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SOCIO-ECONOMIC DRIVERS OF SMOKING AMONG YOUNG MALE STUDENTS IN PAKISTAN: A CASE STUDY APPROACH

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ABSTRACT

This study investigates the relationship between economic growth, foreign direct investment (FDI), energy consumption (renewable and non-renewable), natural resource rent, and environmental degradation in Pakistan from 1970 to 2023. Using the Auto Regressive Distributed Lag (ARDL) model, the findings support the Environmental Kuznets Curve hypothesis—economic growth initially increases environmental degradation but later leads to improvement. FDI significantly contributes to CO_2 emissions, while renewable energy and natural resource rent help reduce environmental harm. The study underscores the need for sustainable policies that promote renewable energy, regulate environmentally damaging FDI, enforce strict environmental laws, and encourage cleaner technologies and efficient resource use to balance growth with environmental sustainability.

Key Words: *Environmental Degradation, Economic Growth, Energy Consumption, Foreign Direct Investment, Natural Resources.*

INTRODUCTION

Environmental Degradation (ED) is one of the vital challenges of the world. The most valuable asset of the world is the world itself. Environmental quality is the indicator of survival for both humans and non-human beings. Nature provides us with the food we eat, the shelter where we live, and the clothing we wear; the insane increase in human activities has inflicted an irreversible impact on the environment. The degradation of the environment is the escalated extraction of natural resources rather than their production, which leads to the erosion of natural resources and the deterioration of environmental quality (Ozturk and Ali 2010). The resources are base of almost all industries, directly or indirectly, in the world, and ED leads to the reduction of natural resources available to consume for the survival of humans and no beings, e.g., the availability of freshwater reserves due to water pollution, air pollution, and soil pollution. A rough estimate unveiled that 80% of the freshwater pollution contains plastic waste that humans use. Plastic water harms the coral reefs, fish, and other marine ecosystems. Emissions of particulate matter (PM 2.5) in the air, such as greenhouse gases (GHGs) such as carbon dioxide (CO_2), methane (CH4), nitrous oxide (N_2O) etc. The GHGs absorb heat from the environment and do not let it release into the atmosphere, increasing the Earth's temperature. According to the World Meteorological Organization (WMO), the world's temperature has risen to 1.20±0.12°C in the last ten years on average. The average increase shows that it is increased only 1.20±0.12°C in all the regions of the world, but it is overall average only in many places the temperature may increase up to 10°C. This spike in the temperature causes the altered pattern of weather and seasons that contributes to droughts and leads living beings to the level of extinction. The greenhouse effect also caused the increase in sea level (National Aeronautics and Space Administration, n.d.). The rising sea levels cause land erosion, Tsunamis, droughts, and

habitat loss. The melting glaciers also accelerate the rate of glacier meltdown due to overwhelming human activities in Antarctica, resulting in increasing habitat loss of marine life and biodiversity.

Intergovernmental Panel on Climate Change (IPCC) warns that if the climatic temperature increases to 1.5°C, the damage to the environment will be irreversible. Soil pollution is also adding to such a phenomenon. The soil is polluted by the utilization of pesticides and fertilizers in the soil and the dumping of wastes from human activity. Deforestation is a mass reduction in the number of trees due to human activities such as agriculture expansion, infrastructure development, and urbanization. Deforestation and soil pollution are causing habitat loss, reduced biodiversity, and a dwindling amount of food available to living organisms. The economic activities are directly or indirectly linked to the natural resources. Entrepreneurs exploit natural resources and put them to human use. This exploitation of natural resources is called natural resources rent, and the increased amount of natural resource rent without increasing such resources leads to ED. Such a phenomenon is mostly observed in developing economies such as Pakistan. Multinational corporations (MNCs) invest in developing economies due to the strict environmental regulations in their own countries, which cause ED. This hypothesis is called the pollution heaven hypothesis; the foreign direct investment (FRDI) backed by pollution heaven always deteriorates environmental quality in developing economies (Copeland and Taylor,1994), and such investment is mainly in industries that heavily generate pollutants to the environment. The nexus continues until the economies invest in green technologies and clean energy.

Unravelling the Nexus of Energy Consumption, Foreign Direct Investment, and Natural Resources Rent with Environmental Degradation and Economic Growth

Pakistan is no exception to ED. Pakistan stood second in the rank of most pollutant country in the world in 2023 (IQAir, n.d.). Pakistan's dependence on fossil fuels for industry, deforestation, and pollution heaven is degrading the environment rapidly (Raza and Nida, 2018). Sectors such as agriculture, transportation, and housing are severely affected by ED. Deforestation not only contributes to climate change but also reduces the amount of oxygen to be consumed. Water pollution is caused by industries reducing the amount of freshwater used for drinking. Despite the efforts to reduce the pace of ED, such as the Pakistan Environment Protection Act 1997 and the establishment of the Global Change Impact Studies Centre Act 2013, the environmental quality is not improving. It is important to access the linkage of ED, energy consumption (EC), FRDI, and total natural resources rent (TNRT) to suggest policy implications for handling the problem of ED in Pakistan.

