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Consequences of Pakistan's Non-Renewable and Renewable Energy Sources to the Environmental Footprint

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Abstract
This study looks at Pakistan's energy usage, both renewable and nonrenewable, as a significant contributor to carbon emissions. The study uses a nonlinear auto-regressive distributed lag (ARDL) to analyze data from 1980 to 2021. The findings indicate that the country's overall carbon emissions are barely impacted by the deployment of renewable energy. This is mostly because nonrenewable resources like coal and natural gas are the main causes of pollution in Pakistan's energy sector. However, the paper notes that there is a direct correlation between economic growth and carbon emissions in the nonrenewable energy sector. Perhaps because of its smaller share of Pakistan's overall energy mix. Further nonlinear analytic theorem has shown the limited impact of renewable energy in addressing environmental issues. The study concludes that the only way to address environmental issues is to increase the share of renewable energy.

***Keywords**: Renewable energy Consumption, Non-renewable energy consumption, Economic growth, Carbon emission, Coal, Natural Gas, ARDL Model, Bound Test,WDI,BP(British Petroleum).*

Introduction

1.1 An overview

With humans using resources equal to 1.7 of the earth's surface, the growing ecological footprint of the world is concerning. It causes enormous soil erosion, overshoots carbon, destroys biodiversity, and stresses the ecosystem to an unparalleled degree. According to, 53% of the world's carbon emissions come from the extraction and processing of these commodities. Meanwhile, notes that the average decline in wildlife populations since 1970 has been 68%, primarily because of habitat loss brought on by overexploitation. These staggering numbers make it abundantly evident that we need to reevaluate global consumption and look for sustainable alternatives. These issues also highlight nations' focus on implementing the climate measures recommended by the Conference of Parties (COP). Globally, both energy use and carbon emissions are increasing. The environment is severely harmed by this. It states that the energy sector accounts for 75% of worldwide greenhouse gas emigrations. Emigration is one of the primary drivers of climate change worldwide. They seriously jeopardize international security. By limiting the increase in global temperatures to 2 °C, the United Nations Framework Convention on Climate Change (UNFCCC) and its Conference of Parties (COP26) aim to allay these concerns. The upcoming COP26 marks a critical turning point in the fight to halt the catastrophic effects of global warming. This objective could not be accomplished due to the energy usage pattern. Consequently, the worldwide agenda for overseeing sustainable development is now used to address climate change in both production and consumption.

Combining renewable and nonrenewable energy sources can help an economy move closer to sustainability. Therefore, governments should be concerned about how different energy sources both renewable and nonrenewable affect carbon emissions and profitable growth. Emissions of greenhouse gases like carbon are thought to be a key contributor to pollution because natural processes like humidity and evaporation have a significant impact on the fundamental components or forces operating on the surface of the climate system. At least in terms of the societal repercussions, it is no longer the case today, perhaps this lesson was inevitable. The recent fires in Russia and the floods that struck Australia and Pakistan are two significant disasters that can be attributed to environmental degradation.

In recent years, Pakistan has struggled with issues of environmental sustainability and energy security. Although the nation's energy mix includes both renewable and nonrenewable sources, the latter mainly fossil fuels continue to dominate the energy scene. Fossil fuels are responsible for more than 61% of the nation's total energy usage. Significant carbon emissions have resulted from this strong reliance on nonrenewable energy. In 2021, Pakistan emitted 229 million tons of CO2, a considerable rise over prior years. The good news is that renewable energy has been steadily gaining popularity. Economic advancement at the expense of the environment is never desirable. In an effort to improve living conditions and develop their economies, emerging economies have been gradually increasing their energy consumption in recent years. In the meantime, it is commonly known that renewable energy has positive effects on both the economy and the environment. Following the turn of the century, environmental harm brought on by unrelenting economic activity and global warming presented opportunities. Globally, the utilization of renewable energy has skyrocketed. Consequently, the energy consumption of hydroelectric facilities is increasing significantly. According to earlier research, employing renewable energy tends to slow down environmental degradation. Our research seeks additional evidence of meaningful connections between renewable energy, environmental deterioration, and economic expansion in the context of Pakistan.

