective efforts to achieve UN's Sustainable Development Goals (SDGs). This motivated authors to investigate the intricate relationship between depletion of natural resources, energy crisis,

industrial output and environmental degradation, focusing how depletion of natural resources, energy crisis, industrial output influence environmental degradation to assess the implications of these factors on the sustainability of present and future generations.

This study contributes into the existing knowledge on natural resources depletion and environmental degradation in several ways. First, it enhances understanding about the complex dynamics of environmental degradation and sheds light on the link between social, economic and environmental factors. Second, the findings of this study highlight the role of policy intervention, international cooperation and efforts of researchers and scientists in achieving UN's Sustainable Development Goals (SDGs). Third, this study emphasizes the urgency of opting sustainable practices and policies to keep the environment clean by cutting down the quantity of the use of non-renewables to secure the future of present and future generations.

2.Literature Review

Natural resources depletion is a major issue in India, Pakistan, and Bangladesh, with profound implications for economic development, environmental sustainability, and public health. This section reviews recent studies focusing on the status, causes, and consequences of natural resources depletion in these countries.

2.1. Natural Resources Depletion and Environmental degradation

The research conducted by Gupta et al. (2021) reveal the alarming rate of the depletion of groundwater in India due to its excessive extraction to meet the growing demand of agriculture and industry. The study suggests to make effective planning for prudent use of ground water in order to control its excessive extraction, otherwise India would have to face severe shortage of water in future. Similarly, Sharma and Bhardwaj (2020) investigated into the

depletion of forest resources in India and disclosed that deforestation is causing environmental degradation and the loss of biodiversity, emphasizing urgent policy intervention for preservation of forest and biodiversity to improve quality of environment and to control climate change. In his study, Khan et al. (2023) investigated into the depletion of natural gas reserves in Pakistan and its impact on energy crisis and economic downturn. The study concludes that gas depletion has caused severe energy crisis in Pakistan due its vital role in power generation. Pakistan was producing about 34% of electricity and providing fuels to transport sector and domestic consumers on large scale. But gas reserves depletion and its high prices in international market constraints its supply to different sector of the economy and forces the country to use fossil fuel, producing emissions and increasing environmental degradation. Ali, et al (2021) also scrutinized the causes of natural resource depletion, renewable energy consumption, and environmental degradation in Pakistan using Panel Least Square and Granger Causality test to analyze time series data spanning from 1990 to 2014. The study concludes that depletion of natural resources, renewable energy consumption has significant positive impact on environmental degradation. Rimos et al (2014) Nawaz et al. (2019), in his empirical analysis also found positive link between natural resources depletion and environmental degradation in Pakistan. Ahmed et al. (2022) explored the depletion of water resources in Bangladesh, highlighting the impact of climate change and unsustainable water management practices on water scarcity and agricultural productivity. They identified that depletion of water resources has negative impact on agriculture production in Bangladesh, suggesting that the government should take concrete measures to prevent

excessive use of water resources. Mahmood et al. (2021) carried out a comparative analysis of the causes of the depletion of natural resources in Pakistan, Bangladesh and Pakistan and highlighted the common issues being faced by three countries, emphasizing policy interventions. The study suggests that three countries should learn lesson from each other strategies and experience and also cooperate with one another to control the rapid depletion of natural resources to ensure their availability in future.

2.2. Electricity consumption and environmental degradation

Energy is the engine of economic growth and it is considered as its core determinant in three countries: Pakistan, India and Bangladesh. However, rising demand for electricity has significant impact on environmental degradation because these countries are using fossil fuel for electricity generation and it is main factor of environmental degradation particularly in the perspective of greenhouse gas emissions and air pollution. The current studies briefly are discussed as under: -

Gupta and Maheshwari (2023) measure the impact of electricity consumption on air quality in India and highlight the need for using green energy sources and green technologies to slow the process of environmental degradation. They also emphasize that renewable sources of energy must be exploited and financial incentives be provided to encourage the people to use them. Mishra et al. (2021) also investigated the negative effects of producing power through furnace oil and its impact on environment in India. They also suggested the shifting from non-renewable to renewable sources. Khan et al. (2022) disclosed that there is close association between electricity consumption and CO_2 emissions and urge to cut the use of fossil fuel to reduce the level of emissions in the air in Pakistan. They disclosed that Pakistan has been suffering due to climate change since long and it is right time to shift

short term policy of non-renewables to renewables for power generation. Majeed et al. (2021) analyzed the consumption of electricity in Pakistan during the period of 1971-2014 through ADF test and ARDL model. The empirical results reveal that power consumption has significant impact on environmental quality. The study suggest that rising electricity demand should be met through promoting green technologies. Michael Kugelman (2013) examined energy crisis and its impact on Pakistan's economy, employing statistical approach. They disclosed that policy inconsistency, leadership failure, political instability and unavailability of clean technofixes are the main causes of energy crisis. Islam et al. (2023) explored the environmental impacts of electricity generation from fossil fuels in Bangladesh, highlighting the need for investment in cleaner energy technologies and energy efficiency measures. Rahman et al. (2021) conducted comparative analysis of electricity consumption and environmental degradation in Pakistan, Bangladesh and India. They also highlighted the specific challenges being faced by these countries due to environmental degradation. They emphasized that three countries should take collective efforts and collaborate to mitigate environmental degradation.

2.3. Urbanization and environmental degradation

Urbanization is a common problem in India, Pakistan, and Bangladesh and brief review of studies conducted on urbanization in these three countries is given below; -

Kumar and Singh (2023) carried out a comprehensive analysis of urbanization trends in India and reveal that urban population is rising rapidly and causing multi-dimensional socio-economic problems. They emphasized

the need for effective urban infrastructure development to reduce the pressure of population. Mishra et al. (2022) also examined the challenges of urbanization and its impact on environmental sustainability. They suggest that there is a need for integrated planning for controlling and managing urbanization. Ahmad et al. (2021) analyzed the causes of urbanization in Pakistan and disclosed that rural-urban migration, high population growth and employment opportunities are the main causes of urbanization. They suggest that necessary amenities should be provided in the rural areas in order to control migration to urban areas. Islam et al. (2023) examined demographic patterns of urbanization in Bangladesh in the context of sustainable development and emphasized the need to control urbanization as it is creating serious issues in the urban areas. They suggest that sustainable development and environmental quality cannot be attained without controlling population growth. Ali et al. (2022) conducted comparative study of Pakistan, India and Bangladesh and disclosed that there are common trends in urbanization in these countries. They suggest that these countries must collaborate in controlling urbanization.

3.4 CO_2 Emissions and Environmental degradation

Greenhouse gas emissions is a global issue and it is also a main issue in India, Bangladesh and Pakistan because it has serious implication for climate change mitigations and environmental quality as well as its negative impact on displacement of vulnerable communities during natural disasters mostly caused by climate change. The latest studies conducted on it to review the trends, drivers and impact of CO2 emission in these three countries are discussed in the following: -

Sharma et al. (2023) identified the role GDP growth in CO_2 emissions in India, besides examining consumption pattern, industrial growth and

economic growth. This study emphasizes the development of renewable resources for power generation and adoption of energy efficiency measures and green technologies to reduce emissions level, sustainable urban planning to lessen the effect of environmental degradation. Patel et al. (2022) examined the sectoral contributions to CO_2 emissions in India and suggested to focus on three sectors such as transportation, industry and power generation for controlling CO2 emissions. This study also suggests specific sectoral strategies and policy intervention to reduce the level of emission and achieve the UN's targets of Sustainable Development Goals (SDGs). Khan et al. (2023) asses the drivers of CO_2 emissions in Pakistan in the context of industrialization and energy production. This study emphasizes the adoption of green technologies, exploitation of renewable energy sources and improvement of energy efficiency to mitigate emissions and achieving environment quality targets. Sikandar, et al (2022) identified collective effects of urbanization, GDP, and energy consumption on the level of CO2 emission in Pakistan. This study utilized CO2 emissions as the dependent variable while independent variables include energy, GDP, urbanization. The study applied different statistical tools such as the ARDL, ADF, PP, and IPS techniques to analyze the data. The study found negative relationship between, GDP growth, urbanization and energy consumption with environmental degradation. Islam et al. (2022) analyzed main contributors of CO2 emissions in Bangladesh, in the context of industrial growth, urbanization and trends of electricity consumption. They suggest that there should be an integrated planning for investing in the development of renewable resources address environmental sustainability by cutting level of emissions. Ali et al. (2021)

conducted a comparative analysis of the drivers of CO2 emissions and its impact on environmental degradation in India, Pakistan and Bangladesh. They argued that these countries have been facing environmental degradation due to excessive use of fossil fuel for generating electricity to meet growing demand due to urbanization. They underscore the significance of regional coordinated policies to combat the serious issue of climate change and tackle emissions.