The study is important as its objective is to explore the connection between EC, FRDI, gross domestic product (GDP) per capita growth, and TNRT on ED. ED has an environmental impact and an economic impact as well. Pakistan has been striving to cope with environmental challenges since the advent of the 21st century. Firstly, the study will assess the impact of EC, FRDI, GDP per capita growth, and TNRT on ED in the most recent years. Secondly, the study will also confirm the Environmental Kuznets Hypothesis (EKC), which provides information about the direction of economic growth (EG) in an environmental scenario. The study will contribute to the existing literature. Thirdly, the study will suggest feasible policy solutions according to the estimated model.

LITERATURE REVIEW

Kazim (2007) examined the linkage between primary EC, EG, urbanization, population growth, and ED in the United Arab Emirates (UAE). The author collected data from World Development Indicators (WDI) from the period stretching from 1972-2005. The author applied Ordinary Least Squares (OLS) to calculate the linkage among variables. The study manifested that urbanization, population growth, and EG were increasing ED in the UAE, which implies a positive relationship among variables. Erdal et al. (2008) explored the correlation between EC and EG in Turkey during the period from 1970-2006. The authors gathered data from the Turkish Statistical Institute and the Turkish

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Ministry of Petroleum. The study has applied the Granger Causality Test to assess the correlation between the variables. The study pointed out the bidirectional causality between EC and EG in Turkey. The authors also suggested that Turkey adopt green energy to reduce dependence on fossil energy and improve environmental quality.

Rufael (2009) investigated the association between EG and EC for the period 1971-2004 in seventeen African countries. The data was gathered from WDI. The author has applied Toda Yamamoto Granger Causality to estimate the association among variables revealing that EC had a less significant impact, while the impact of the labour force and capital formation was significantly high, on GDP. Ozturk and Acaravci (2010) explored the connection between EG and EC in Turkey, stretching the period from 1965 to 2005. The authors collected data from WDI and the Turkish Statistical Bureau and handled the Auto Regressive Distributed Lag Model (ARDL) and Granger Causality to calculate the connection between variables. The study unveiled that there was no causal relationship between EC, EG, and CO_2 emissions. The study also explored how the employment ratio causes EG. The energy conservation policies were not hindering EG.

Burnett and Begstrom (2011) investigated the connection between EC in the technological innovation sector, EG, and ED using the EKC in the United States of America (USA). The authors disclosed that the EKC was valid for the USA; this was because the USA was adopting environmental policies to reduce carbon emissions.

Jafari et al. (2012) explored the association among EC, EG, and CO2 in Indonesia. The study gathered data from WDI and employed the regressive ARDL and Granger Causality Test to calculate the association among variables. The study reported that no causality exists among the variables. The Malaysian Government failed to implement environmental policies due to low economic growth. The study proposed stopping or dwindling deforestation to reduce CO2 emissions in Malaysia.

Saboori and Suleiman (2013) examined the relationship between EC, EG, and ED using the EKC, which was used from 1980 to 2009 in Malaysia. The study has collected data from the US Energy Information Administration (EAI) and WDI. The study used the ARDL, Granger Causality Test, and Johansen Julius Maximum Likelihood (JJML) to assess the relationship among variables. The study discovered that the EKC was invalid for aggregate EC data, and the EKC was valid for Malaysia when EC was disaggregated into its components, such as coal, oil, gas, and electricity.

Aremu (2014) highlighted the correlation between EC, EG, and ED in Nigeria, stretching the period from 1981 to 2011. The author has collected data from WDI and applied the Vector Autoregressive Model (VAR) and Granger Causality Test to calculate the correlation among variables. The author revealed that EC was positively correlated with EG and ED, and a bidirectional causality exists between EC and economic growth. The study also reported unidirectional causality between EG and carbon emissions. Sehrawat et al. (2015) highlighted the linkage between EG, EC, and ED in India for the period from 1971 to 2011. The study has employed the ARDL to assess the relationship among variables. The study explained that there exists a positive long-run linkage among variables, which implies that financial development and EG were increasing ED.

Desteck (2016) explained the correlation between EC and EG from the period stretching from 1971-2011 in selected countries. The author has applied an asymmetric causality approach to estimate the correlation between variables. The study revealed that negative shock in renewable energy consumption (RAEN) was increasing EG in South Africa and Mexico, while positive RAEN shock negatively impacted Indian EG. Sek (2017) examined the impact of EC and EG in China using time series data from the Data Stream from 1966 to 2015. The study reports a positive impact of EC on Chinese EG and vice versa on ED. The author has proposed policies to increase EG that support the environmental quality in China.

Raza and Nida (2018) explored the impact of financial development, EC, and EG on ED in Pakistan. The authors collected data from WDI, the Economic Survey of Pakistan, and the Handbook of Statistics of Pakistan from 1972 through 2014. The study used the ARDL to estimate the connection among variables. The

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investigation disclosed the positive connection between EC, EG, and carbon emissions in Pakistan.

Bekun (2019) elucidated the nexus between carbon emission, resource rent, and non-renewable energy in 16 European Union countries. The study has applied the Panel Pooled Mean Group ARDL to estimate the linkage among variables. The results of the study showed a positive association between resource rent, EC, and EG. The results also showed that overdependence on non-renewable energy sources leads to expedited ED. The study suggested policies to mitigate ED along with economic growth.

