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Nexus between Green Resources, Energy Consumption, and Environmental Quality in Pakistan

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Abstract

This study's most prominent goal is to examine how Pakistan's green resources, energy use, economic expansion, and urbanization affect environmental health while controlling for the role of national governance. The time series data from the years 1990 to 2022 was used. To analyze the link among green resources, energy consumption, and environmental quality by using econometric techniques such as unit root test, ARDL model, and diagnostic tests. The outcome of this study demonstrates that three variables such as non-renewable energy, (GDP) as economic growth and urbanization are significantly associated with environmental degradation while renewable energy sources like solar, wind, and water energies decrease the degradation of the environment. The conclusion of this study reveals that green resources especially renewable sources (RENG) significantly improve environmental quality. The outcomes of this study will also put up better policy options for policymakers for environmental protection by the utilization of green resources (RENG) or environmental-friendly sources in Pakistan.

1. Introduction

Energy acts as the impulse to enhance the (HDI) Human Development Index of a nation. However, an unintended consequence of economic growth is environmental degradation brought on by excessive energy use. Environmental degradation is unavoidable as a result of the widespread use and exploitation of non-renewable energy, particularly from the burning of fossil fuels. The state of the environment is becoming increasingly dangerous on a global scale. Environmental degradation is a primary concern in developed and developing countries (Asghar et al., 2020). The problem of environmental degradation has arisen with time along with the massive use of green resources energy consumption and technologies. Green resources are strongly associated with environmental quality such as climate mitigation and environmental sustainability (Namahoro et al., 2021). The Environmental Kuznets Curve (EKC) hypothesis, which was first studied by Grossman and Kruger (1991), links environmental changes with the economic performances of nations. It explains industrial strategies and technological advancements that aim to reduce environmental degradation. According to the hypothesis, increasing production through high input levels and excessive use of natural resources degrades the environment and causes an increase in environmental degradation (Leitão et al., 2023). However, growing economic activity can occasionally increase energy consumption burn fossil energy carriers, and raise carbon dioxide (CO2) discharge (Hussain et al., 2021).

To find out the effects of green resources and energy consumption (EC) on air quality we take CO2 as a proxy to check the environmental degradation in Pakistan. Renewable energy is a natural source of energy such as energy generated from the sun, water, and wind. Clean energy is the type of energy which do not release pollutants into the air (Chen et al., 2020). Such type of energy which is produced from sunlight, wind, tidal waves, and rain does not pollute the environment and

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these sources are readily available on Earth. Green initiatives could help with addressing urgent environmental issues, lowering climate change, and conserving resources. They are required to build a more sustainable and health-conscious future (Koçak & Şarkgüneşi, 2017).

Green resources help economic development while also addressing environmental issues. The prime cause of the change in the climate of South Asian countries is the rise in the absorption of Green House Gases (GHG). Due to rapid increase in industrialization and other anthropological activities CO2 and GHG are constantly increasing in South Asia. Pakistan and India are the biggest contributors to CO2 emissions in the region. Maldives is the highest in terms of per capita having high levels of CO2 emissions (Tao & Wu, 2021).

The energy sector is a huge emitter of greenhouse gasses in the air and induces climate change. The energy sector can be divided into four sectors such as residential sector, commercial sector, transportation, and industrial sector. Statistical Review of World Energy 2022 indicates that core consumption amounted to 3.86 petajoules in Pakistan for the year 2021 and was dominated by gas at 41.7%, followed by oil at 26.4%, coal at 17.4%, hydroelectricity at 9.35%, nuclear at 3.6% and another renewable was 1.3% (Khan et al., 2019). There is a substantial impact of shocks of energy consumption on the quality of the environment. The amount of CO2 emissions increases with increasing energy consumption. According to earlier surveys, the largest source of greenhouse gas (GHG) emissions worldwide, accounting for 35% of total emissions, is the energy sector. In the current assessments of the International Energy Agency (IEA), transportation accounted for 23% of global CO2 emissions. Through transportation systems, automobiles, and light and heavy diesel vehicles production of CO2 emissions is about 60 %. The steady rise in GDP especially in developing countries will proceed to increase demand for mobility and vehicle use that's why the transport sector emits more CO2 (Misha Khan 2020). The rise in urbanization which leads to higher demand for mobility become one of the big challenges in Asian Countries. This leading mobilization and increased demand for mobility in Asian cities causes high levels of pollution into the air, increasing road accidents, congestion problems, and high levels of GHG emissions in urban areas (Wan et al., 2022). Authorities in both national and local governments are unaware of how to address this ongoing issue. Pakistani government officials are still having difficulty quantifying and comprehending the CO2 emissions of their present urban transportation system. Pakistan has a weak disaster preparedness system and a geographical location that makes it particularly vulnerable to climate change. Pakistan is affected by global warming in many ways, as it experiences more frequent and severe weather events. Among others, air pollution is also a significant problem in South Asia. South Asia is predicted to face a 6-7 C0 warm-up by the end of the 21st century (Faheem et al., 2022). The two main cities of Pakistan Karachi and Lahore are observed in 2022 that its air quality is 20 times more polluted than WHO limits. The increasing number of automobiles continuously contributes to the rise in urban air pollution. CO2 emissions, Nitrous oxide, and ozone are common gases spat by cars, trucks, and other vehicles that are dangerous for human health. Some poisonous particles and harmful gases in the air create air pollution which leads to environmental degradation (Ozturk et al., 2022).