Recent studies have examined the significant effects of nonrenewable energy sources on the environmental footprint. Concluded that China's reliance on coal was the main cause of its growing carbon footprint, calling for an immediate switch to cleaner energy sources. Similarly, a study by Ref. [23] showed that India's continued reliance on coal was causing its temperature estimates to climb. Increased investments in wind and solar energy were suggested by both studies. European countries have led the renewable revolution after observing these worldwide tendencies. Additionally, praised the country's combination of solar and wind energy, claiming that it has resulted in a noticeable decrease in greenhouse gas emissions. The focus of their study was on reproducing these models in areas with comparable climates. There are still issues despite the global push for renewables. As mentioned, African countries struggle to adapt to solar technology despite having an abundance of sunlight.

The interaction has not received enough attention, particularly when assessed in terms of carbon emissions. It should be mentioned that the majority of research have traditionally used linear models, which may not adequately represent the possible non-linearities present in these kinds of connections. However, by employing the nonlinear ARDL estimation in a novel approach, this study aims to investigate both short-term dynamics and long-term equilibriums between energy kinds and carbon emissions. It is true that Pakistan offers an interesting backdrop for this study because of its struggles with the conflict between environmental and energy demands. In this sense, a better comprehension of these relationships is required due to the country's distinct energy mix and vulnerability to climate change. Thus, our work is well-positioned to close a current knowledge gap. In order to align energy strategies with environmental prudence in Pakistan's unique socio-economic landscape, policymakers can benefit from an enhanced perspective provided by revealing the subtle associations through nonlinear estimations.

1.2 Objectives of the study

1. Using a non-linear ARDL model to completely account for how energy factors affect carbon emissions
2. To investigate the relative contributions of renewable and nonrenewable energy sources to environmental emissions by analyzing their effects separately.
3. To offer an ideal energy portfolio that enables Pakistan to strike a balance between environmental sustainability and economic growth, which can also be the foundation for policymaking

2.0 Relevant Review Literature

Cudjoe (2023) examined municipal solid waste processing technology, a crucial component of sustainable urban development, before moving on to sustainable development and resource management. While Khan et al. (2022) concentrated on boosting the usage of renewable energy in Pakistan; Praveenkumar et al. (2022) investigated the possibility of harnessing solar radiation in India. Thoy and Go (2022) offer a distinct viewpoint through their investigation of the incorporation of photovoltaic components into architecture. Zhu et al. (2022) examined sustainability using a fuzzy AHP technique, while Ryter et al. (2022) talked about how material production affects the environment.

In the framework of technology integration and its effects on the environment, Rehman et al. (2023) looked into the integration of electric vehicles into energy systems. Tariq et al. (2022) created a comprehensive management strategy for renewable energy, whereas Aboagye et al. (2022) investigated trends in solvent consumption in the chemical industry. Finally, Safiullin et al. (2016) investigate the relationship between renewable energy distribution and modern economy.

Petrovic (2022) provided an intriguing perspective on the relationship and influence between ecology and environmental economics throughout environmental economics study. Maris (2022) focuses on the relationship between the human economy and the natural environment. Taking a more focused approach, Larnaudie et al. (2022) investigate the synthesis of biofuels from lignocellulosic biomass, a subject that is becoming more and more significant in the age of renewable energy. While Degirmencioglu Aydin and Aydin (2023) emphasize the significance of promoting green growth in the economy, Eaton et al. (2023) bring up the subject of health by looking at the effects of the urban environment. Zemo and Termansen (2022) investigate how environmental identity affects conservation decisions, whereas Majdawati and Annisa (2022) investigate the deployment of CCHP systems in university buildings. Finally, Gaur et al. (2022) draw attention to the difficulties in managing the growing amount of garbage.