2.5 GDP growth and environmental degradation

Singh et al. (2023) examined the link between GDP growth and environmental degradation in India and stated that there is trade-off between two variables. They emphasized that India should opt sustainable development strategies to foster economic growth, mitigate environmental degradation and improving environmental quality. Mishra et al. (2022) contended that rapid economic growth in India has caused depletion of resources, biodiversity loss and environmental pollution. They urged to take policy intervention to stop the use of fossil fuel to control CO2 emission and adoption of green strategies to foster economic growth and mitigate environmental degradation. Khan et al. (2023) conducted study to examine relationship between electricity consumption, industrial growth, urbanization and environmental degradation and emphasized the use of green technologies, strengthen environmental rules and regulation and formulation of effective policies to meet environmental challenges. Imran, et al. (2015) investigated into energy shortage and its association with GDP growth, using time series data from 1982 to 2011. They found that there is negative relationship between economic growth and energy crisis. They suggest that efforts should be made to employ renewables to reduce dependence on fossil fuel which is the main driver of environmental pollution. Ahmed et al. (2022) determined the condition of environmental

degradation in Bangladesh in the context of GDP growth and emphasized the need to create balance in the use of environmental protection and improving economic growth. They also proposed to adopt sector specific policies and investment planning to develop clean technologies and achieve UN's Sustainable Development Goals (SDGs). They suggest context-specific policy intervention to balance environmental sustainability and economic growth.

2.6 Research gap

The review of different studies reveals many gaps in the academic literature. For example, there is a lack of a comprehensive study on environmental degradation in Pakistan, India and Bangladesh. There are many individual studies conducted on this topic but there is no collective study on depletion of natural resources, electricity consumption, urbanization GDP growth, electricity transmission losses and CO_2 emissions. There is need for research which synthesizes these variables into a comprehensive framework. Moreover, there are some comparative studies mentioned here, there is still gaps to compare the environmental issues and policy intervention in three countries. While individual studies provide valuable insights into the environmental issues in each country, a comparative analysis could offer a broader perspective on common challenges, regional variations, and potential policy interventions. Additionally, there is limited longitudinal studies in the literature that track the trends and changes in environmental degradation over time, particularly in response to policy interventions and economic developments. Longitudinal research could provide valuable insights into the effectiveness of policies aimed at mitigating environmental degradation and

promoting sustainable development in the region. Therefore, it is confirmed that there is need for research to bridge this gap.

2.7 Hypotheses of study

In the light of reviewed literature, the following hypotheses are constructed for testing statistical relationship between variables.

Ho: Natural resources depletion negatively associates with environmental degradation in India, Pakistan, and Bangladesh.

H_1: Natural resources depletion positively associates with environmental degradation in India, Pakistan, and Bangladesh.

Ho: Electricity consumption negatively correlates to environmental degradation in India, Pakistan, and Bangladesh.

H_1:Electricity consumption positively correlates to environmental degradation in India, Pakistan, and Bangladesh.

Ho: Urbanization negatively correlates to environmental degradation in India, Pakistan, and Bangladesh.

H_1: Urbanization positively correlates to environmental degradation in India, Pakistan, and Bangladesh.

Ho: There is a negative link between CO_2 emissions and environmental degradation in India, Pakistan, and Bangladesh.

H_1: There is a positive link between CO_2 emissions and environmental degradation in India, Pakistan, and Bangladesh.

Ho: GDP growth negatively correlates to environmental degradation in India, Pakistan, and Bangladesh.

H_1: GDP growth positively correlates to environmental degradation in India, Pakistan, and Bangladesh.

Ho: Industrial output negatively correlates to environmental degradation in India, Pakistan, and Bangladesh.

H_1: Industrial output positively correlates to environmental degradation in India, Pakistan, and Bangladesh.

These hypotheses will be tested using empirical data and appropriate statistical methods to ascertain the nature and strength of the relationships between the variables of interest, providing valuable insights for policymakers and other stakeholders in formulating sustainable development strategies in three countries.

3. Data and Methodology

The objectives of this study are to examine relationship between depletion of natural resources, energy crisis, industrial output, GDP and population growth with environmental degradation in India, Pakistan and Bangladesh, using 30 years panel data spanning from 1992 to 2022. The dependent variable is environmental degradation, which is proxied CO_2 emissions, while independent variables include natural resources depletion, electricity consumption, urbanization, industrial output, electric power transmission and distribution loses and GDP growth. The energy electricity consumption is proxied for energy crisis. Different statistical tools such as descriptive statistics, ADF unit root test, Correlation Matrix and Panel cointegration approach and PGM test were employed to determine long-term relationship between dependent and independent variables. First, the results of individual country were computed and discussed through statistical techniques and then these results were compared, exhibiting overall significance of relationship between variables in three countries. The statistical tools are fit to the data to analyze relationship between selected variables. The 30 years panel data of

three countries are sufficient to examine the trends and pattern of variations in the variables in three countries.

5. Results

5.1 Environmental degradation

5.1.1 Environmental degradations in India

India ranked among top five CO2 emitters in the world because the level of emissions has risen rapidly in the last two decades due to fast economic growth. It produces more than 2.5 billion CO2 emissions per year because more than 70% of its electricity is generated by coal. India did not signatory of COP26 declaration under which the signatory countries have committed to reduce methane emissions significantly because it is major methane emitter. However, it has supported global pledge to reduce emission by 2030. It has also promised to cut the use of fossil fuels and promote energy production from renewable resources such as wind, solar and hydropower for this purpose. Climate Action Tracker emphasizes that India needs to phase out coal power plants before 2040 to mitigate environmental degradation. It has also pledge to produce 50% electricity from renewable energy sources by 2030 and achieve UN's zero emission target by 2070. India produces about 1.5 billion tons of CO2 emissions from coal, 750 million tons from oil and 25s million from gas. India produces more than two tons per capita CO2 emissions per annum from fossil fuels and industry. India's share of cumulative global CO2 emissions in 2022 was 3.37% while it was only 1.5% in 1990 (Global Carbon Budget, 20123). In this way, its global share has been more than doubled during last 32 years.

