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Energy Consumption, Power Transmission Losses, and Environmental Degradation in Nigeria

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Abstract **Review Article**

Environmental degradation has become a major challenge in Nigeria due to increasing energy demand, electricity sector inefficiencies, and rising carbon dioxide (CO_2) emissions. This study examined the effects of energy consumption, electric power transmission and distribution losses, economic growth, and population growth on environmental degradation in Nigeria using annual data from 1990-2025 and the Autoregressive Distributed Lag (ARDL) approach. The data were sourced from World Development Bank (WDI.). Unit root, bounds cointegration, and diagnostic tests were conducted to ensure model reliability. The long-run results revealed that energy consumption, economic growth, and population growth positively influenced environmental degradation, while power transmission losses exerted a negative effect; however, these relationships were statistically insignificant. In the short run, energy consumption significantly increased environmental degradation, whereas economic growth, population growth, and power transmission losses exhibited significant dynamic effects. The error correction term confirmed a stable long-run equilibrium. The study recommends investment in renewable energy, modernization of electricity infrastructure, improved energy efficiency, and strengthened environmental policies to achieve sustainable environmental management in Nigeria.

Keywords: Environmental degradation, energy consumption, power transmission losses, ARDL, carbon dioxide emissions, Nigeria.

1. Introduction

Environmental degradation has emerged as one of the most pressing global development challenges of the twenty-first century, posing significant threats to sustainable development, public health, biodiversity, and economic productivity. The increasing concentration of greenhouse gases, particularly carbon dioxide (CO_2), resulting from anthropogenic activities has intensified climate change and heightened concerns regarding environmental sustainability. Although energy consumption remains indispensable for economic growth and industrial development, the continued dependence on fossil fuel-based energy systems has substantially contributed to environmental degradation across both developed and developing economies (IPCC, 2023). Consequently, balancing economic development with environmental sustainability has become a central objective of governments and international development agencies.

The relationship between energy consumption and environmental quality has attracted considerable scholarly attention over the past two decades. The Environmental Kuznets Curve (EKC) suggests that environmental degradation initially increases with economic growth but eventually declines as cleaner technologies are adopted (Grossman & Krueger, 1995). However, empirical evidence remains mixed, particularly in developing countries where rapid urbanization, industrial expansion, weak environmental regulation, and dependence on fossil fuels continue to intensify environmental deterioration. Recent studies also suggest that environmental outcomes depend not only on energy consumption but also on the efficiency of electricity generation, transmission, and distribution systems (Owebor et al., 2025).

Nigeria presents an important case because, despite abundant energy resources, the country continues to experience chronic electricity shortages and an unreliable national grid. Persistent technical and commercial losses have encouraged widespread dependence on petrol- and diesel-

In addition to inadequate electricity generation, Nigeria's electricity sector suffers substantial transmission and distribution losses due to ageing infrastructure, overloaded transmission lines, obsolete equipment, poor maintenance, electricity theft, and weak institutional governance. Since electricity generation in Nigeria is predominantly gas-fired, higher generation requirements inevitably increase greenhouse gas emissions and environmental degradation (Janicke et al., 2023; Surana & Jordaan, 2019).

Existing empirical studies have extensively examined the relationship between energy consumption and environmental degradation. Nevertheless, relatively little attention has been devoted to the environmental implications of electric power transmission and distribution losses. Most Nigerian studies investigate transmission losses from engineering or operational perspectives rather than within a macroeconomic framework (Ajao et al., 2021; Adamu et al., 2022). Consequently, limited evidence exists on how transmission losses influence environmental degradation. Against this background, this study investigates the effects of energy consumption and electric power transmission and distribution losses on environmental degradation in Nigeria while controlling for economic growth and population growth. Empirical studies have shown that increased energy consumption is associated with higher carbon emissions and declining environmental quality in the country (Nwaimo et al., 2025). The environmental consequences include climate change, air pollution, ecosystem degradation, and increased vulnerability to extreme weather conditions such as flooding and drought.

By explicitly incorporating transmission losses into the environmental degradation model, the study extends the existing literature and provides new evidence on the environmental consequences of electricity sector inefficiencies. The findings are expected to contribute to energy policy by demonstrating whether improvements in transmission efficiency can complement energy sector reforms and environmental sustainability initiatives in Nigeria.