Klenk (2018) examined globally, solar photovoltaic energy is growing in popularity. Over 3,500 MW of solar PV systems have been constructed globally to far. Since 1970, the price of PV systems has been continuously falling (Peters et al., 2019). Due to this price reduction, small-scale residential PV system utilization has being promoted globally. Environmental specialists have started extensive research projects to use renewable energy sources, such solar energy, because of recent events. More attention is being paid to using solar photovoltaic energy as a power source, which is encouraging for the technology's future. Presenting the latest developments in solar photovoltaic energy systems is the aim of this contribution.

Data and Methodology

3.1 Introduction

This study clarifies the relationship between carbon emissions and variables like trade openness, economic development policies, and the use of renewable and non-renewable energy. It discusses the precise effects on factors including trade value, economic growth, energy use, and carbon emissions. Using the conventional linear-logarithmic model, this study investigates the connections between carbon emissions, GDP, trade openness, and the consumption of renewable and nonrenewable energy. Each person's impact on carbon emissions is examined using particular models and equations 1 and 2 represent the economic model used in the study.

$$CO2t = f\,(GDP, Open, Hydro, Nuclear) \text{ -- } (1)$$

$$CO2t = f\,(GDP, Open, Oil, Coal, Gas) \text{ -- } (2)$$

In order to quantify the different contributions of "renewable and nonrenewable energy consumption" to carbon emissions, Researchers divided the previous model into two distinct models, as shown in Equations 3 and 4. CO2 stands for carbon emissions, GDP for gross domestic product, and openness for trade openness. Hydro stands for hydroelectricity; nuclear energy for nuclear energy, which represents renewable energy; and oil, coal, and gas for oil, coal, and gas use, respectively; εt is the error term; and ln is the natural logarithm.

Model 1. Renewable energy consumption.

$$CO2t = \alpha 0 + \beta 1 lnGDPt + \beta 2 lnOpent + \beta 3 lnHydrot + \beta 4 lnNucleart + \varepsilon t \text{------------------ } (3)$$

Model 2. Non-renewable energy consumption.

$$CO2t = \alpha 0 + \beta 1 lnGDPt + \beta 2 lnOpent + \beta 5 lnOilt + \beta 6 lnCoalt + \beta 7 lnGast + \varepsilon t \text{----------- } (4)$$

This study's Model 1 illustrates the relationship between GDP, trade openness, and carbon emissions and the use of nuclear and hydroelectric power. Conversely, Model 2 looks at how GDP, trade openness, and carbon emissions are affected by using non-renewable energy sources including coal, oil, and natural gas. The study used time series data from 1980 to 2021 that came from two main sources: the World Development Indicators and BP (British Petroleum) Statistics. BP Statistics provided the data on carbon emissions as well as the use of nuclear, hydroelectric, natural gas, coal, and oil energy. Additionally, information on trade openness and GDP per capita was extracted from the World Development Indicators.

3.2 Estimation technique

The Auto-Regressive Distributed Lag (ARDL) bounds testing technique is used in this work to identify long-term and short-term trends at a fine level. the ARDL approach in 2001, Pesaran et al.(2001) to check for co-integration between several variables . Regardless of whether the variables are integrated at level I (0) or the first difference I (1), this method provides a number of benefits. Because the model's lag structure may be changed and long-term predictions are accurate with correct t-statistics. It yields reliable results regardless of sample size. In order to create a flexible, unrestricted error-correction model with long-term data and takes short-term fluctuations in to the long-term equilibrium. The ARDL method employs a simple linear transformation, particularly well- suited to time series data with endogeneity and serial correlation in this approach.