5.1.2 Environmental degradation in Pakistan

Presently most of electricity in Pakistan is generated through fossil fuels and emissions emit from fossil fuel combustion and it is account for around 90%

of total CO2. The overall contribution of greenhouse gas (GHG), and transport sector is 40% an 23% respectively. Industrial emissions from factories and power plants, emitting pollutants such as nitrogen, Sulphur dioxide and other particulate into the air and the agricultural sector, which generates most of the methane and nitrous oxide emission and burning of the solid waste are major contributors to air pollution. The outdoor and indoor pollution causes 22,000 and 28,000 deaths every year, respectively. The victims of those who are poor and solely rely on biomass fuel such as wood, crop residues and animal dung for cooking, heating and lighting homes. Although sufficient improvement has been noted but it is estimated that more than 50% of the people are still rely on fossil fuels. Pakistan has been producing more than 8 tons emission per capita and 200 million tons of total emission annually. Pakistan's Share of global cumulative CO_2 emissions is 0.31% (Global Carbon Budget, 2023). It has committed to achieve zero emission target by 2050.

5.1.3 Environmental degradations in Bangladesh

As compared to India and Pakistan Bangladesh produces less CO2 emissions and its total annual production in 2022 was 100 million tons, while its on average per capita CO2 emissions per annum production was nearly 06 tons. Its share in cumulative Global CO2 emissions in 2022 was 0.1%. The main sources of CO_2 emissions are Gas (58.33 million tons), Oil (34.00 million tons) and coal (8.22 million tons) In this way, the share of coal in electricity production is lowest as well as in CO2 emissions.

The overall trends of CO_2 emissions in India, Pakistan and Bangladesh from 1990 to 2022 are shown in the Figure 1.

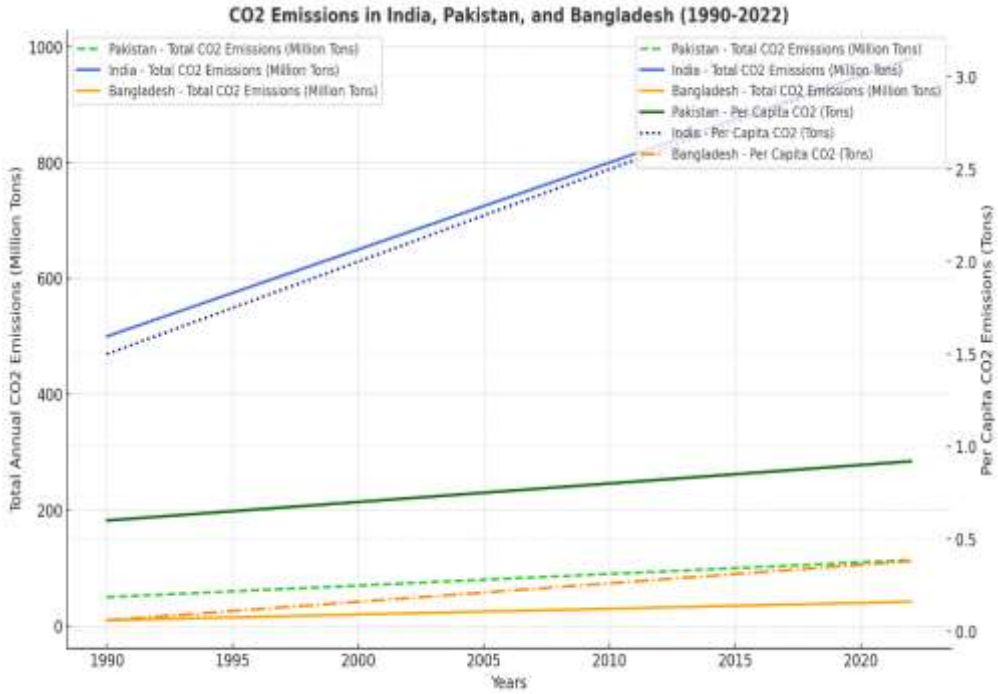


Fig 1: CO2 emissions trends in Pakistan, India and Bangladesh

The results in Figure 1 show that rapid increase was noted in India due to its heavy reliance on coal and significant industrial activity while in Pakistan CO2 emissions exhibits a moderate upward trend driven by fossil fuel combustion in electricity production and industrial emissions. However, in Bangladesh CO2 emissions show slower growth due to limited coal usage. Per capita CO2 emissions in Idia show consistent growth while in Pakistan it exhibited upward trend steadily and in Bangladesh it remains comparatively low due to limited fossil fuel use.

5.2 Natural Resources Depletion in India, Pakistan and Bangladesh

We compare the trend of natural resources depletion in Pakistan, India and Bangladesh through diagrams in order to understand in which country the natural resources were depleted rapidly during study period of 1992-2022. The trends of natural resources are depicted in Figure 2.

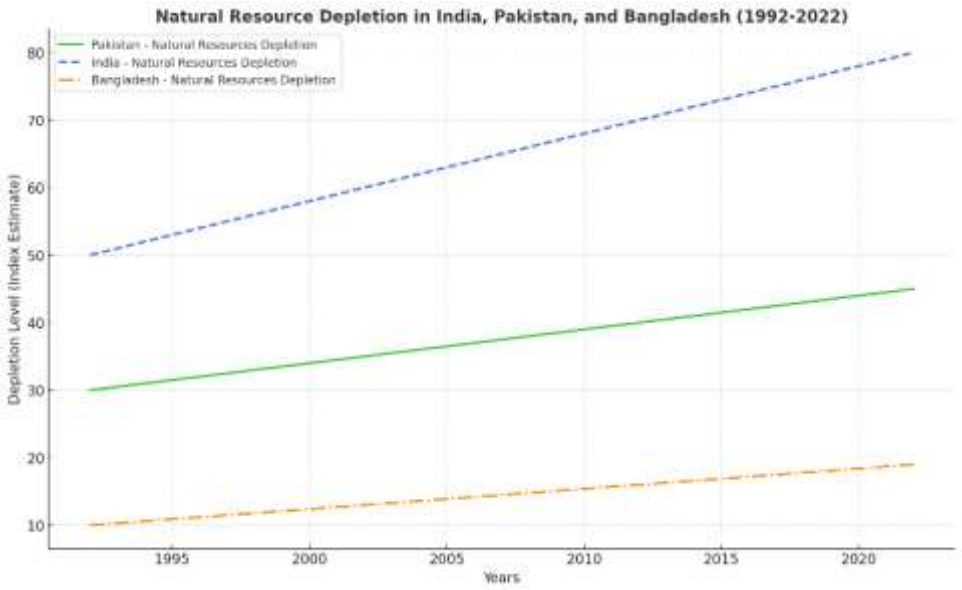


Fig 2: Natural resource depletion in India, Pakistan, and Bangladesh during 1992-2022:

In this Figure 2 shows that India recorded a rapid natural resources depletion due to extensive industrial activities and resource extraction, while Pakistan shows a steady increase in resource depletion over time. However, Bangladesh reflects a gradual but consistent rise in depletion levels.

5.3 Electric Consumption in India, Pakistan and Bangladesh

In this section we will compare electricity consumption in Pakistan, India and Pakistan **in** order to understand consumption pattern in three countries. The visual glance of following diagrams shows steep electricity consumption in Pakistan while in India and Bangladesh the consumption pattern was gradual. The above graph shows three curves for the three countries: Bangladesh, India and Pakistan. The amount of electric power consumption varied in three countries during

different years from 1992 to 2022. The graphs show the comparison of values of electric power consumption in three countries where its value shows an increasing pattern throughout the study period. In this way, we can easily compare the electric power consumption values in these countries. The trend of power consumption in three countries during 1990 and 2022 are depicted in the Figure 3.