Ozcan et al. (2019) highlighted the bond between EC, EG, and ED in 35 OECD countries from the period stretching from 2000-2014. The author collected data from the Environmental Performance Index (EPI) from Yale Centre of Environmental Law and Policy, Ecological Footprint (EF) from Global Footprint Network, and EG from WDI-World Bank. The author used the Generalized Method of Moments (GMM) and Panel Vector ARDL to estimate the association among variables. The author has revealed the positive association between EF, CO2 Emission, and EPI with EG. Due to the heavy mining of non-renewable energy components and export products, CO2 emission has been escalating.

Ahmed et al. (2020) investigated the association of TNRT, urbanization, human capital, ecological Footprint, and EG in China from a period stretching from 1970-2016. The study has applied the Bayer and Hack cointegration test and footprint causality test to examine the linkage among variables. The study revealed that enhanced natural resource rent increases the rate of ecological Footprint. The study also revealed that EG and urbanization were positively bonded with ED, and vice versa, in the case of human capital formation. The study has also proposed policies to reduce ED. Al-Zgool et al. (2020) investigated the relationship between EC and EG in Bahrein. The author collected data from 1980 to 2018 from the World Bank (WB) database. The study applied the ARDL to estimate the relationship among variables. The study revealed that there exists a positive association between EC and EG in Bahrein.

Ummalla and Goyri (2020) investigated the relationship between clean EC, energy growth, and carbon emissions in BRICS countries. The author collected data from WDI and BPSR around the world. The study has pointed out that there exists a positive connection between clean EC and EG. The study also discovered that the EKC was valid for BRICS countries, and a unidirectional causality exists between EC and EG. Muhammad et al. (2021) investigated the linkage between ED, EG, FRDI, and EC in BRICS developing and developed countries from 19991-2018. The author gathered data on ED from the Joint Research Centre (JRC-2019), fuel, natural gas, foreign direct investment, urbanization, and trade openness from WDI. The author used the GMM to assess the linkage among variables. The outcome of the study has shown that FRDI escalated the ED in BRICS and developing countries while it reduced the ED in developed countries. Total natural resources, e.g., coal, natural gas, minerals, oil exploitation, and EG, were responsible for ED in BRIC and developing and developed economies. Baydoun and Aga (2021) examined the bond between EC, EG, financial development, and environmental stability in the Gulf Cooperation Council (GCC), stretching from 1995 to 2018. The author has applied Cross-Sectional Dependence (CSD), Slope Heterogeneity (SH), Cross-Sectional ARDL, and Dumit Rescue and Hurlin (DH) Causality Approach to access the bond among variables. The study pointed out that EC and EG were responsible for the ED of the GCC. The study also disclosed that trade openness and globalization have reduced the ED in GCC. The study discovered the one-way causality between EG and ED in GCC.

Udemba and Yalcintas (2021) highlighted the relationship between ED, non-renewable energy resources, FRDI, and EG in the period stretching from 1970-2018 in Algeria. The author has collected data from the WDI and British Petroleum Statistical Review (BPSR) of world energy. The author has applied a non-linear asymmetric version of the ARDL to calculate the relationship among variables. The study disclosed that positive and negative shocks to EC and EG have also increased and decreased carbon emissions, respectively. The study has

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also disclosed that positive shocks to FRDI have decreased the ED in Algeria.

Gao et al. (2021) explored the connection between renewable and non-renewable energy sources and the ecological footprint in China. The author compared the different clean energy resources and their impact on ecological footprint. The study employed a Life Cycle Framework to estimate the connection among variables. The author pointed out that the cleanest energy sources cause ED to some extent, but among all the sources, wind energy was the least culprit for ED. The provinces of China, such as Anhui, Shandong, and Jiangsu, had an ecological surplus. The study laid stress on enhancing wind power generation as it was the most feasible source of energy generation in China.

Anwar and Elfaki (2021) highlighted the linkage between EC and EG, capital formation, and ED in Indonesia. The author collected data on CO2 emissions from the British Petroleum Statistical Review of the world. The data on trade openness and EG was collected from WDI. The data collection ranged from 1985 to 2018. The author has used the ARDL and Ordinary Least Square (OLS) to estimate the correlation among variables. The results of the study showed that cointegration existed among EC, EG, ED, and EG. The study also discovered a long-run positive relationship between EC, EG, and ED, while there was a negative linkage between gross fixed capital formation and ED. The author has suggested that Indonesia may adopt environmental policies to diminish ED. Usman et al. (2022) studied the relationship between ecological footprint, human capital, and nuclear energy in twelve selected economies. The author collected from WDI over the range of 1980-2015. The author applied Cross-Sectional ARDL to estimate the connection among the variables. The present study found that the increase in human capital, such as education, was negatively correlated with the ecological footprint, and the use of nuclear energy was also negatively connected with the ED in the selected developed economies. The author suggested economic managers make policies to enhance public investment in human capital formation and nuclear energy use.

Jamil (2022) examined the correlation between EC and EG in India, Pakistan, and China. The author compiled data from WDI and IMF databases stretching from 1975-2001. The author used the ARDL, Granger Causality, and modified OLS to calculate the correlation among variables. The study has disclosed the unidirectional causality between EC and EG in the long run and short run. The study emphasized the use of non-renewable energy resources such as wind, solar, and geothermal energy to mitigate ED.