The study is structured in the following sections: after the introduction, second section presents the literature review, followed by theoretical review in the third section. Methodology and results are discussed in the fourth section. The fifth section contains the conclusion and recommendations.

2.0 Brief Literature Review

2.1.0 Conceptual Literature

2.1.1 Energy consumption

Energy Consumption is the amount of energy utilized by households, industries, commercial establishments, transportation systems, and governments to support economic production and human activities. It constitutes one of the most important indicators of economic development because energy serves as a critical input in production, industrialization, technological advancement, and improvements in living standards. According to the (IEA, 2024) energy consumption encompasses the total quantity of primary and secondary energy used within an economy over a specified period and is generally measured in kilograms of oil equivalent, tonnes of oil equivalent, or kilowatt-hours depending on the energy source.

2.1.2 Power Transmission and Distribution Losses

Power transmission and distribution losses is the proportion of electricity generated that is lost before reaching final consumers due to technical inefficiencies, operational deficiencies, and commercial leakages within the electricity network. These losses occur during the transmission of electricity from power generation plants through high-voltage transmission lines and during its distribution to residential, commercial, and industrial consumers. According to (World Bank, 2024), electric power transmission and distribution losses are measured as the percentage of electricity output lost in the transmission and distribution network, including losses arising from technical inefficiencies and non-technical factors such as electricity theft, illegal connections, and metering inaccuracies.

2.1.3 Environmental Degradation

Environmental degradation refers to the deterioration of the natural environment resulting from human activities that adversely affect the quality, sustainability, and regenerative capacity of ecosystems. It encompasses air pollution, water pollution, soil degradation, deforestation, biodiversity loss, desertification, climate change, and the depletion of natural resources. Environmental degradation has become one of the most pressing global challenges because it threatens economic development, public health, food security, and ecological sustainability. According to (UNEP, 2021), environmental degradation occurs when natural ecosystems are damaged through excessive exploitation of natural resources, pollution, and unsustainable production and consumption patterns, thereby reducing the environment's ability to provide essential ecosystem services.

2.2.0 Theoretical Literature

Analysis of demand for energy is not different from that of any other commodity. There are characteristics of energy demand, institutional features of energy markets, and problem of measurement that require particular attention in analyzing energy markets. But the microeconomic foundation of energy demand is the same as for other commodities. This study is anchored on two major theories:

2.2.1 Environmental Kuznets Curve (EKC) Theory

Environmental studies have drawn several theoretical perspectives to explain the relationship between industrial activities and community outcomes. Prominent among these is the Environmental Kuznets Curve (EKC) theory. The Environmental Kuznets Curve suggests that environmental degradation initially increases with economic growth but begins to decline after a certain level of income is reached (Grossman & Krueger, 1995, Deacon & Norman, 2004). The theory implies that economic development initially leads to environmental pollution due to increased industrialization and energy consumption.

While this theory provides a macro-level explanation for the growth environment relationship, its applicability to developing countries remains contested, as many nations have yet to reach the turning point where environmental improvements occur.

2.2.2 STIRPAT Model

STIRPAT Model (Stochastic Impacts by Regression on Population, Affluence, and Technology)
This model is one of the most widely applied theoretical and empirical frameworks for analyzing the determinants of environmental

degradation. Developed by Dietz and Rosa (1994, 1997), the model extends the traditional IPAT identity by introducing a stochastic regression framework that allows researchers to estimate the magnitude and statistical significance of the impacts of population, affluence, and technology on environmental quality.

The STIRPAT model (Stochastic Impacts by Regression on Population, Affluence, and Technology) explains how human activities influence environmental degradation.

The STIRPAT model can be expressed as:

$I = aP^bTA^cT^d$-------------------------- (1)

Where:

I = Environmental impact (CO_2 emissions)

P = Population

A = Affluence (GDP per capita)

T = Technology (energy efficiency)

This model allows researchers to analyze how energy consumption and technological inefficiencies influence environmental degradation (Dietz & Rosa, 1997). The STIRPAT model provides an appropriate theoretical foundation for examining the determinants of environmental degradation in Nigeria because the variables employed in this study correspond closely to the model's core components.