The higher rate of deforestation is a significant threat to the quality of the environment in this region. The rate of deforestation in Pakistan is continuously rising. Many people use tree woods to remain warm in winter months, especially in northern areas of Pakistan. This increase in upland vegetation and continued deforestation indicates an alarming risk of land-sliding and surface erosion (Ivanovski et al., 2021).

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In Pakistan, many of the country's richest soil areas and water resources are being contaminated by industrial wastes and poisonous chemicals all of which are harmful to human health. This increase in environmental degradation is fueled by multiple factors including resources such as non-renewable resources, fossil fuels, and energy consumption.

2. Literature review

Rehman and Zeb (2018) in their study explore 4 important determinants that are responsible for environmental damage in Pakistan. They collected data from 1972 -2018 taken from the World Bank (WB) database, the Pakistan Bureau of Statistics, and Pakistan's State Bank. They used OLS, ARDL, and ADF techniques to investigate air pollution in Pakistan. Their research explores that population, energy consumption, industrialization, and economic growth are responsible for environmental degradation. All mentioned variables have positive and strong impacts on CO2 emissions which leads to environmental decline in Pakistan.

Khan et al., (2020) investigated in their research that in Pakistan energy consumption and economic development are the important factors that are liable for carbon dioxide emissions in the environment due to leading economic activities. The annual data for the years 1965-2015 was taken from the site of the World Bank (WB). They used ARDL, Augmented-Dickey Fuller (ADF), and Phillip-Peron (PP) unit root test methods. They found that the rising levels of CO2 emissions in the environment affect human health badly. They concluded that an energetic link is present between energy consumption (EC), and economic growth (EG) on atmospheric quality.

Aftab et al., (2021) explore in their research that massive energy consumption and economic growth have an energetic and powerful impact on carbon dioxide emissions in Pakistan. They used secondary data of years (1971-2019) gathered by World Development Indicators (WDI) and other economic forums. They utilized Auto-Regressive Distributed Lag (ARDL), ADF, and PP estimations to check the significance of the data. They explore in their study that due to CO2 emissions in the environment, the quality of air and water becoming worse which creates health and other physical and mental issues in Pakistan.

Majeed et al., (2021) by using data from (1071-2014) of Pakistan investigated in their research that distinct origins of energy usage have several systemic outcomes on bionomic balance. They used NARDL and BDS test approaches to check the asymmetrical relationship between the selected variables. They reveal that positive shocks by utilizing oil and gas as a source of energy increase the ecological footprint. Thus, increasing consumption by using oil, natural gases, and coal has a worsening influence on environmental quality. The asymmetrical impact is also present in coal, electricity usage, and environmental footprint. Energetic shocks are directly associated with the environmental conditions. Positive blows have a severe impression on environmental quality.

Faheem et al., (2022) explore in their research that renewable energy sources like solar, wind, and water in Pakistan reduce environmental degradation in different ways, while non-renewable energy sources and development-related economic activities like industrialization and urbanization have a positive relationship with CO2 emissions. They employed ARDL and unit root tests to analyze time series data spanning the years 1980 to 2018. This research provides Pakistani policymakers with recommendations on what kinds of laws and policies to enact to promote the use of renewable energy sources and potentially slow down environmental deterioration.