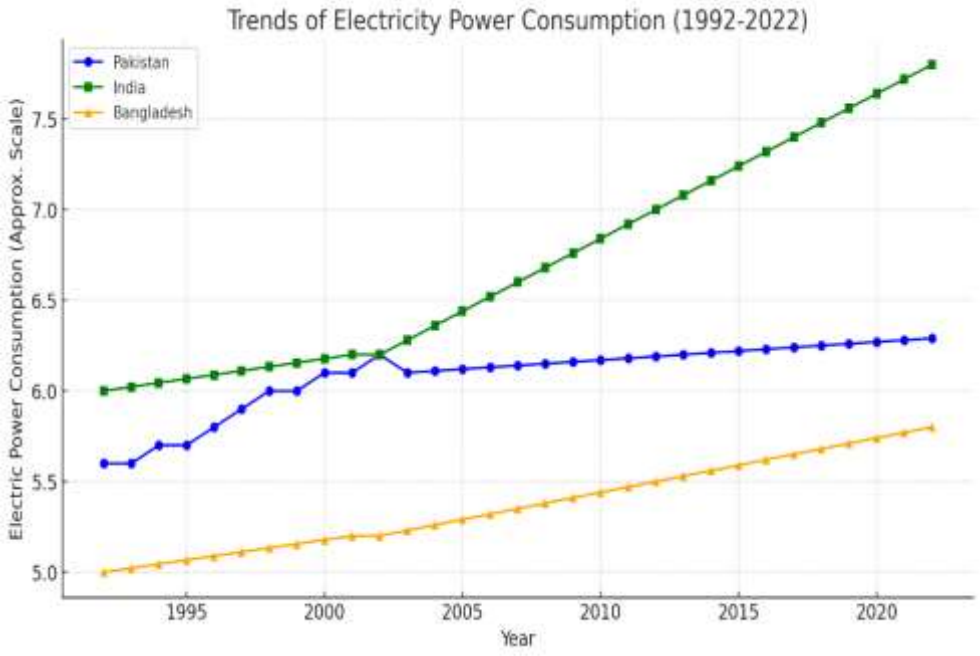


Fig 3: Electricity consumption pattern in Pakistan, India and Bangladesh.

5.4 Transmission and distribution losses in Pakistan, India and Bangladesh

The losses from Electric power transmission and distributions are enormous. These losses are occurred between sources of supply and points of distribution and supply of power to consumers including theft. These losses are estimated to be around 30%, which is a huge loss. These losses are shifted to domestic consumers, who are bearing this cost and suffering inflated bills every month. These losses produce huge gap between demand and supply of electricity, causing load-shedding from 6th to 12 hours daily. Industrial and agricultural

output is also suffering due to shortage of electricity. According to the World Bank (2010), consistent supply of electricity is essential for economic growth and electrification of less developed areas around the globe is crucial for development. Edward Foster (2017) suggested the use of renewable energy sources to reduce the cost and meet the growing demand. India, Pakistan and Bangladesh are making efforts to reduce these losses and from 1992 to 2022 India and Pakistan were most successful than Bangladesh. Figure 10 shows three curves for the three countries Bangladesh, India and Pakistan, indicating downward trend of losses from 30% in 1992 to 2022 in Bangladesh, from 25% in 1992 to less than 20% in 2022 in Pakistan and from 20% in 1992 to around 16% in 2022 in India. The transmission and distribution losses in three countries are shown in Figure 4.

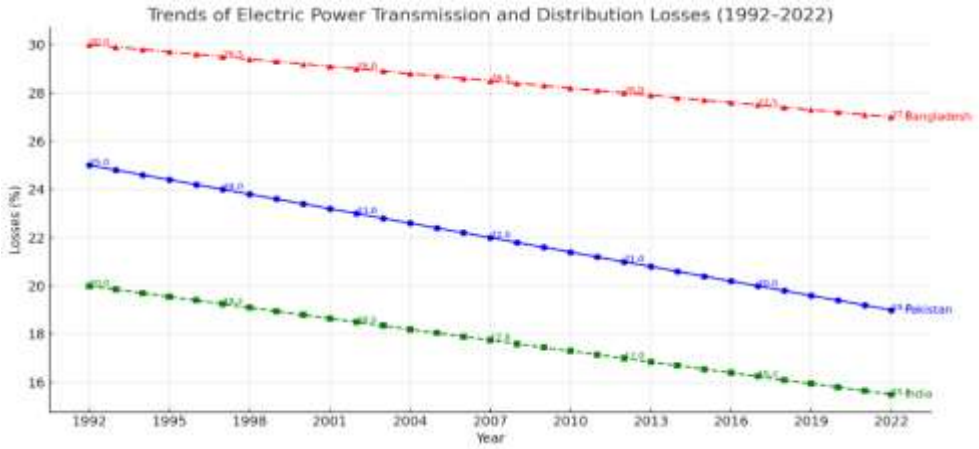


Fig 4: Transmission and distribution losses in India, Pakistan and Bangladesh

5.5 Comparison of Gross Domestic Product

The graph shows three curves for the three countries Bangladesh, India and Pakistan. The amount of gross domestic product varied in three countries during different years from 1992 to 2022. The graphs show the comparison of values of gross domestic product in three countries where its value shows an increasing continuous pattern

throughout the study period. In this way, we can easily compare the gross domestic product values in these countries.