Bildirci et al. (2023) investigated the relationship between energy intensity, foreign direct investment, EG, and PM 2.5 emissions in China, India, Germany, the United States of America, Canada, and the United Kingdom. The authors have collected data from WDI over the period 1995-2019. The study has applied the Panel Fourier Bootstrapping ARDL and Granger Causality (Granger, 1963) to assess the relationship among variables. The study discovered the bidirectional causality between urbanization, EG, Energy Intensity, and PM 2.5 emissions. The ARDL approach also confirmed the long-run positive linkage among urbanization, EG, energy intensity, and PM 2.5 emissions.

Butt et al. (2023) investigated the correlation between non-renewable energy Consumption (NECN), EG, and exports in the Chinese economy. The study collected data from WDI. The author applied the Granger causality test to assess the relationship among variables. The study pointed out that the Chinese economy was facing escalated ED due to the use of non-renewable energy in production. Gibba et al. (2024) explored the linkage among foreign direct investment, EG, and greenhouse gas emission (GHGE) in Oil Producing and Exporting Countries (OPEC) during the period stretching from 1983-2022. The authors collected data from WDI. The investigation has applied the ARDL to estimate the linkage among variables. The study disclosed EG was positively correlated with GHGE, while FRDI and trade openness were negatively correlated with GHGE. The study has also suggested that OPEC may adopt policies that reduce the GHGE.

Udemba et al. (2024) have examined the influence of disaggregated demographic

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variations on ED in Russia. The author collected data from the Russian Ministry of Economic Affairs and handled ARDL to get the results. The study manifested that human activity, such as urban migration, construction, tourism, etc., has contributed to the ED in Russia. The study also found that financial inclusion and environmental mitigation technologies helped to reduce ED. Human activities and carbon emissions have affected the natural environment in the world. Wang et al. (2024). The author gathered data from the WDI of selected countries of the world and applied the ARDL method to access the results. The study validated the EKC in the world and suggested that carbon emissions must be reduced by the adoption of cleaner energy.

Achuo and Ojong (2024) tested the EKC in 46 African countries between 1966 and 2022. The authors collected data from WDI and employed OLS to access the connection among variables. The results unveiled that EC, EG, and CO2 were positively correlated. The study also confirmed EKC in African countries.

METHODOLOGY

Data for all the study variables is downloaded from the WDI website from the period stretching from 1970-2023. The variables and their units of measurement are in the table below.

Table 3.1 Variables and units of measurement

Variables	Units
CO2	CO2 emissions (Metric ton per capita)
TNRT	Total natural resources rents (% of GDP)
(GPPR)*2	(GDP growth (annual %)) *2
GPPR	GDP growth (annual %)
RAEN	Renewable energy consumption (% of total energy consumption)
FRDI	Foreign direct investment (% of GDP)
NECN	Non-renewable energy consumption (% of total energy consumption)

Our model is concerned with the estimation of the nexus among EC, ED, GDP growth rate, and FRDI. ED is the dependent variable for which CO2 emissions are used as a proxy. CO2 gas is a GHG that traps heat produced by burning fossil fuels and does not let it go into the environment. Independent variables are GDP Growth per capita annual percentage. FRDI explains the next flow of capital in the economy. EC is disaggregated into NECN and RAEN to estimate the distinct impact on CO2 emission.

Following is the functional form of the theoretical model:

$$CO2 = f(GPPR, (GPPR)*2, FRDI, NECN, RAEN, TNRT) \quad (3.1)$$

The econometric form of our model is as follows:

$$CO_2 = \lambda_1 + \lambda_2 GPPR + \lambda_3 GPPR^2 + \lambda_4 FRDI + \lambda_5 NECN + \lambda_6 RAEN + \lambda_7 TNRT + \varepsilon \quad (3.2)$$

$$\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6, \lambda_7 > 0$$

Before applying for ARDL. Augmented Dicky Fuller (ADF) unit root test was applied to check the stationarity of the variables. The ARDL technique will apply the following UECMs (unrestricted error correction models). To determine the factor of CO2, the associated UECM is given below:

Following is the functional form of the theoretical model:

$$CO2 = f(GPPR, (GPPR)*2, FRDI, NECN, RAEN, TNRT) \quad (3.1)$$

The econometric form of our model is as follows:

$$CO_2 = \lambda_1 + \lambda_2 GPPR + \lambda_3 GPPR^2 + \lambda_4 FRDI + \lambda_5 NECN + \lambda_6 RAEN + \lambda_7 TNRT + \varepsilon \quad (3.2)$$

$$\lambda_1, \lambda_2, \lambda_3, \lambda_4, \lambda_5, \lambda_6, \lambda_7 > 0$$

RESULTS AND DISCUSSION

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Table 4.1 shows the descriptive statistics. Skewedness is the property of time series that explains how much the time series deviated from the symmetrical. The deviation may be positive or negative; if the mean is greater than the median, it would be positively skewed and vice versa. In Table 4.1, the FRDI, GPPR, and TNRT are positively skewed, while CO2, NECN, and RAEN are negatively skewed.

C.K. Tylor highlighted the concept of Kurtosis to explore the peak and flatness of the distribution. Kurtosis reveals how closely values are spread in a normal distribution. There are three types of kurtoses: platykurtic, mesokurtic, and leptokurtic. The standard criteria of the Kurtosis are that if the kurtosis value of the variable is equal to 3, then the variable is mesokurtic or normally distributed; if the kurtosis value of the variable is less than 3, then it will be platykurtic or flat normal distribution, and if the value of the variable is greater than 3 then the variable will be leptokurtic of thin of peak distribution. According to this criterion, the FRDI, GPPR, and TNRT are leptokurtic, and CO2, NECN, and RAEN are platykurtic.