Danish et al., (2018) in their study claim that environmental quality decreases when non-renewable energy sources are used to beget energy while renewable energy sources can help to improve air

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quality. Unit root and Johnson's Cointegration tests are used to check the consistency of parameters from 1970 to 2011. Ultimately, they proposed that generating energy from renewable sources (wind, solar, hydropower, and geothermal) could reduce pollution and that the energy mix process ought to incorporate more sophisticated renewable energy technologies.

Lin et al., (2019) investigated in their research paper that co2 emissions rate is becoming higher and higher from the power sector of Pakistan during the years 1978-2017. The LMDI and Kaya identities were applied to observe the rate of change in the CO2 emissions from Pakistan's power sector. Their analysis found that overall economic activities increase due to the increasing rate of the population as a result leading intensity of CO2 emissions into the environment, but this rising carbon intensity could be reduced by using clean and green energy techniques.

Hussain et al., (2019) utilize data from 1971 to 2006 that is based on the Environmental Kuznets Curve (EKC). They used a variety of econometric techniques, including the Granger Causality tests, ADF, unit root test, and Johnson co-integration VECM. Their results verify that Pakistan's environmental pollution is mostly caused by energy consumption from burning gas and oil. The Granger Causality test demonstrates that energy use and environmental quality are correlated over the long run.

Mirza and Kanwal (2018) discovered a strong association between economic growth (EG) and energy consumption (EC). They discovered that a nation's need for energy consumption rises in tandem with its economic growth. The use of energy-generating sources that prevent the release of airborne pollutants is crucial for the expression of energy. The link between economic growth, energy consumption including environmental quality has remained ambiguous in various data sets, geographical areas, and organizational contexts. The goal of this study is to gather more proof that energy consumption, CO2 emissions, and economic growth are causally related.

Data statistics and Methodological analysis

2.1. Source of data with explanation of variables

For analysis of data in the current work, time series data has been used from the years 1990 to 2022 which is taken from WDI. The economic variables included in this study are CO2 emissions (metric tons per capita or head) that are used to present compatibility with the environment. Green resources (wind, air, solar) represent renewable energy (RENG). Energy consumption (EC) variables (such as fossil fuels) represent as non-renewable energy consumption of the economy. GDP (constant 2015 US dollar) is a convenient intermediary for EG—urbanization variable (CO2 emissions from residual buildings, transportation, industries, and constructions).

2.2. Model specification.

2.2.1. Economic Model

$EQ = f(GR, EC, EG, URB)$ …… (1)

CO2 emissions are taken as a proxy so the model can be written as

2.2.2. Econometric Model

$CO_{2\,t} = \beta_1 + \beta_2 GR_t + \beta_3 EC_t \beta_4 EG_t + \beta_5 URB_t + \mu_t$ ……... (2)

2.3. Econometric Techniques

2.3.1. Unit Root Test

Economic researchers use an econometric measure called a unit root test to determine whether the data that time series they are using is stationary or non-stationary. The more conventional techniques are the DF (Dickey-Fuller), PP (Phillip-Peron), and ADF (Augmented Dickey-Fuller) tests. ADF (Augmented Dickey-Fuller) test in its general form can be written as

$$\Delta x_t = \beta + \sum_{i=1}^{n} \Delta x_{t-1} + e_t \quad \text{....} \quad (3)$$

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2.3.2. ARDL Model

This econometric model examines both the variables' short- and long-term associations. The dependent variables' lagged values are represented by the AR component in the ARDL model. Pesaran et al., developed an ARDL-bound approach in 2001 to ascertain whether long- and short-term links exist among the variables. This process is comparatively new and offers numerous benefits over traditional cointegration tests. The following ARDL bound testing technique is developed based on the hypothesis to interrogate the long-term link amid the variables.

$$\Delta CO2_t = \beta_o + \beta_1 \Delta GR_{t-1} + \beta_2 \Delta EC_{t-2} + \beta_3 \Delta EG_{t-3} + \beta_4 \Delta URB_{t-4+} \mu_t \ldots\ldots (4)$$

$$\Delta CO2_t = \sum_{i=1}^{n} \beta_o + \sum_{i=1}^{n} \beta_1 \Delta GR_{t-1} + \sum_{i=1}^{n} \beta_2 \Delta EC_{t-2} + \sum_{i=1}^{n} \beta_3 \Delta EG_{t-3} + \sum_{i=1}^{n} \beta_4 \Delta URB_{t-1} + \mu_t \ldots\ldots (5)$$

3. Outcomes and Discussions

Before continuing, the following descriptive statistics are provided in Table which shows that all variables are normally distributed. We carefully examined the descriptive statistics that confirm the study's used series. It displays summary statistics, including the variable's mean, median, maximum, minimum, and standard deviations. Indicators such as Jarque-Bera, Kurtosis, and Skewness are used to examine the distribution characteristics of variables. The significant p-value obtained from the Jarque-Bera test indicates that the distribution of the variables co2, EC, EG, GDP, and URB is normal.