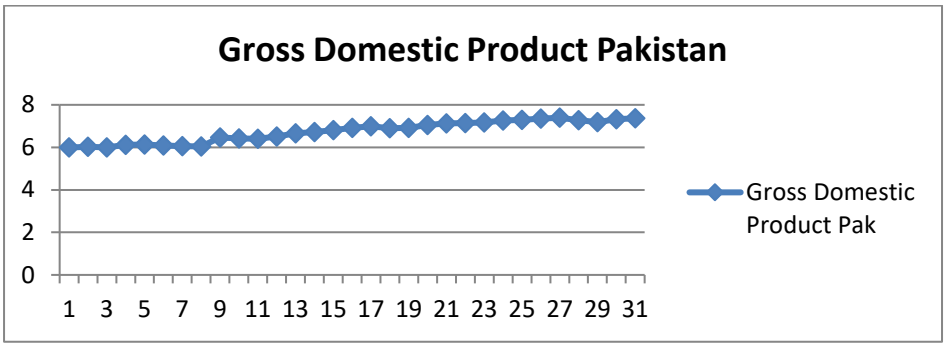


Fig 5: Trends of Gross Domestic Product during 1992-2022

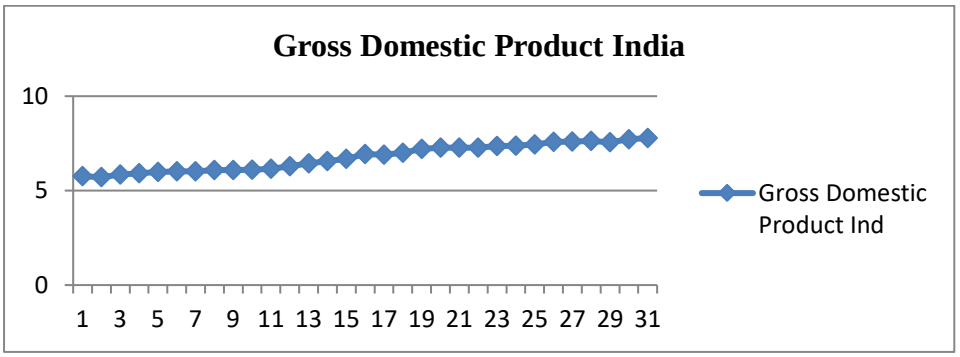


Fig 6: Trend of Gross Domestic Products in India during 1992-2022

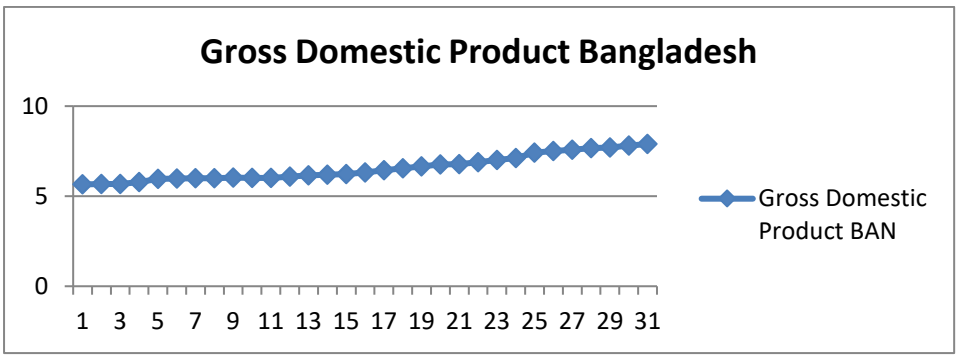


Fig 7: Trends of Gross Domestic products in Bangladesh

3.1.6 Urbanization

Urbanization is the process of increasing proportion of a population lives in urban areas, leading to expansion of cities and towns. One of the main causes of urbanization is the migration of people from rural to urban areas because economic and education opportunities, improved infrastructure, and better living standard. According to the United Nations Department of Economic and Social Affairs (UN DESA), urbanization is the increase of number of people that live in urban areas, leading to predominantly physical growth of urban areas and population. Figure 18 shows three curves for the three countries, Bangladesh, India and Pakistan. The amount of urban population growth varied in three countries during different years from 1992 to 2022. The graphs show the comparison of values of urbanization in three countries where its value shows an increasing continuous pattern throughout the study period. In this way, we can easily compare the urbanization values in these countries.

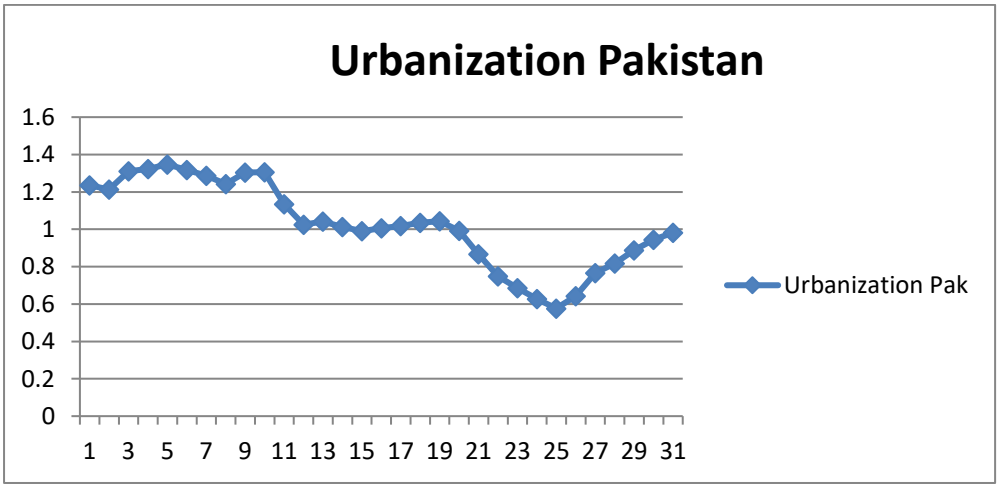


Fig 8: Trends of Urbanization in Pakistan during 1992-2022

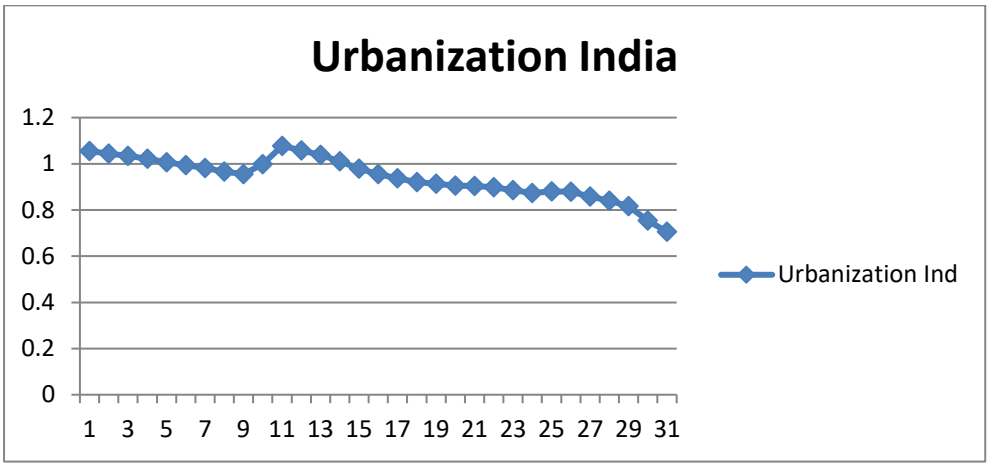


Fig 9: Trends of Urbanization in India during 1992-2022

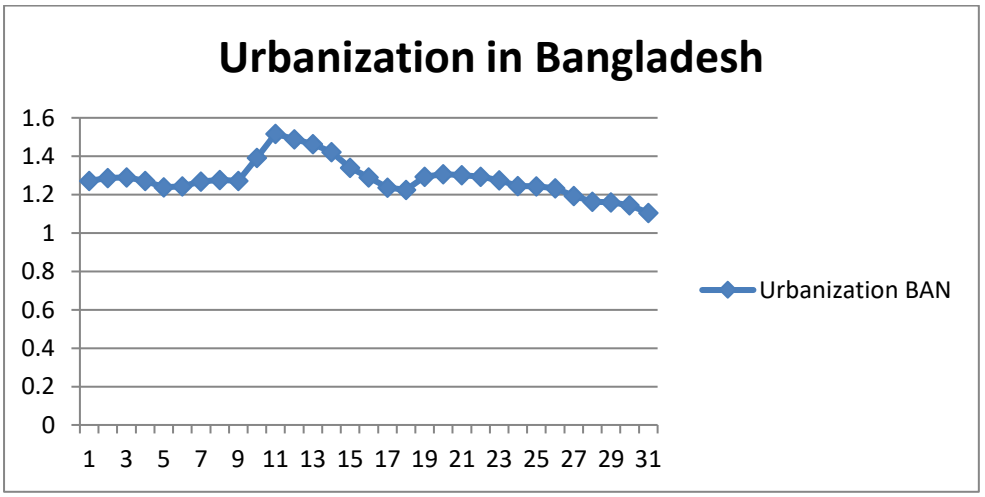


Fig 10: Trends of Urbanization in Bangladesh during 1992-2022

5.2 Empirical Analysis

5.2.1 Descriptive Analysis

An average mean value of carbon dioxide (CO_2), natural resource depletion (NRD), electricity consumption (EPC), electric power transmission and distribution loses (EPTD), gross domestic product (GDP), and urban

population growth (URB) is shown in the descriptive statistics table as being,12.12470, 0.045644,5.831846, 2.862979, 6.690351 and 1.081898 respectively. Carbon dioxide (CO_2), natural resource depletion (NRD), electric power consumption (EPC), electric power transmission and distribution loses (EPTD), gross domestic product (GDP), and urbanization (URB) are at their maximum values respectively at 14.71493, 1.189407, 7.00719, 3.414889, 7.896666 and 1.517373.

Carbon dioxide (CO_2), natural resource depletion (NRD), electricity consumption (EPC), electric power transmission and distribution (EPTD), gross domestic product (GDP), and urban population growth (URB) have relative standard deviations of1.563784, 0.480512, 0.653791, 0.324356, 0.640223and 0.210325. Carbon dioxide (CO_2), natural resource depletion (NRD), electric power consumption (EPC), electric power transmission and distribution loses (EPTD), gross domestic product (GDP), and urbanization (URB) all have skewness values that are, respectively, 0.223126, -0.145307, -0.853924, -1.132044, 0.109142 and -0.186494. Carbon dioxide (CO_2), natural resource depletion (NRD), electric power consumption (EPC), electric power transmission and distribution loses (EPTD), gross domestic product (GDP), and urban population growth (URB) all have similar kurtosis values of 1.885508, 2.479915, 3.672153, 5.215168, 1.677488, 2.341178. The results are shown in Table 1.