The ARDL model was applied to two different models for the purposes of this study. The first (Model 1) examines GDP, trade openness, carbon emissions, and the use of renewable energy. The second (Model 2) looks at GDP, trade openness, carbon emissions, and non-renewable energy usage. The following are these models:

ARDL Model 1: Eq-5 reports GDP, trade openness, carbon emissions, and renewable energy consumption.

$$\Delta CO2t = c0 + \sum q \; i=1 \; \beta 1 \Delta CO2,t- r + \sum q \; i=0 \; \beta 2i \; \Delta lnGDPt- r + \sum q \; i=0 \; \beta 3i \; \Delta lnOpent- r + \sum q \; i=0 \; \beta 4i \; \Delta lnOilt- r + \sum q \; i=0 \; \beta 5i \; \Delta lnCoalt- r + \sum q \; i=0 \; \beta 6i \; \Delta lnGast- r + \gamma 1lnCO2,t- 1 + \gamma 2lnGDPt- 1 + \gamma 3lnOpent- 1 + \gamma 4lnOilt- 1 + \gamma 5lnCoalt- 1 + \gamma 6lnGast- 1 + \varepsilon t \quad (5)$$

Where Δ is the first difference operator and ρ denotes the lag length. We derived two hypotheses from Eq. (4) for the long relationships.

The first is the null hypothesis of no co-integration

$(HO : \leftthreetimes 1 = \leftthreetimes 2 = \leftthreetimes 3 = \leftthreetimes 4 = \leftthreetimes 5 = 0)$, which tested against the second one, i.e.,

The alternative hypothesis $(H1 : \leftthreetimes 1 \neq \leftthreetimes 2 \neq \leftthreetimes 3 \neq \leftthreetimes 4 \neq \leftthreetimes 5 \neq 0)$.

ARDL Model 2: Non-renewable energy consumption, trade openness and carbon emission is presented in Eq-6

$$\Delta CO2t = c0 + \sum q \; i=1 \; \beta 1 \Delta CO2,t- r + \sum q \; i=0 \; \beta 2i \; \Delta lnGDPt- r + \sum q \; i=0 \; \beta 3i \; \Delta lnOpent- r + \sum q \; i=0 \; \beta 4i \; \Delta lnOilt- r + \sum q \; i=0 \; \beta 5i \; \Delta lnCoalt- r + \sum q \; i=0 \; \beta 6i \; \Delta lnGast- r + \gamma 1lnCO2,t- 1 + \gamma 2lnGDPt- 1 + \gamma 3lnOpent- 1 + \gamma 4lnOilt- 1 + \gamma 5lnCoalt- 1 + \gamma 6lnGast- 1 + \varepsilon t \quad (6)$$

Where Δ is the first difference operator and q denotes the lag length. The null hypothesis of no co-integration $(HO : \gamma 1 = \gamma 2 = \gamma 3 = \gamma 4 = \gamma 5 = \gamma 6 = 0)$, which tested against the second one, i.e., the alternative hypothesis $(H1 : \gamma 1 \neq \gamma 2 \neq \gamma 3 \neq \gamma 4 \neq \gamma 5 \neq \gamma 6 \neq 0)$.

Econometric Analysis

4.1 Descriptive Analysis

First, researcher used the descriptive test to examine whether the variables under study are descriptive in nature and whether any possible outliers are present in the series under study. The dependent variables like trade openness, GDP, and carbon emissions are control variables. The variables are divided into four categories. Nuclear and hydro energy use are included in the renewable energy section. Table 4.1 reports nonrenewable evidence of an outlier in the series under study. However, econometric analysis can be performed using the variables.

Table 4.1: Descriptive analysis

Variable	Mean	Std. Dev.	Min	Max
Dependent variable				
$lnCO_2$ **Control variable**	15.301	1.275	13.092	**15.670**
lnGDP	23.324	0.968	22.52	**23.993**

lnOpen	3.161	1.550	1.048	**4.771**
Renewable energy variables				
lnHydro	28.092	0.907	27.26	**28.616**
lnNuclear	25.693	1.713	22.43	**27.430**
Nonrenewable energy variables				
lnOil	3.245	0.748	2.855	**3.544**
lnCoal	28.478	0.959	27.478	**29.154**
lnGas	**5.014**	**0.728**	**4.787**	**5.177**

Notes: ln represents the natural logarithm. CO2 is the dependent variable, which represents the carbon emission. GDP and openness are the control variables that represent economic growth and trade openness. Renewable energy variables are lnHydro and lnNuclear, which mention hydro and nuclear energy consumption. Oil, coal, and gas reflect the nonrenewable energy consumption given by oil, coal, and gas consumption.