Table:1 Results of Descriptive Statistics

	LCO2	**LGR**	**LEC**	**LEG**	**LURBN**
Mean	-0.568757	3.888701	4.069545	26.08167	3.529483
Median	-0.548231	3.869742	4.089121	26.13274	3.531758
Maximum	-0.456453	4.061994	4.134789	26.71460	3.630482
Minimum	-0.679611	3.740048	3.957097	25.42783	3.420215
Std. Dev.	0.063882	0.082621	0.045199	0.388197	0.060810
Skewness	-0.259020	0.360433	-1.049366	-0.014310	-0.114189
Kurtosis	1.857296	2.341821	3.291015	1.747474	1.925123
Jarque-Bera	2.164440	1.310166	6.172872	2.158257	1.660336
Probability	0.338843	0.519399	0.045664	0.339892	0.435976

The study uses a correlation matrix method to verify that the data for the current investigation are free of the multicollinearity problem after looking at the descriptive statistics of the data. The correlation coefficient results are displayed in Table 2, which indicates that there is no multicollinearity issue in the data because the coefficient of correlation between the variables is less than o.80.

Table:2 Results of Correlation Analysis

	LCO2	LGR	LEC	LEG	LURBN
LCO2	1.000000				
LGR	0.133675 ***	1.000000			
LEC	0.076351 **	-0.901584 ***	1.000000		
LEG	-0.452699 ***	-0.932320 ***	0.806085 ***	1.000000	
LURBN	-0.425629 ***	-0.927415 ***	0.817914 ***	0.995758 ***	1.000000

* Significant of 1% Level, ** significant of 5% Level, and *** significant of 10% Level.

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We first determine each variable's stationary level before applying the ARDL model to figure out the long-term linkage of variables. One common feature of time series data is stationarity. This study employed the PP (Phillip and Peron 1988) and ADF (Augmented Dickey-Fuller 1979) tests to determine stationarity in the data. Checking the time series data for many of the economic variables reveals that they are non-stationary.

The results of the unit root test based on ADF and PP (both with level and on first difference trend) tests are shown in Table 3. When variables are viewed at the level of the study, it demonstrates that every variable has a unit root problem. Nevertheless, after calculating their first difference, every variable is free from the unit root issue. Consequently, all variables are becoming stationary at first difference. Following our analysis of the data's stationarity, we proceed to the following stage.

Table:3 Results of ADF and PP Test

	ADF		**PP**	
Variables	**Level**	**1st Difference**	**Level**	**1st Difference**
Co2	0.4953	0.0000	0.5001	0.0000
GR	0.4115	0.0000	0.2738	0.0003
EC	0.1148	0.0001	0.0880	0.0001
EG	0.998	0.0042	0.9864	0.0042
URB	1.0000	0.0003	0.3415	0.0002

All the values are probability values

The estimated outcomes show that the short- and long-term relationships between the variables under study can be examined using the ARDL and ARDL Bound tests.

Table:4 ARDL Bond Test Result

Value of F-statistics	**Lower Bond** I (0)	**Upper Bond** I (1)
10.533494	2.2	3.09
	2.56	3.49
	2.88	3.87
	3.29	4.37

Table 4 shows ARDL bound test results; the co-integration relationship between the study variables was examined using the F statistic. The estimated F-statistics value of 10 is demonstrated by the empirical results. That exceeds the value of the upper bound.

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Table: 5 Dynamic ARDL Results				
Variables	**Coefficient**	**Std-Error**	**t-Statistic**	**Prob**
C	-0.067709	1.414494	-0.047868	0.9622
LCO2(-1)	0.606741	0.110700	5.480963	-1.485651
LGR	-1.485651	0.142200	-10.44765	0.0000
DLGR	-1.421028	0.125767	-11.29893	0.0000
LEC	1.039391	0.470602	2.208639	0.0370
DLEC	0.408750	0.207899	1.966101	0.0610
LEG	0.066948	0.028412	2.356341	0.0270
DLEG	0.026328	0.007810	3.371181	0.0025
LURB	2.255174	0.527039	4.278953	0.0002
DLURB	2.157078	0.481345	4.481356	0.0001
Coint eq (-1)	-0.393259	0.053766	-7.314231	0.0000
R-squared	0.837243	Adjusted R-squared		0.831631