Table 1

Descriptive statistics

	LCO_2	**LNRD**	**LEC**	**LEPTD**	**LGDP**	**LURB**
Mean	12.12470	0.045644	5.831846	2.862979	6.690351	1.081898
Median	11.85210	0.038592	5.962344	2.844529	6.687126	1.042815
Maximum	14.71493	1.189407	7.007191	3.414889	7.896666	1.517373
Minimum	9.377843	-1.006120	4.071111	1.642275	5.652373	0.576477
Std. Dev.	1.563784	0.480512	0.653791	0.324356	0.640223	0.210325
Skewness	0.223126	-0.145307	-0.853924	-1.132044	0.109142	-0.186494
Kurtosis	1.885508	2.479915	3.672153	5.215168	1.677488	2.341178
Jarque-Bera	5.584780	1.375414	13.05307	38.87814	6.962159	2.221021
Probability	0.061275	0.502727	0.001464	0.000000	0.030774	0.329391

5.2.2 Correlation Matrix

The correlation matrix demonstrates how strongly the variables are related to one another. The correlation coefficients between carbon dioxide (CO_2), natural resource depletion (NRD), electric power consumption (EPC), electric power transmission and distribution loses (EPTD), gross domestic product (GDP), and urban population growth (URB) are shown in Table 2.

Table 2

Correlation Matrix results

	LCO2	**LNRD**	**LEPC**	**LEPTD**	**LGDP**	**LURB**
LCO2	1					
LNRD	-0.6299	1				
LEPC	0.8486	0.6075	1			
LEPTD	0.3751	0.3393	0.2406	1		
LGDP	0.4045	0.1587	0.7166	-0.1616	1	
LURB	-0.7088	-0.4469	-0.7095	-0.2896	-0.5733	1

Natural resource depletion and CO_2 emissions are negatively correlated, according to the correlation matrix. The interrelation between electricity consumption and CO_2 is positive. CO_2 emissions along with electric power transmission and distribution loses are positively correlated. Gross domestic product and CO_2 emissions are positively correlated. There is a negative association between urban population growth and CO_2 emissions.

5.2.3 Panel Unit Root Test

Table 3 exhibits the ADF test for checking stationarity in the variables. This research used two types of stationary tests, such as the Augmented Dickey Fuller (ADF) test and the Im-Pesaran-Shin (IPS) test, which is also known as the Pesaran-Shin test. However, DF test is mostly used to check stationarity. The estimated results of two tests show that some variables are non-stationary at the level but others are non-stationary at the first difference.

Table 3: Results of Panel Unit Root Test					
	IPS		**Fisher ADF**		**Level of integration**
	Level	**1st Difference**	**Level**	**1st Difference**	
LCO2	2.86796	-2.79183***	0.38072	18.3219***	I(1)
LNRD	-0.74538	-3.75761***	7.05938	25.2295***	I(1)
LEPC	1.87434	3.12161***	1.66487	20.9457***	I(1)
LEPTD	0.69550	4.21865***	3.18820	29.7749***	I(1)
LGDP	2.5850**	-4.60501***	0.88408**	31.9899***	I (0)
LURB	1.01437	-3.18670***	3.11369	21.0323***	I(1)

Here***** ,****means that variable is significant at 1% and 5% respectively.

In both the IPS and ADF tests, CO_2 was significant at the 1st difference with t-statistics -2.79183***. In the IPS and ADF methods, the NRD was also stationary at the first difference with t-stats -3.75761*** and 25.2295** respectively. With t-statistics 3.12161***, the first difference between the IPS and ADF methods revealed that EPC is significant. EPTD has a t-statistics of 4.21865*** at the initial difference between the ADF and IPS technique. In terms of levels and the first difference between the ADF and IPS methods, GDP is found to be significant at -4.60501*** and21.0323***.URB is significant at the first IPS and ADF difference with t-stats -3.18670*** and 21.0323*** respectively. The results of panel unit root tests show that the variables are stationary at 1st difference and at the level so we can use Pool Mean Group (PMG) technique for further analysis.

5.2.4 Panel Co-integration Test

Panel co-integration test is used to check the reliability of the variables. Here, Kao Residuals co-integration test is applied on the model, which posits that

the probability value is 0.0394 and t-statistics value is -1.757888, confirming results of ADF test. The results KAO test is presented in Table 4.

Table 4

KAO test results

			t-Statistic	Prob.
ADF			-1.757888	0.0393
Residual variance			0.003303	
HAC variance			0.004412	

5.2.5 Estimation of Pooled Mean Group (PMG) results

As some variables are stationary at level and some are stationary at first difference that why pooled mean group methodology is applied to check the short run and long run relationship between variable in the model under consideration.

First, the data analysis has been conducted for three countries: Bangladesh, India and Pakistan individually. After that the results of three countries were compared to determine overall impact of natural resources depletion, electricity consumption, urbanization, GDP, industrial output on environmental degradation. For estimation, we applied Pooled Mean Group (PMG) estimation, which is a method used in panel data analysis, particularly in the context of econometrics. It is often employed when dealing with panel data that consists of both cross-sectional (across different entities) and time-series (over different time periods) dimensions. The Pooled Mean Group

(PMG) estimator is used to estimate the coefficients of a panel data model, typically in the context of dynamic panel models. This combined the effect of both the Pooled OLS (Ordinary Least Squares) estimator, which pools data across all entities and time periods, and the Mean Group (MG) estimator, which estimates separate coefficients for each entity and then averages them. It is a valuable tool in panel data analysis for modeling and understanding complex association between variables across different entities and time periods. These results are illuminated in Table 5

Table 5

Results of PGM Test for Bangladesh				
Variable	**Coefficient**	**Std. Error**	**t-Stats**	**Prob.***
LNRD	-0.0896	0.0031	-28.3736	0.0001
LEPC	0.3692	0.0463	-7.9610	0.0041
LEPTD	0.0996	0.0016	-60.2837	0.0000
LGDP	0.0411	0.0158	-2.5975	0.0805
LURB	0.2193	0.0247	-8.8582	0.0030

The results relating to Bangladesh reveal if one unit increases in natural resources depletion (LNRD) the CO_2 emissions will likely to decrease by 8 percent which is significant at 5% because its standard error is 0.0031, t-stats is -28.3736 and probability value is 0.0001. Similarly, a one unit increases in electricity consumption (LEPC) is associated with a 0.36 percent increase in CO_2 emissions because standard error value is 0.0463, t-stats is -7.9610 and prob. Value is 0.0041. A one unit increase in line and transmission losses (LEPTD) is associated with 0.09 percent increase in CO_2 because std. error is 0.0061, t-stats is -60.2837 and prob. Value is 0.0000. Similarly, a one unit increases in

GDP growth (LGDP) will likely to cause a 0.04 percent increase in CO_2 emissions because Std. error is 0.0558, t-stats is -2.5975 and prob value is. 0.0805. These results are presented in Table 6

Table 6

Results of PGM Test for India				
Variable	**Coefficient**	**Std. Error**	**t-Stats**	**Prob.***
LNRD	-0.0149	0.0003	39.7583	0.0000
LEC	0.3425	0.1046	-3.2723	0.0467
LEPTD	0.4133	0.0149	27.6402	0.0001
LGDP	0.1350	0.0050	26.7639	0.0001
LURB	0.3178	0.0466	6.8146	0.0065