4.2 Multicollinearity

The multicollinearity of the variables listed in Table 4.2 is further examined. We have employed the variance inflation factor test (VIF) for this purpose. The variables' values are below 10, which suggests that multicollinearity is not present. LnHydro has the lowest VIF value (4.04), while LnNuclear has the highest value (9.06).

Table: 4.2 Multicollinearity

Variables	VIF
lnCO_2	**7.93**
lnGDP	**8.01**
lnOpen	**6.75**
lnHydro	**4.04**
lnNuclear	**9.06**
lnOil	**7.72**
lnCoal	**5.88**
lnGas	**4.76**
Mean VIF	**6.77**

4.3 Unit Root Test

In order to determine whether any of the data series in this study include a unit root or not, the Augmented Dickey-Fuller (ADF) tests is essential at first stages. Table 4.3 displays the outcomes of the Unit Root testing. As can be shown, with the exception of coal use, every variable is non-stationary in its level forms. According to statistics, these variables become stationary at the first difference. In other words, the null hypothesis is rejected. All of the sets of variables under investigation reach stationarity when the first difference is measured. These findings indicate that the parameters under study exhibit varying degrees of stationarity. However, under these circumstances, the ARDL approach is the best one to take into account for econometric research.

Table:4.3 Augmented Dicky Fuller Test

Variables	Level	Difference
lnCO2	0.943	**0.001*** **
lnGDP	0.951	**0.002*** **
lnOpen	0.378	**0.000*** **
lnHydro	0.256	**0.000*** **
lnNuclear	0.785	**0.001*** **
lnOil	0.534	**0.000*** **
lnCoal	0.013**	**0.000*** **
lnGas	**0.572**	**0.000*** **

Note: ***, **, * indicate the level of significance at 1 %, 5 % and 10 %.

4.4 Cointegration

We proceed to ARDL-bound testing to determine whether the variables are cointegrated after the unit root confirms. Table 4.4 presents the integration results for models 1 and 2. The results show that all of the variables have a long-term association. The F-statistics exceed the required upper bound values. This disproves the null hypothesis that cointegration does not exists.

4.1.1 Bound Test for Model 1

Model 1	F-statistic	I0 Bound	I1 Bound
Model 1 ***lnCO2=f(lnGDP, lnOpen, lnHydro, lnNuclear)***	**6.321**	**4.21**	**5.36**

4.1.2 Bound Test for Model 2

Model 2	F-statistic	I0 Bound	I1 Bound
lnCO2=f(lnGDP, lnOpen, lnOil, lnCoal, lnGas	**6.246**	**3.78**	**5.11**

Two diagnostic techniques for serial correlation and heteroscedasticity, the Breusch-Godfrey test and the ARCH test, offer unmistakable proof that the error term is white noise. Furthermore, the Ramsey RESET test validates the model's sufficiency.

Results and Discussions

5.1 ARDL Estimation

Table 5.1 ARDL Estimation

Variable	Long-run estimates		Variable	Short-run estimates	
	Coefficient	Prob.		Coefficient	Prob
Model 1: Renewable energy sources lnGDP	1.646**	0.019	D(lnGDP)	—0.084	**0.593**
lnOpen	0.155	0.790	D(lnOpen)	—0.050	**0.531**
lnHydro	0.124	0.741	D(lnHydro)	0.043	**0.526**
lnNuclear	0.021	0.496	D(lnNuclear)	0.002	**0.523**
C	—4.846***	0.000	Count Eq (-1)	—0.145**	**0.031**
Model 2: non-renewable energy sources					
lnGDP	—0.945	0.122	D(ln GDP)	—0.203	**0.424**
lnOpen	—0.331***	0.007	D(lnOpen)	—0.258***	**0.000**
lnOil	0.215	0.121	D(lnOil)	0.327***	**0.000**
lnCoal	0.340***	0.008	D(lnCoal)	0.277***	**0.000**
lnGas	0.524***	0.000	D(ln Gas)	0.209***	**0.000**
C	—3.923***	0.000	Count Eq (-1)	—0.070*	**0.098**
Diagnostic test					
R2	0.994	0.993			
Adjusted R^2	0.994	0.992			
F-statistics	1400.972	1377.436			