2.1 Empirical Literature

The relationship between energy consumption, power transmission losses, and environmental degradation has received considerable attention in energy economics and environmental sustainability literature. Many studies have examined the environmental consequences of increased energy demand, particularly in developing economies where fossil fuels dominate energy production. However, relatively few studies have incorporated electricity transmission inefficiencies into the analysis of environmental outcomes. This section reviews both conceptual and empirical studies relevant to this research.

Acheampong (2018) investigated the causal relationship between economic growth, energy consumption, and CO_2 emissions across several countries and found that economic growth significantly contributes to environmental degradation, particularly where economic expansion is driven by fossil fuel energy. Similarly, Dogan and Seker (2016) reported that while renewable energy consumption improves environmental quality, economic growth supported by non- renewable energy increases carbon emissions.

Using data from China, Shahbaz et al. (2020) demonstrated that rapid economic growth accompanied by industrial expansion exerts upward pressure on CO_2 emissions, although technological innovation and environmental policies can moderate this effect. Likewise, Bekun, Emir, and Sarkodie (2019) found that economic growth significantly increases carbon emissions in South Africa, emphasizing that sustainable growth requires greater investment in renewable energy and energy-efficient technologies. Nathaniel and Bekun (2020), using evidence from Nigeria, reported that economic growth contributes positively to environmental degradation because increased industrial activities and energy consumption continue to depend largely on fossil fuels. Similarly, Akadiri et al. (2022) concluded that economic expansion in Nigeria has intensified environmental degradation due to increased energy demand and inadequate adoption of clean energy technologies.

Using panel data for developing economies, Wang, Dong, and colleagues (2021) reported that rapid population growth significantly increases CO_2 emissions by raising energy demand and accelerating urban expansion. Likewise, Muttarak (2021) argued that population dynamics influence environmental outcomes through changing consumption patterns, migration, and environmental policy urbanization, suggesting that demographic characteristics should be incorporated into climate and Dzhumashev and Kazakevitch (2025) demonstrated that the interaction between production, population, and environmental quality creates long-run challenges for sustainable growth, highlighting the importance of considering demographic dynamics alongside economic and technological factors. Within the Nigerian context, rapid population growth has substantially increased electricity demand, transportation activities, residential energy consumption, and pressure on already inadequate electricity infrastructure. Consequently, households and businesses increasingly rely on self-generated electricity from petrol and diesel generators, thereby increasing fossil fuel consumption and carbon emissions

Surana and Jordaan (2019) provided one of the earliest global assessments of the environmental implications of T&D losses, demonstrating that reducing electricity losses could significantly lower greenhouse gas emissions and contribute to climate change mitigation. They argued that improving transmission efficiency is one of the most cost-effective strategies for reducing emissions because it minimizes unnecessary electricity generation. Similarly, Saygin et al. (2021) reported that improvements in electricity transmission infrastructure enhance energy efficiency and reduce carbon emissions by lowering system losses and optimizing electricity delivery. Their findings suggest that modernizing electricity networks is essential for achieving sustainable energy transitions, particularly in developing economies where transmission losses remain relatively high. Using cross-country evidence, IEA (2023) highlighted that electricity grid modernization and investments in transmission infrastructure are indispensable for decarbonizing the power sector. The report emphasized that countries with lower transmission losses generally experience lower carbon intensities because efficient electricity systems require less energy input to satisfy final demand. Within developing countries, Adewuyi and Awodumi (2023) observed that persistent electricity infrastructure deficiencies increase dependence on self-generation through petrol and diesel generators, thereby intensifying carbon emissions and environmental degradation. The authors argued that strengthening electricity transmission systems could substantially reduce fossil fuel consumption and improve environmental sustainability. In the Nigerian context, Oyedepo (2012) observed that the country's electricity sector is characterized by obsolete transmission facilities, inadequate maintenance, and insufficient investment, resulting in significant technical losses and unreliable electricity supply. Consequently, households and industries increasingly rely on private generators powered by fossil fuels, thereby increasing greenhouse gas emissions. More recently, Owebor et al. (2025) identified transmission and distribution losses as one of the major obstacles to decarbonizing Nigeria's electricity sector, stressing that reducing system losses would simultaneously improve electricity reliability and environmental quality.