Table 4.1 also contains the values of the Jarque-Bera (JB) test for the values of all endogenous and exogenous variables. The JB test points out that if the series is normally distributed or not, it is also called the goodness of fit of the model. The hypotheses for this are H1: the series is not normally distributed, and Ho: the series is normally distributed. The JB test results are examined on the probability or p-values. If the p-values are zero or near zero, then the null hypothesis is rejected, and vice versa for alternative hypotheses. For this given criterion, CO2, RAEN, GPPR, and NECN are normally distributed, while FRDI and TNRT are not normally distributed.

Table 4.1 Descriptive Statistics

	CO_2	FRDI	GPPR	NECN	RAEN	TNRT
Mean	0.709382	0.669465	1.958217	50.74964	48.92813	2.011039
Median	0.711122	0.524257	1.816338	53.54954	47.95000	1.442397
Maximum	0.918473	3.035719	8.322102	62.47639	58.10000	9.329521
Minimum	0.505906	-0.062662	-2.970295	35.29485	41.60000	0.740027
Std. Dev.	0.109617	0.634652	2.277852	9.300052	4.358102	1.553442
Skewness	0.060948	2.144554	0.152412	-0.452549	0.312579	2.632091
Kurtosis	2.121767	7.926978	3.041792	1.669824	2.392611	11.27708
Jarque-Bera	1.113715	94.23305	0.212993	4.853571	1.012993	208.4804
Probability	0.573007	0.000000	0.898978	0.088320	0.602603	0.000000

Source: Authors' Calculations

Table 4.2 explicates the way of association among variables that variables in our model are positively or negatively associated with each other. The results of the correlation matrix are presented following:

Table 4.2 Correlation Analysis

	CO_2	FRDI	GPPR	NECN	RAEN	TNRT
CO_2	1					
FRDI	0.55084	1				
GPPR	0.10951	0.1091	1			
NECN	0.97464	0.4891	0.1183	1		
RAEN	-0.98182	-0.4497	-0.1278	-0.9817	1	
TNRT	0.61114	0.2653	0.3771	0.6520	-0.6787	1

Source: Authors' Calculations

Table 4.2 manifests that CO2 is positively linked to the FRDI, GPPR, NECN, and TNRT, while CO2 is negatively correlated with the RAEN. Although the association of the CO2 with the GPPR is positive, their relationship is weak. Time series is non-stationary or has a unit root if the variance and mean of a time series are not constant and the shocks malign the pattern of the time series. The Augmented Dicky Fuller (ADF) test is one

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of the statistical procedures to check the stationarity and non-stationarity of the time series. The time series is said to be stationary at I(0) 0r I(1) with a lag. The results of the examined variables, ED, EC, EG, FRDI, and TNRT, are shown in Table 4.3. The Table reveals that the FRDI, GPPR, RAEN, and TNRT are stationary at I(0), and CO2 and NECN are stationary at I(1).

Table 4.3 ADF Test

Unit Root Test on Level							
Variables	**None**	**Lags**	**Intercept**	**Lags**	**Intercept and Trend**	**Lags**	**Conclusion**
CO_2	1.7039	0	-1.1480	0	-4.0696	2	I(1)
FRDI	-1.8968	1	-3.0848	1	-3.2056	1	I(0)
GPPR	-4.9750	0	-7.2657	0	-7.1927	0	I(0)
NECN	3.6021	0	-1.3472	0	-0.6721	0	I(1)
RAEN	-2.2813	0	-1.1984	0	-2.8733	0	I(0)
TNRT	-1.9746	0	-2.6956	1	-3.7553	0	I(0)

Source: Authors' Calculations

The bounds test informs about the exitance of the long-run relationship among variables. The statistics for our model are given in the Table 4.4:

Table 4.4 The F-test for Cointegration

	5% Critical Value Bounds		10% Critical Value Bounds	
F-Statistics	**I(0)**	**I(1)**	**I(0)**	**I(1)**
4.0016	3.1	3.87	2.63	3.35

Source: Authors' Calculations

Since the F-statistics > upper bounds critical value, it implies that CO2 has a long-run relationship with economic factors given in the model. Table 4.5 shows the long-run relationships between CO2 and independent variables. The GPPR value of 0.013558 shows the positive relationship between CO2 emission and GPPR growth. One unit increase in GPPR, 0.013558 units, will be an increase in CO2 emission. When the GPPR increases, the demand for services and goods also increases, which leads to the production of more goods and services in the economy, resulting in CO2 emissions. Our results are supported by Al-zgool (2020), Muhammad et al. (2021), and Gibba and Jallow (2024). GPPR2 value -0.001920 indicates a negative linkage of CO2 emission with squared GPPR. This situation is called EKC. The result revealed that the EKC is true for Pakistan. The EKC postulates that with economic growth, the environment initially degrades, but over time, the environmental conditions improve. The situation may be referred to as environment halo. Our inferences are backed by Saboori and Sulaiman (2013), Baydoun and Aga (2021), and Achuo and Ojong (2024).