	Prob. F-statistics		0.000		0.000						
	Durbin-Watson stat		1.289		1.045						
	$\chi 2$ Arch		0.278 [0.600]		0.238 [0.628]						
	$\chi 2$ LM		1.658 [0.131]		1.255 [0.295]						
	$\chi 2$ RESET		**9.176 [0.004]**		**0.093 [0.761]**						

We investigated the long- and short-term dynamics of models 1 and 2 after the bound integration approach has established the actuality of cointegration. The results for both models are shown in Table 4.1.1 and 4.1.2. Advanced profitable growth is one of the main causes of environmental decline in Pakistan, according to the long-run estimation in Model 1, which is verified by the GDP and shows a significant and positive measure. This conclusion is similar to those of the following studied in Nepal as well. This connection suggests that rising economic growth increases energy demand in the industrial sector, transport sector, etc., which raises carbon emissions. The findings show that the population of Pakistan is growing, its cities are becoming more developed, and its industry is expanding, so energy consumption has increased. Since fossil energies are responsible for most of Pakistan's energy consumption, renewable options only comprise a small portion of the total energy mix. Thus, like in the example of Brazil and Algeria, a rise in energy consumption boosts the GDP concurrently with increased carbon emissions. According to some researchers, renewable energy reduces carbon emissions as GDP rises, just like discovered for developed countries. However, this statement does not apply to Pakistan due to the fundamental difference between economies. According to References mentioned, Pakistan's carbon, emissions are anticipated to increase until it reaches a certain level of economic activity because it is now functioning below that level. When energy consumption falls below the optimal threshold, the scale and composition of goods become more prominent, and the technological impact is negligible. In the short run, GDP is insignificant, indicating no relationship between GDP and carbon emissions.

5.2 Discussion for Model 1

The trade openness components in model 1 are negligible in both short- and long-term estimations, suggesting that trade openness and the environmental deterioration process in Pakistan are unrelated. The lesser amount of trade in Pakistan is the cause of this insignificance. The use of nuclear, hydrogen, and renewable energy sources has been shown to have no effect on carbon emissions. The results show that in order to combat Pakistan's environmental deterioration, renewable energy needs to be further developed.

5.3 Discussion for Model 2

Despite the focus on Model 2, it is clear that there is a very small short- and long-term link between GDP and carbon emissions when looking at the relationship between non-renewable energy consumption, GDP, trade openness, and carbon emissions. That being said, this is not the situation. It has been asserted that the reduction in carbon emissions caused by income levels only lasts until a certain point, after which they begin to climb as income levels continue to rise. According to the study, carbon emissions will increase in tandem with income growth, indicating a positive correlation between the two for Pakistan. In this equation, non-renewable energy use serves as a bridge. Fossil fuel use in Pakistan raises carbon emissions, which reduces the nation's economic energy efficiency and harms the environment.

5.4 Over all Discussions

Furthermore, because of the long-term negative effects of carbon emissions, the costs of using non-renewable resources increasingly exceed their financial benefit. Pakistan must enact reasonable laws governing the use of fossil fuels in order to prevent a drop in GDP brought on by the excessive and inappropriate use of non-renewable energy sources. Both short- and long-term carbon emissions are significantly correlated negatively with the trade intensity outcomes in Model 2. The findings indicate that trade growth reduces carbon emissions over the estimating period.