3.0 Methodology

The methodology is designed to provide both descriptive and econometric insights into the relationships between energy consumption, power transmission losses and environmental degradation in Nigeria. Through rigorous statistical analysis, the study aims to examine the impact of energy consumption on environmental degradation in Nigeria, investigate the effect of power transmission losses on environmental degradation, analyze the relationship between electricity inefficiency and carbon emissions in Nigeria and provide policy recommendations for improving energy efficiency and environmental sustainability in Nigeria.

3.1 Model Specification

The functional forms of the models are specified as follows.

CO_2= f (EC, PTL, GDP, POP) ----------------- (2)

Where: CO_2 = Carbon dioxide emissions (proxy for environmental degradation), EC = Energy consumption, PTL = Power transmission losses, GDP = Economic growth, POP = Population growth

The log-linear Econometric Model

$LnCO_2 = \beta_0 + \beta 1LnECt + \beta_2 LnPTL_t + \beta_3 GDP_t + \beta_4 POP_T + U_t$ ------------------------------------- (3)

Where: β_0= intercept, β_1 - β_2= long-run relationship coefficients and μ = Error term

ARDL Model Specification

The unrestricted ARDL (p, q, r, s, v) model is specified as:

$\Delta LnCO_{2t} = \alpha_0 + \sum_{i=1}^{p} \alpha_1 \Delta LnCO_{2t-1} + \sum_{i=1}^{q} \alpha_2 \Delta LnEC_{t-1} + \sum_{i=1}^{r} \alpha_3 \Delta LnPTL_{t-1} + \sum_{i=1}^{s} \alpha_4 \Delta GDP_{t-1} + \sum_{i=1}^{v} \alpha_5 \Delta POP_{t-1} + \lambda_1 LnCO_{2t-1} + \lambda_2 LnEC_{t-1} + \lambda_3 PTL_{t-1} + \lambda_4 GDP_{t-1} + \lambda_5 POP_{t-1} + \epsilon_t$------------------- (4)

Where $\Delta =$ First difference operator

$\alpha_0 =$ Constant term

$\alpha_1 - \alpha_5$= Short-run dynamic coefficients

$\lambda_1 - \lambda_5$=Long-run coefficients

$p, q, r, s\ and\ v =$ Optimal lag lengths selected using the Akaike Information Criterion (AIC)

3.2 Research Design

The research design for this study is quantitative and explanatory, employing a time series econometric research design to examine the relationship between energy consumption, power transmission losses, and environmental degradation in Nigeria. The study also utilizes a time series research approach, which involves analyzing data collected over a specific period. The time series approach is appropriate because the variables under investigation: energy consumption, power transmission losses, and environmental degradation change over time and their dynamic interactions need to be examined. Annual data covering a period such as 1990–2025 can be used to capture long-run and short-run relationships among the variables.

Furthermore, the study adopts an econometric modeling framework, specifically the Autoregressive Distributed Lag (ARDL) model, to analyze the relationship between the variables. The ARDL model is suitable because it can be applied when variables are integrated at different orders I (0) and I (1) and allows the estimation of both short-run and long-run dynamics (Pesaran, Shin & Smith, 2001).

In this study, environmental degradation is proxied by carbon dioxide (CO_2) emissions, while the key explanatory variables include energy consumption (EC) and power transmission losses (PTL). Control variables such as economic growth (GDP) and population growth (POP). CO_2 and PTL were transformed into natural logarithms to stabilize their variance, reduce skewness, and facilitate elasticity interpretation while GDP and POP were retained in their original form because they are already expressed as growth rates (annual percentage change). The data are sourced from World Development Indicator (WDI)

4. Analysis and Discussion

1. Unit Root Tests:

The study deployed conventional unit root tests using Augmented Dickey Fuller (ADF) techniques to test for the presence of unit root in the series. Table 1 below shows that CO_2, EC, GDP and PTL are stationary at first difference while only POP is stationary at level with constant and trend. Therefore, since the data does not contain I (2) series, it lends support to the use of ARDL bound testing approach to co-integration.