FRDI exhibits a positive connection with CO2 emission, assuming the value is 0.010378, which means that the unit increase in FRDI increases to 0.010378 CO2. When industrialization increases backed by foreign capital, the demand for capital goods increases, which requires the production of such goods that increase CO2 emission. The results are advocated by Rufael (2009), Raza and Nida (2018), and Udemba and Yalçıntas (2021). NECN has a value of 0.003811 with a probability value of 0.4234, which means that NECN is insignificant. There is no relationship between NECN and CO2 emission in Pakistan.

Table 4.5 Long-Run Estimates

Dependent Variable: D(CO_2) Selected Model: ARDL (1, 1, 1, 0, 0, 0, 0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
GPPR	0.013558	0.004225	3.208968	0.0063

$GPPR^2$	-0.001920	0.000763	-2.517932	0.0246
FRDI	0.010378	0.003971	2.613733	0.0204
NECN	0.003811	0.004621	0.824591	0.4234
RAEN	-0.026227	0.003901	-6.723476	0.0000
TNRT	-0.029976	0.008949	-3.349813	0.0048
C	2.240288	0.463439	4.834054	0.0003

Source: Authors' Calculations

In our study, RAEN is negatively associated with CO2 emission. The results manifest that a one-unit increase in RAEN is associated with a -0.026227 decrease in CO2 emission. This is because the economy uses cleaner energy, e.g., solar, wind, geothermal, etc., in its industries. Due to the use of RAEN, the environmental quality of Pakistan is improving. The results are in line with the Ummalla. and Goyar (2020) and Ali et al. (2022). TNRT explicates a negative correlation with CO2 emission. TNRT assumes a -0.029976 value, which implies that a unit increase in TNRT is linked with a -0.029976 decrease in CO2 emission.

GPPR has a positive coefficient of 0.013558, which means that as EG increases, CO2 emissions also increase. This suggests that EG, in the short run, might be associated with higher ED, possibly due to industrialization, increased energy demand, and higher consumption of fossil fuels. $GPPR^2$ has a negative coefficient of -0.001920, indicating a quadratic relationship. This implies that the positive impact of EG on CO2 emissions diminishes at higher levels of economic growth, which aligns with the concept of an EKC, where at higher income levels, the economy may shift towards cleaner technologies and sustainable practices that reduce emissions.

The coefficient for FRDI is 0.010378, which is statistically significant (p-value = 0.0204). This means that an increase in FRDI is associated with higher CO2 emissions. One possible explanation for this is that foreign investments may bring in industries that are energy-intensive or rely on fossil fuels, thus contributing to higher emissions. Alternatively, FRDI might promote EG and consumption, which, as previously noted, leads to higher emissions. RAEN shows a negative and statistically significant relationship with CO2 emissions, with a coefficient of -0.026227. This suggests that an increase in the consumption of renewable energy leads to a reduction in CO2 emissions. As Pakistan adopts cleaner sources of energy (e.g., solar, wind, and geothermal), the environmental quality improves, leading to a reduction in the carbon footprint of the economy. This result aligns with the findings in studies by Ummalla and Goyar (2020) and Ali et al. (2022), which emphasize the role of renewable energy in mitigating climate change. TNRT has a negative coefficient of -0.029976, indicating that an increase in the rent derived from natural resources (such as minerals, oil, and gas) is associated with a reduction in CO2 emissions. This could reflect the fact that higher natural resource rents might lead to better investments in environmental protection or a shift towards more efficient use of natural resources. However, it's also possible that the government may use this rent to fund environmental protection initiatives or invest in cleaner technologies, thus reducing emissions.

The short-run analysis or ECM results are given in Table 4.6.

Table 4.6ECM or Short-Run Analysis

Dependent Variable: $D(CO_2)$				
Selected Model: ARDL (1, 1, 1, 0, 0, 0, 0)				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	1.857443	0.369856	5.022071	0.0002
ECT	-0.829109	0.086042	-9.636151	0.0000
GPPR(-1)	0.011241	0.003165	3.552032	0.0032
$GPPR^2$(-1)	-0.001592	0.000658	-2.418219	0.0298
FRDI	0.008605	0.003452	2.492481	0.0258

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NECN	-0.003159	0.003761	-0.840139	0.4149
RAEN	-0.021745	0.003186	-6.825693	0.0000
TNRT	-0.024854	0.006225	-3.992609	0.0013
D(GPPR)	0.004859	0.002063	2.355443	0.0336
D(GPPR^2)	-0.000874	0.000485	-1.802395	0.0930
CointEq(-1)	-1.647818	0.087251	-18.88620	0.0000

Source: Authors' Calculations

The cointegration coefficient value -1.647818 shows the short-run convergence to the equilibrium. The convergence will be in one year and more than 6 months.

CONCLUSIONS AND POLICY IMPLICATIONS

The empirical analysis of ED, EC, EG, FRDI, and TRNT is presented. The study has used the ARDL statistical estimation technique to assess the correlation among the variables. The study revealed that GPPR and FRDI are positively associated with CO2 emission, which implies that as the FRDI and GPPR increase, the amount of CO2 emission increases, causing ED. The GPPR2, RAEN, and TNRT are negatively linked to the CO2 emission. GPPR2 informs about the EKC and verifies that the EKC phenomena are present in Pakistan; with the increase in GPPR, the amount of CO2 increased earlier and decreased later, verifying an inverted U-shaped EKC. The RAEN and TNRT are due to the country's struggle to secure the environment through the adoption of green technologies, clean fuel consumption, and environmental restrictions.