The results for India show that, if one unit of natural resources depletion (LNRD) increases the CO2 emissions is likely to decrease by -0.01 percent, which is significant at 5%. Its t-statistic value is 39.7583, standard error is 0.0003. A one unit rises in electricity consumption (LEC) is associated with a 0.34 percent increase in CO_2 emissions. Its t-statistic value is –3.27 and its standard error is 0.1046. A one-unit rise in line losses and distribution losses (LEPTD) is associated with a 0.41 percent increase in CO_2 emissions which is significant at 5% level. Its t-statistic is 27.6402 and standard error is 0.0149. One unit increases in GDP will likely to cause an increase of 0.13 percent in CO_2 emissions. These results are illustrated in Table 7

Table 7

Results of PGM Test for Pakistan				
Variable	**Coefficient**	**Std. Error**	**t-Stats**	**Prob.***
LNRD	-0.0141	0.0040	-3.5407	0.0383
LEPC	0.1584	0.1695	0.9345	0.4190
LEPTD	0.1204	0.0369	3.2543	0.0473
LGDP	0.0087	0.0148	0.5909	0.5961
LURB	0.1411	0.0351	4.0129	0.0278

The results in table 7 relating to Pakistan show that if one unit increase in natural resources depletion (LNRD) , CO2 will likely to decrease by -0.01 percent, which is significant at 5% because its standard error is 0.0040, t-stats are -3.5407 and probability value is 0.0383. Similarly, a one unit increases in electricity consumption (LEPC) will likely cause a 0.15 percent increase in CO2 emission because its standard error value is 0.1695, t-stats is 0.9345 and prob. Value is 0.4190. A one unit increases in Line losses and distribution losses (LEPTD) will likely to cause 0.12 percent increase in CO2 emissions as its std. error is 0.0369, t-stats is 3.2543 and prob. Value is 0.0473. Similarly, a one unit increases in GDP (LGDP) is associated with an 0.0087 percent increase in CO2 emissions as its std. error is 0.0351, t-stats 0.5909 and prob. Value is 0.5961. Table 8 shows these results.

Table 8

Comparison of Short-Run Results for three countries

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNRD	-0.074900	0.037998	-1.971171	0.0540
LEPC	0.041725	0.019893	-2.097507	0.0477
LEPTD	0.514611	0.088034	5.845567	0.0000
LGDP	0.158371	0.014342	11.04236	0.0000
LURB	0.561821	0.301600	1.862798	0.0759

The results in Table 8 relating to three countries, India, Pakistan and Bangladesh show If natural resources depletion (LNRD) increases by one unit (-1), CO_2 emissions are likely to decrease by 0.07 percent, which is significant in the short term at 5% level. Its t-statistic value is -1.971171, and its standard error is 0.03. Similarly, a one unit increases in electricity consumption (LEPC) is associated with a 0.04 percent increase in CO_2 emissions. Its t-statistic value is -2.09 and its standard error is 0.04. A one-unit rise in Line and distribution losses of electricity (LEPTD) is associated with a 0.51 percent increase in CO_2 emissions, which is significant in the short term at 5% level. Its t-statistic is 5.84 and its standard error is 0.01. In the short run, if one unit increases in GDP will likely to results an increase of 0.15 percent in CO_2 emissions. Urbanization shows positive association with CO2 emissions as its coefficient value is 0.561821, indicating one unit increases in urbanization is association with CO2 emission increase by 56.18% in the short run.

The long-term findings of the study are presented in Table 9

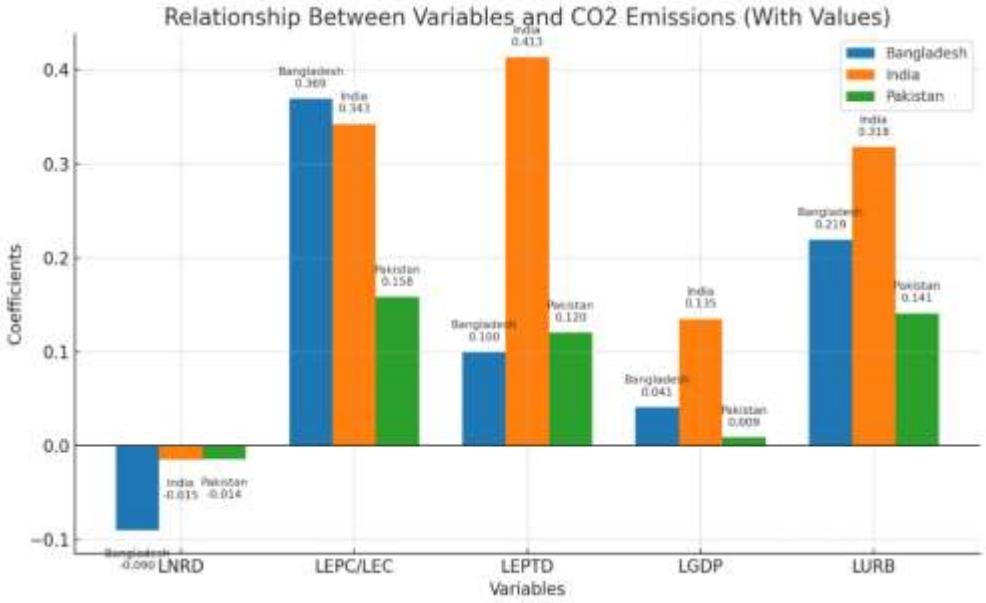
Table 9

Comparison of long run results for three countries

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LNRD	-0.234082	0.072434	-3.231663	0.0021
LEPC	0.436570	0.088237	-4.947688	0.0000
LEPTD	0.783806	0.255904	3.062893	0.0035
LGDP	0.234082	0.072434	-3.231663	0.0021
LURB	-0.436570	0.088237	-4.947688	0.0000

The long run results about India, Pakistan and Bangladesh depicted in Table 9 show if one unit increase in natural resources depletion (NRD), it will likely to cause 0.23 percent decrease in CO_2 emissions in the long run This relationship is significant at 5% level. Its t-statistic value is -3.23 and its standard error is 0.072. A one-unit rise in electricity consumption (EPC) is associated with an increase 0.43% rise in CO_2 emission in the long run. Its t-static value is -4.94, and its standard error is 0.08. A one-unit increase in electricity line and distribution losses (EPTD) will result in a 0.78 percent increase in CO_2 emission, which is significant at a 5% level over the long term. Its t-static value is 3.06, and its standard error is 0.25. If GDP increases by one unit is associated with an increase in CO_2 emission by 0.23 percent in the long run. The association between urbanization and CO2 emission in the short run is negative as the coefficient value -0.436570 shows, indicating if one unit increases in urbanization there is likely be decreased in the level of CO_2 emissions in the long run.

The overall results, showing a clear picture of relationship between variables (LNRD, LEPC/LEC, LEPTD, LGDP, LURB) and CO_2 emission in India Pakistan, and Bangladesh are depicted in Figure 11



In Figure 11, each bar reflects the coefficient value from the PMG test, indicating how changes in these variables affect CO_2 emissions in India, Pakistan and Bangladesh during the study period.

5.2.6 Pair-wise Granger Causality Test

The causality of variables has been checked by employing Pair-wise Granger Causality test. Table 10 exhibits estimated results of this test.

Table 10.