Table 1. ADF unit root test

	ADF statistics at level		ADF statistics at first difference		
Variables	ADF Statistics	Prob	ADF Statistics	Prob	Order of Integration
CO2	-1.376721	0.5823	-6.331241	0.0000	I (1)

EC	-2.004096	0.2838	-6.067985	0.0000	I (1)
GDP	0.370878	0.9787	-2.021317	0.0429	I (1)
POP	-3.119022	0.0358	-1.908706	0.3239	I (0)
PTL	-2.095178	0.2477	-6.592961	0.0000	I (1)

Source: Author's computation (2026)

2. Bound cointegration test

The results of the bound test for existence of long-run are presented in table 2. The bound test results indicated that F- statistics value of 4.31is greater than upper and lower critical values. Therefore, these results confirm the existence of long-run relationship in the model and such, both the short-run and long-run models can be estimated using ARDL estimation technique. Having found a long run relationship between our series, we estimated the short-run and long-run model to obtain the long run coefficients whose results are presented on tables 3 and 4 respectively.

Table 2. Bound test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	4.305530	10%	2.2	3.09
k	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37

Source: Author's computation (2026)

4.4 Short-run relationship of the model

The short-run presented in table 3 indicates that the lagged values of CO_2 emissions exhibit negative and statistically significant effects during the first and second lag periods. This suggests that increases in past CO_2 emissions reduce current emission growth, reflecting an adjustment process possibly driven by environmental regulations, technological improvements, or adaptation mechanisms. However, the third lag is statistically insignificant implying that its effect disappears after two periods. EC exerts a positive and highly significant effect on CO_2 emissions in the current period, this indicates that a 1% increase in energy consumption raises CO_2 emissions by approximately 1.22% in the short run, confirming that Nigeria's energy sector remains heavily dependent on fossil fuels. However, the first and second lagged values of EC are negative and statistically significant, suggesting that although energy use initially increases emissions, the adverse environmental impact diminishes over time, possibly due to efficiency improvements or delayed policy responses. GDP has a negative and statistically significant effect on CO_2 emissions across almost all lag periods. The current GDP coefficient (-1.85E-05; $p = 0.0036$) suggests that improvements in economic growth contribute to reductions in CO_2 emissions. Similar negative and significant effects are observed for the first and third lags, while the second lag is marginally significant ($p = 0.0558$). These findings imply that economic expansion in Nigeria may increasingly be associated with cleaner production technologies, structural transformation, or improvements in environmental management. POP significantly influences CO_2 emissions indicating that population changes are associated with an immediate decline in emission growth. However, the first lag becomes positive and significant suggesting that the environmental consequences of population expansion emerge after a time lag through increased energy demand, transportation activities, and industrial production.

EC displays mixed short-run effects on CO_2 emissions. The current coefficient is negative and significant, indicating that current petroleum consumption initially reduces emission growth. However, the first, second, and third lagged coefficients are all positive and statistically significant, implying that sustained petroleum consumption eventually contributes to higher CO_2 emissions. This finding reflects the cumulative environmental effects of prolonged dependence on petroleum products within the Nigerian economy.

The coefficient of the error correction term is negative and statistically significant at the 1% level ($p = 0.0001$). These confirm the existence of a stable long-run equilibrium relationship among carbon emissions, energy consumption, economic growth, population growth, and petroleum consumption. Specifically, the coefficient implies that approximately 17.5% of any short-run disequilibrium is corrected annually, indicating a relatively slow adjustment process towards the long-run equilibrium following economic shocks.

Table 3. Short run estimates from ECM

ECM Regression

Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
DLOG(CO2(-1))	-0.372011	0.140311	-2.651337	0.0243
DLOG(CO2(-2))	-0.370439	0.113355	-3.267941	0.0085
DLOG(CO2(-3))	-0.145125	0.093514	-1.551897	0.1517
DLOG(EC)	1.215363	0.113892	10.67119	0.0000
DLOG(EC(-1))	-0.542899	0.157283	-3.451733	0.0062