ED and increasing TRNT are alarming phenomena in the world and Pakistan. The ED is running our planet and making it unhabitable. In the view of the scientists, if ED is not mitigated and the mining of natural resources is not reduced, the human race will have a long-term and irreversible climatic impact. ED has eroded the fertile land, reduced the amount of land for cultivation, changed the pattern of the seasons, affected the agricultural output, and caused food insecurity. It has also polluted the water reservoirs that have reduced the marine assets and marine life, and finally, it has also contaminated the air. The contaminated air has GHGs such as carbon dioxide, methane, etc., and PM 2.5, which are severely harmful to the living organism. The increasing human footprint on the natural resources causes increasing natural resource rent. The increasing natural resources rent is making fewer resources available for the senior generations.

The present study explored the relationship between EC, FRDI, EG, and natural resources rent and ED in Pakistan. The study complied with data from WDI. The study employed CO2 emissions as a proxy for ED in Pakistan. This has revealed a positive connection between CO2 emissions and GDP per capita growth rate, implying that when the economy increases the rate of GDP per capita growth, the environment degrades rapidly, and the phenomenon is also called pollution heaven. The study further tests the EKC that unveils that when any economy starts growing, the environment deteriorates at an earlier stage, but concerning the adoption of green and efficient technologies and the use of cleaner energy in the production process, the environmental quality improves over time. The study has supported the EKC in Pakistan, which means that environmental quality is improving over time, along with the increase in GDP per capita growth. This phenomenon is dubbed as environment halo. The investigation discloses that FRDI is also causing ED in Pakistan. This is because when MNCs invest in pollutant industries in developing economies owing to the strict environmental policies in their home countries, the environment degrades the FRDI host country, along with increasing the income level. The present work discovered the linkage of RAEM and NECN with CO2 emissions. The study shows that there is no correlation between NECN and CO2 emissions in Pakistan and the negative association of renewable energy in Pakistan. The consumption of cleaner and green energy, such as wind, solar, and geothermal energy, dwindled the amount of CO2 emissions in Pakistan. Natural resource rent is an important aspect of the economy as most industries are

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directly or indirectly linked to the extraction of natural resources stock. The increasing natural resources rent is making fewer resources available for the senior generations. Enhanced natural resource rent can cause ED if the extraction methods are not environmentally friendly, and extensive extraction of natural resources has a devastating impact on the environment and living organisms. Our study has discovered that increasing natural resource rent is causing ED in Pakistan. The results underscore the importance of promoting renewable energy and managing FRDI in a way that minimizes their environmental impact. Additionally, they suggest that natural resource rents can be a tool for environmental improvement, provided they are allocated toward sustainable practices. Policymakers should focus on fostering cleaner EC, improving the efficiency of economic growth, and ensuring that foreign investments contribute to environmentally friendly industries.

5.1 Practical Implications

5.1.1 Environmental Quality and Economic Growth: The relationship between EG and CO2 emissions s shows an initial increase in emissions as the economy grows, but this impact wanes at higher levels of growth. This supports the EKC hypothesis, suggesting that after a certain level of economic development, the economy might start transitioning to cleaner technologies, improving environmental quality.

5.1.2 Role of Foreign Direct Investment: The positive relationship between FRDI and CO2 emissions s suggests that foreign investments, especially in energy-intensive industries, could exacerbate ED unless accompanied by stricter environmental regulations or the promotion of cleaner technologies.

5.1.3 Renewable Energy as a Solution: The negative relationship between RAEN and CO2 emissions highlights the importance of transitioning to renewable energy sources. Policy measures that incentivize the adoption of renewable energy can significantly help reduce emissions and improve environmental quality, contributing to sustainable economic development.

5.1.4 Natural Resource Rent and Emissions: The negative correlation between TNRT and CO2 emissions s suggests that higher rents from natural resources might be used effectively for environmental preservation, including the adoption of cleaner technologies and the promotion of more sustainable practices in resource extraction industries.

5.2 Policy Suggestions

The policy implication in Pakistan needs to be heftily implemented due to the severity of the ED impact. However, the policymakers of Pakistan and even the government and organizations are sluggish in adopting new technologies to reduce carbon emissions and natural resource rent. A crucial reason is that in Pakistan, the state-owned enterprise is managed by inefficient and non-concerned persons. They are mostly retired influential officials with no experience running the business. The absence of entrepreneurial skills by such officials proved a disaster for the enterprise. Further, the tenure of the government and the official is also very short, so they cannot make long-term policies but focus on their own short-term monetary or social benefits. There may be a lot of factors, such as overlapping foreign aid, inefficient government, corruption, etc., that may be responsible for Pakistan to adopt the new efficient and environmentally friendly technologies such as hydro, solar, wind, etc. Geopolitical politics and vested interest of the internationally developed countries urge them to make big promises to developing countries like Pakistan, but the aid they promise to build mega projects is subject to the strings attached. Such stings are subject to the source or the utilization. The projects started with such aid are delayed due to the volatility of the aid, the projects that are not only delayed but also remain incomplete due to insufficient funds. To untap the potential of renewable and non-renewable energy resources in the country requires highly skilled professionals and