Dynamic analysis for ARDL for both short- and long-term relationships is shown in Table 5. Based on the findings, the coefficient GR indicates that a one-unit increase in GR will result in a long-term reduction of -1.485 percent and a short-term reduction of -1.42 percent in CO2 emissions. There is an adverse correlation in the middle of GR and carbon dioxide emissions. This relationship results from the production and consumption sectors of the economy using clean and green energies (water, solar, and wind). There is a decrease in CO2 emissions from renewable resources. According to the coefficient EC, there will be a long-term increase in CO2 emissions of 1.039 percent and a short-term increase of 0.408 percent for every unit increase in EC.

Likewise, the coefficient EG indicates that a one percent rise in GDP per capita (EG) will result in a 0.06 percent long-term increase and a 0.026 percent short-term increase in CO2 emissions. This is because higher GDP per capita typically translates into higher rates of CO2 emissions per person. According to data from the World Bank, the global trend for air pollution increased during the same period that the global GDP per capita increased by half between 1990 and 2016. According to the coefficient URB, a one percent increase in URB will cause a 2.15 percent short-term and 2.25 percent long-term rise in CO2 emissions. Air pollution results from an expansion in population density relative to that relationship. The results of some earlier studies are comparable. (Danish et al., (2018), Rehman and Zeb (2018), Aftab et al., (2021). Additionally, serial correlation, normality tests, and potential heteroscedasticity are examined in the model. To verify the heteroscedasticity issue in the data, several tests, including the Breusch-Pegan-Godfrey and Harvey tests, were conducted. The findings are shown in the table below.

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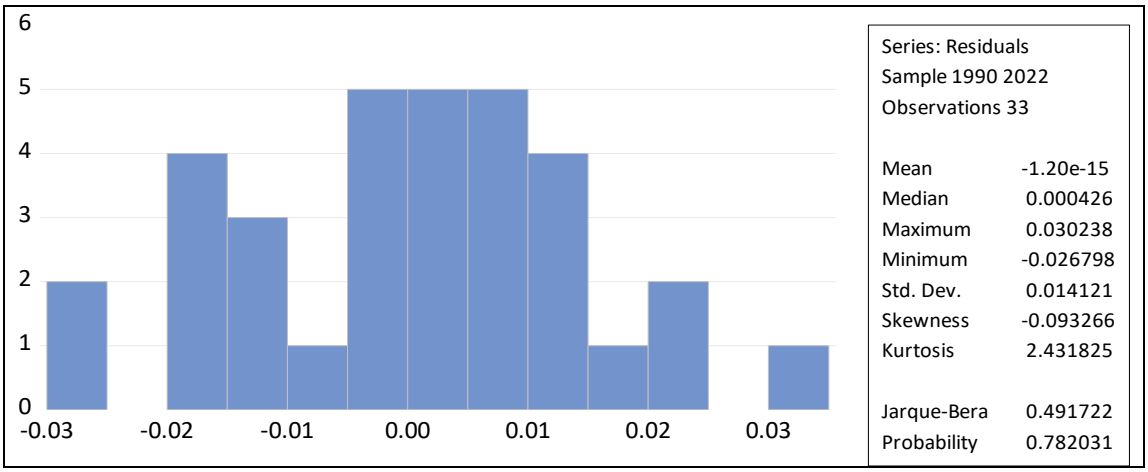
Table:6 Outcomes of Diagnostic Tests		
Diagnostic Tests	**P value**	**Results**
Heteroscedasticity (Breusch-Pagan-Godfrey)	0.8551	There is No problem of heteroscedasticity
Heteroscedasticity (Harvey)	0.9407	There is No problem of heteroscedasticity
Serial correlation (serial correlation LM test)	0.7495	There is No problem with serial correlation
Normality test (Jarque-Bera)	0.782031	Distribution of data is normal

Figure: 1



Source: E Views Output

The model is examined using serial correlation, normality tests, and potential heteroscedasticity. To check for hetero problems in the data, a variety of tests, including the Breusch-Pegan-Godfrey and Harvey tests, were conducted. The model is homoscedastic and lacks serial correlation, according to the data. According to the normalcy test, the distribution of the data is normal table 6 represents the findings.