Pairwise Granger causality test

Causality in variables	**F-Statistics**	**Probability**
LCO2 does not Granger Cause LNRD	4.54725	0.0358
LNRD does not Granger Cause LCO2	5.52699	0.0210

LCO2 does not Granger Cause LEPC	4.05126	0.0472
LEPC does not Granger Cause LCO2	7.33040	0.0082
LCO2 does not Granger Cause LEPTD	3.62771	0.0601
LEPTD does not Granger Cause LCO2	4.22214	0.0429

The estimated results of pair-wise granger causality test show that LCO_2 does not granger cause LNRD with probability value 0.0358 and F-statistics 4.54. Secondly, LNRD does not granger cause LCO_2 with probability value 0.02 and F-statistics 5.52. LCO_2 does not granger cause LEPC with probability value 0.04 and F-statistics 4.05. LEPC does not granger cause LCO_2 with probability value 0.008 and F-statistics 7.33. LCO_2 does not granger cause LEPTD with probability value 0.06 and F-statistics 3.62. LEPTD does not granger cause LCO_2. showing p-value 0.04 and F-statistics 4.22.

5.2.7 Model summary

Table 11 exhibits model summary, showing variation in dependent variable (environmental degradation) due combined changes in dependent variables: natural resources depletion, electricity consumption, electricity line and distribution losses and GDP growth.

Table 11

Model Summary

Statistic	**Value**	**Test**	**Value**	**p-value**
R-squared (R^2)	0.8726	**Bruch-Pagon Test**	2.0372	0.1255
Adjusted R-squared	0.854	**Ramsey RESET Test**	1.1961	0.2491
Durbin-Watson Statistic	2.0476	**Jarque-Bera Test**	1.5831	0.4531

The R-squared ($R^2 = 0.8726$) suggests that the model illustrates approximately 87.3% of the variation in the dependent variable, demonstrating a strong fit of the model to the data. Adjusted R-squared (0.854) shows that After adjusting for the number of predictors, the model still explains 85.4% of the variation in the dependent variable, which again confirms the reliable good-fit of the model. The Durbin-Watson Statistic (2.0476) is near to 2, suggesting no autocorrelation in the residuals. The Bruch-Pagon Test for Heteroscedasticity ($p = 0.1255$) demonstrates that there is no heteroscedasticity in the model. The Ramsey RESET Test for Model Specification ($p = 0.2491$) suggest that the model does not suffer from omitted variable bias. The Jarque-Bera Test for Normality ($p = 0.4531$) indicates that the residuals conform to normality.

6. Discussion

The key findings of this study are explained in the following.

The descriptive statistics analysis shows the values of means, standard errors, t-statistics and probability of variables. The results reveal that the data of all variables are normally distributed. The results of correlation matrix shows that Natural resource depletion and CO2 emissions are negatively correlated. The correlation between electricity consumption and CO2 emission is positive. CO2 emissions have positive correlation with electric transmission and distribution loses while Gross domestic product and CO2 emissions are also positively correlated. However, there is a negative correlation between urban population growth and CO2 emissions. The results of two-unit root tests reveal that the variables in the model are stationers at different levels and it allows us to use Pooled Mean group model for analysis. Pooled Mean Group

(PMG) Approach was employed to determine short and long-run relationship between variables in India, Pakistan and Bangladesh. The short run results relating to three countries, India, Pakistan and Bangladesh show If natural resources depletion (LNRD) increases by one unit (-1), CO2 emissions are likely to decreased by 0.07 percent and this relationship is significant in the short term at 5% level. Its t-statistic value is -1.971171, and its standard error is 0.03. Similarly, a one unit increases in electricity consumption (LEPC) is associated with a 0.04 percent increase in CO2 emissions. Its t-statistic value is -2.09 and its standard error is 0.04. A one-unit rise in Line and distribution losses of electricity (LEPTD) is associated with a 0.51 percent increase in CO2 emissions, which is significant in the short term at 5% level. Its t-statistic is 5.84 and its standard error is 0.01. In the short run, if one unit increases in GDP will likely to results an increase of 0.15 percent in CO2 emissions. Urbanization shows positive association with CO2 emissions as its coefficient value is 0.561821, indicating one unit increases in urbanization is association with CO2 emission increase by 56.18% in the short run.

The long run results of India, Pakistan and Bangladesh show if one unit increase in natural resources depletion (NRD), it will likely to cause 0.23 percent decrease in CO2 emissions in the long run This relationship is significant at 5% level. Its t-statistic value is -3.23 and its standard error is 0.072. A one-unit rise in electricity consumption (EPC) is associated with an increase 0.43% rise in CO2 emission in the long run. Its t-static value is -4.94, and its standard error is 0.08. A one-unit increase in electricity line and distribution losses (EPTD) will result in a 0.78 percent increase in CO2 emission, which is significant at a 5% level over the long term. Its t-static value is 3.06, and its standard error is 0.25. If GDP increases by one unit is associated with an increase in CO2 emission by 0.23 percent in the long run. The

association between urbanization and CO2 emission in the short run is negative as the coefficient value -0.436570 shows, indicating if one unit increases in urbanization there is likely be decreased in the level of CO2 emissions in the long run.

The Pair-wise Granger causality test show that LCO2 does not granger cause LNRD with probability value 0.0358 and F-statistics 4.54. Secondly, LNRD does not granger cause LCO2 with probability value 0.02 and F-statistics 5.52. LCO2 does not granger cause LEPC with probability value 0.04 and F-statistics 4.05. LEPC does not granger cause LCO2 with probability value 0.008 and F-statistics 7.33. LCO2 does not granger cause LEPTD with probability value 0.06 and F-statistics 3.62. LEPTD does not granger cause LCO2. showing p-value 0.04 and F-statistics 4.22.

The results of model summary show that the value of $R^{2,}$ is 0.8726 and adjusted R^2 value is 0.854, suggesting that 85% to 87% variation in CO_2 emissions are on account of combined effect of independent variables, proving that the model is goodness of fit to the data and its results are robust. Similarly, the value of Durbin Watson Statistics 2.047560 demonstrates that there is no problem of heteroskedasticity issue in the model because t-statistics value is 2.03. These results are in line with the findings of Gupta, & Maheshwari, (2023), Singh, et al (2023), Ahmad, et al (2023), Khan & Khan, (2023) Ahmed, et al. (2022). Ali, et al. (2022). Islam, et al. (2022). Mahmood, (2021). Mishra, (2021) and Lee, et al. (2021).

6.1 Policy implications

This study has several practical implications which are discussed as under: -

First, the findings of this study emphasizes that the policy makers should must concentrate on controlling depletion of natural resources specifically in the context of mitigating CO_2 emissions. There must be practical strategies to conserve natural resources and promoting sustainable development to reduce environmental degradation. Second, having positive association between electricity consumption and CO_2 emissions, there an urgent need for transition towards renewable energy sources and cleaner technology. The policy makers should provide necessary incentive for adoption of renewable energy technologies and develop energy efficiency to reduce environmental impact on electricity consumption. Third, the positive association between CO_2 emissions and electricity transmission line losses sheds light on the importance of investing in efficient electricity transmission and distribution infrastructure. Building efficient infrastructure could help reduce energy losses and lower CO_2 emissions. Fourth, the study exhibits positive association between GDP growth and CO_2 emissions and it indicates that there is close link between economic development and environmental challenges. Fifth, the study suggest that green finance, green industries and green sustainable practices can be adopted to mitigate the impact of GDP growth on CO_2 emissions. Sixth, there is negative association between urbanization and environmental degradation in the short run. However, in order to reduce the environmental impact of urbanization there is need for promoting green transportation, energy efficient buildings and recycling of wastes. Seventh, the study suggest that India, Pakistan and Bangladesh should cooperate and opt collaborative strategies to cope with common environmental challenges. Cross-country cooperation and collective efforts as well as policy interventions are crucial to address environmental issues.

Data availability statement

The data which is used in the findings of this study will be made available on strong request.

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