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technologies. However, due to political instability, decreasing employment, and reduced national output, skilled and educated professionals are leaving the country at a very high rate. This, again, is aggravating the situation in Pakistan. In the present scenario, Pakistan is also not working to untap the renewable energy potential like other nations are doing. Pakistan is still dependent on fossil fuel energy. Following are the policy suggestions for the economic managers of Pakistan:

• The policymakers of Pakistan may mitigate the factors that are causing ED. To overcome the problem of ED and dwindling natural economic resources, the Government of Pakistan may prioritize replacing fossil energy with cleaner and green energy. In this regard, solar, wind, geothermal, and biogas projects may be initiated at macro and micro levels. In Pakistan, the large majority of the population lives in rural areas. They are mostly engaged in agriculture-based businesses. The animal dung causes ED as it contains the greenhouse gas methane. Such waste of animal dung can be converted to biogas and can be utilized in household uses. On one side, biogas will reduce the demand for natural gas and wood for household burning but also reduce the cost of living of rural pollution. This will provide a win-win situation for the population, environment, and government as well.

• Pakistan's share in the use of renewable energy is still puny. Pakistan has not yet utilized its solar potential is up till now. All the areas of Pakistan, especially Punjab and Sindh, are very suitable for solar-based electricity production that is almost at zero variable cost. The macro-level production of electricity not only reduces the fossil fuel bill of the government but also provides cheap electricity to industrial consumers that enables them to compete in the international market with cheap and quality products. Solar power will also provide cleaner energy and reduce ED by reducing the amount of carbon emissions in the environment. The industries use a big chunk of the electricity from the total national electricity production, and by converting them to renewable energy, a hefty amount of carbon emissions can be reduced. The economic managers of Pakistan may encourage the use of cleaner energy to reduce ED in Pakistan.

• Pakistan's existing infrastructure of hydroelectricity is depreciating. The dams are technically dwindling the production of electricity and storage of the water due to the inefficient designs. The spillways of our dams are on the above of the dam that must be in the bottom of the dam to remove the silt when they are open, but the engineering mistake is costing Pakistan billions of dollars as day by day the silt is being settled in the bottom of our dams that cannot be removed. In this regard, Pakistan is at a crossroads either in building new dams for the generation of electricity or shifting to other sources of power generation, such as solar and wind, to meet the existing or future demand for electricity. Mega projects cannot be started by international financial institutions such as the International Monetary Fund (IMF). WB, etc., are not supporting Pakistan for such projects.

• The behaviour of the consumers ought to be changed. Consumers are habitual in using fossil fuel-based energy, and the government produces energy that is mostly fossil fuel-based. The consumer's behaviour towards EC and conservation can be altered by government subsidies and proper training. The government may provide subsidies for household consumers for solar and wind energy systems. The proper training and subsidy can also be given to the rural consumers to adopt and produce the biogas-based energy. The biogas can not only fulfill house requirements but also farm energy requirements, such as extraction of water from solar tube-wells can also be done. The self-sufficient production of cleaner energy in urban areas by solar and wind and biogas in rural areas will substantially reduce the debt burden of the government of Pakistan and will also reduce the emissions of GHGs such as methane and CO_2, etc.

• The Multinational Enterprises (MNEs) or MNCs should be brought under the national environment policies. The MNEs that invest in the developing country are driven by strict

environmental regulations in their home country. The MNEs cause severe damage to the environment of the host country, and such corporations may also be brought under the national environmental policy to reduce ED. The contaminated water they release into the water bodies should be cleaned. The smoke they emit in the air should be filtered, and the waste they dump in the soil may be recycled or safely dumped. In this way, the MNEs may be restricted to reducing water, soil, and land pollution in Pakistan.

- The government of Pakistan may adopt the EKC. The EKC is of the view that at an early stage, ED increases and later decreases along with the EG in the economy. At an early stage of EG to elevate the economy from poverty, the government relaxes the environmental regulations and attracts FRDI, but later, the growth is achieved, and the governments focus on environmentally friendly industries that reduce ED. In this regard, the government of Pakistan may also focus on environmentally friendly policies for the new industries. The government may also provide cleaner energy and subsidies, and the industries that affect the environment in Pakistan may be mitigated or even closed to reduce ED. The government also applies strict Standard Operating Protocols (SOPs) to dump wastewater, material, and smoke in the air after cleaning.

- The natural resources rent should also be reduced. Natural resource extraction is also reduced as they are dwindling at a faster rate than they are being produced or discovered. The extraction of natural resources also causes neuronal degradation because the technologies that are being used for the extraction of natural resources are outdated and not environmentally friendly. The government should introduce environmentally friendly technologies for the extraction of natural resources with a limit on the amount of the extraction. The discovery of new natural resources may also be expedited. EG, along with balanced natural resource extraction and powerful environmental impact assessment (EIA), should also be made.

Finally, all the suggestions are fruitful if the Government of Pakistan may make strict monitoring policies. The enforcement of the reforms that will be introduced ought to be made along with all the subsidies to materialize the gains of the environmentally friendly policies. If the proposed policies are not enforced or neglected, the situation of ED and natural resources rent will continue to deteriorate, and the people of Pakistan will have to face adverse consequences.

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