To make sure the data is stable, a stability test is also used. The CUSUM and CUSUM of squares tests are employed for this reason. Because of the blue line falls between two red lines that demonstrate the reliability of coefficients, the results of the CUSUM including the CUSUM of squares show that the model is stable. It is a visual aid that illustrates the stability of the data being used through a graph.

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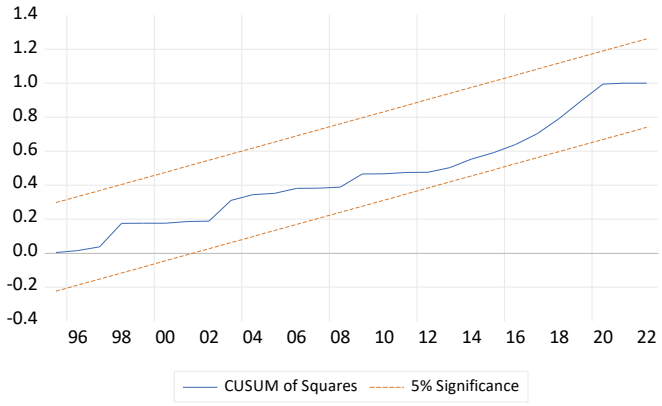
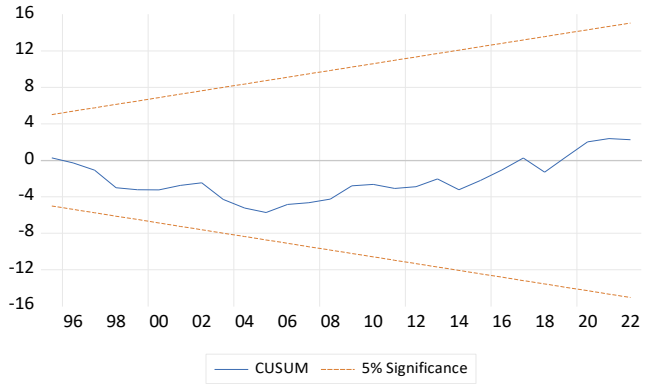
Figure: 2

CUSUM test



CUSUM square test



output: E Views

4. Conclusion and policy implications

Examining the connections between renewable resources, energy use, economic growth, urbanization, and environmental quality between 1990 - 2022 is the main objective of this article. The ADF and PP results express that the all-time series data is stationary at first difference but non-stationary at level. Using the ARDL model to analyze the short and long-term correlations, it is discovered that energy consumption has a negative impact on CO2 emissions. It is concluded that energy from non-renewable sources is responsible for rising CO2 discharge, however, energy from renewable sources may lower long-term carbon dioxide emissions. In a similar vein, urbanization, and economic expansion harm the environment. The study's findings support the theory that since people naturally emit CO2, a growing population will eventually result in higher levels of emissions. Such environmental degradation creates alarming risks to human health which may decrease productivity in the long run and hence affect economic growth. Environmental quality troubles are warnings to the economy of every country and the lives of people. The results show that environmental degradation also hurts the life expectancy of not only human beings but also every living creature. This study determines that three variables by utilizing energy that isn't renewable sources, urbanization, energy consumption plus economic growth are responsible for environmental degradation while green resources like solar, hydro, and wind energies significantly improve environmental quality. The findings of this study offer appropriate policy implications.

1. Policymakers should adopt renewable energy resources (RENG) such as hydro, solar, and wind energy to produce energy in the power production sectors. It is important to support clean and renewable energy sources since they have long-term effects on the environment that are gradually felt. Energy consumption from fossil fuels including oil, gas, coal, and waste materials should be prohibited in favor of clean and green energy sources.
2. The energy consumption of fossil fuels such as oil, gas, coal, and waste materials should be banned. To avoid severe environmental degradation to abnormal levels “Green-Practices” should be adopted for environmental protection.

3. Another important suggestion for the policymakers is that the local governments should play a role in preserving the green-rich areas where forests are under great stress because of cutting trees for domestic purposes. The government should need to educate the local people and motivate them towards tree plantations because trees are very important for a healthy planet.
4. Preventing environmental degradation can be done by taking various measures such as the plantation of trees, reservations of natural resources by the construction of dams, and producing energy from solar, hydro, and wind sources. Green initiatives should be a priority as they can prevent and control the realm of pollution.
5. Since Pakistan meets the criteria to be classified as a developing country, the study's conclusions can be applied to other developing countries.

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