Coal use and carbon emissions have strong and favorable short- and long-term relationships. According to research by for China, India, and Pakistan. Using coal may boost economic growth but has a major detrimental effect on the environment. China's coal use has a significant long-term impact on carbon emissions and economic growth, according to their analysis of the disparate relationships between coal consumption and carbon emissions in China and India. China has used a number of tactics to cut back on its coal use, but doing so has come at the price of successful economic expansion. The scenario in Pakistan is similar. Although technology can reduce it, carbon emissions from burning coal can still affect the landscape. Pakistan should reduce the amount of coal it uses in its overall energy mix, according to policymakers. Carbon emissions and natural gas use are positively and statistically significantly correlated, both in the short and long term. Natural gas dominates Pakistan's whole energy mix.

Furthermore, the costs of exploiting non-renewable resources are becoming greater than their financial benefits due to the long-term harmful effects of carbon emissions. To avoid a decline in GDP due to the excessive and inappropriate use of non-renewable energy sources, Pakistan must implement suitable legislation governing the use of fossil fuels. In Model 2, there is a substantial negative correlation between the trade intensity results and both short- and long-term carbon emissions. The results show that during the estimating period, trade growth lowers carbon emissions.

Carbon emissions and coal use are positively correlated in both the short and long term. based on studies conducted for Pakistan, India, and China. Although using coal has a significant negative impact on the environment, it may increase economic growth. Their examination of the different correlations between coal consumption and carbon emissions in China and India indicates that China's usage of coal has a major long-term impact on both economic growth and carbon emissions. China has employed a variety of strategies to reduce its coal consumption, but these have come at the expense of prosperous economic growth. In Pakistan, the situation is comparable. Carbon emissions from burning coal can still have an impact on the landscape, even though technology can lessen them. According to policymakers, Pakistan should use less coal in its overall energy mix. In the short and long run, there is a positive and statistically significant correlation between the consumption of natural gas and carbon emissions. Pakistan's entire energy mix is dominated by natural gas.

Despite being the country's second-largest energy source, there is no discernible long-term relationship between crude oil emissions and carbon emissions. Pakistan is now more dependent on crude oil because of a growing energy crisis and a sharp decline in natural gas supplies. But in addition to the oil's supply, uncertainty has also increased.

In Pakistan, it is imperative to investigate sustainable energy generation methods. More precisely, using any non-renewable energy source instead of oil has a significant long-term effect on carbon emissions.

5.5 Conclusions

Important information has been obtained by comparing Pakistan's carbon emissions from renewable and non-renewable energy sources. This question and its intensity have their roots in Pakistan's rapidly growing environmental worries as well as an energy path marked by pessimism. It is a response to the nation's environmental and socioeconomic problems as well as an academic endeavor. A crucial contradiction between the environmental cost of non-renewables and the unrealized potential of renewables is clarified by empirical estimates. The only practical option that is greener and emits less emissions is renewable energy. Although the action is short-term economically justified, the nation must swiftly and effectively enact mitigation strategies due to its high reliance on nonrenewable resources.

5.6 Policy Implications

These findings are a clear call for change from a policy perspective. To reduce dependency on non-renewable resources, authorities should prioritize a gradual paradigm shift toward renewables. This supports global sustainability and could lead to financial benefits including the creation of green jobs and technological advancements. The study does have some drawbacks, though. Despite offering comprehensive information, some conclusions might not be generally relevant because they are specific to Pakistan. Furthermore, the temporal scope of the data places restrictions on it and might miss abrupt changes or long-term trends. There are several options for future research. These cross-national comparisons offer valuable information on the responses of economies with various energy-environment matrices.

Finally, new technologies for renewable energy are being developed. Further research is required to determine their viability and integration. In essence, this report explains the complexities of Pakistan's energy crisis and suggests a plan for fostering economic expansion while preserving environmental integrity. Such a balance is necessary for a sustainable future, in addition to being desirable.

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