DLOG(EC(-2))	-0.410411	0.165476	-2.480189	0.0325
D(GDP)	-1.85E-05	4.89E-06	-3.782815	0.0036
D(GDP(-1))	-2.01E-05	5.85E-06	-3.444551	0.0063
D(GDP(-2))	-1.31E-05	6.07E-06	-2.163771	0.0558
D(GDP(-3))	-2.33E-05	6.79E-06	-3.430942	0.0064
D(POP)	-1.932924	0.287374	-6.726163	0.0001
D(POP(-1))	0.818122	0.294861	2.774602	0.0196
DLOG(PTL)	-0.239497	0.078925	-3.034496	0.0126
DLOG(PTL(-1))	0.731471	0.097196	7.525767	0.0000
DLOG(PTL(-2))	0.743240	0.109311	6.799312	0.0000
DLOG(PTL(-3))	0.276553	0.102862	2.688597	0.0228
CointEq(-1)*	-0.175494	0.028192	-6.224932	0.0001

R-squared	0.931951	Mean dependent var	-0.011757
Adjusted R-squared	0.859366	S.D. dependent var	0.080413
S.E. of regression	0.030156	Akaike info criterion	-3.860068
Sum squared resid	0.013641	Schwarz criterion	-3.081396
Log likelihood	78.76109	Hannan-Quinn criter.	-3.601960
Durbin-Watson stat	2.250758		

Source: Author's computation (2026)

4.4 Long-run relationship of the model

Table 4 revealed the long-run impact of EC has positive but statistically insignificant impact on environmental degradation. This implies that higher energy consumption is associated with an increase in carbon dioxide (CO_2) emissions. A 1% increase in energy consumption is associated with an estimated 0.026% increase in CO_2 emissions in the long run. However, the lack of statistical significance indicates that this relationship is not sufficiently strong to conclude that energy consumption exerts a systematic long-run effect on environmental degradation over the study period. This can be attributed to Nigeria's heterogeneous energy mix, where electricity from the national grid coexists with widespread self-generation using fossil-fuel generators, biomass, and other informal energy sources.

PTL ha a negative and statistically insignificant impact on CO_2, implying that increases in transmission losses are associated with a slight reduction in CO_2 emissions in the long run. This result is contrary to theoretical expectations, which generally predict that higher transmission losses reduce electricity system efficiency and require additional electricity generation, thereby increasing emissions. The insignificant coefficient suggests that transmission losses alone may not be a dominant driver of environmental degradation in Nigeria. Instead, the country's persistent reliance on privately owned diesel and petrol generators, limited electricity access, and operational inefficiencies across the power sector may have a greater influence on emissions than transmission losses recorded on the national grid. Consequently, improvements in transmission efficiency, while economically desirable, may not automatically translate into measurable reductions in CO_2 emissions unless accompanied by broader reforms that expand reliable electricity supply and reduce dependence on fossil-fuel self-generation.

GDP is positive but statistically insignificant, this indicates that economic expansion is associated with a marginal increase in environmental degradation, but the effect is not statistically significant. The positive sign is consistent with the early stage of the Environmental Kuznets Curve (EKC) hypothesis, which argues that economic growth initially leads to higher pollution because of increased industrial production, urbanization, and energy consumption. However, the insignificant result suggests that economic growth has not been a decisive long-run determinant of CO_2 emissions during the study period. This may reflect Nigeria's growth pattern, where fluctuations in the oil sector, services, and agriculture have not consistently translated into proportional increases in industrial emissions. It may also indicate that other structural factors such as energy composition, technological efficiency, or environmental regulation play a more important role in determining environmental quality than aggregate economic growth alone. POP is positive but statistically insignificant, suggesting that population growth is associated with a slight increase in CO_2 emissions, although the relationship is not statistically significant.

The Bruesch-Godfrey Serial Correlation LM test indicates that the estimated model does not suffer from serial correlation because the probabilities of F-statistics and Chi-square are both greater than 5% significant level.

Table 4

Levels Equation

Case 2: Restricted Constant and No Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG(EC)	4.628679	6.726374	0.688139	0.5070
GDP	2.16E-05	6.08E-05	0.354788	0.7301
POP	1.170876	2.642929	0.443022	0.6672
LOG(PTL)	-4.819027	8.233069	-0.585326	0.5713
C	-6.956937	14.80861	-0.469790	0.6486

Breusch-Godfrey Serial Correlation LM Test:

F-statistic	0.411214	Prob. F(2,8)	0.6761
Obs*R-squared	2.983043	Prob. Chi-Square(2)	0.2250

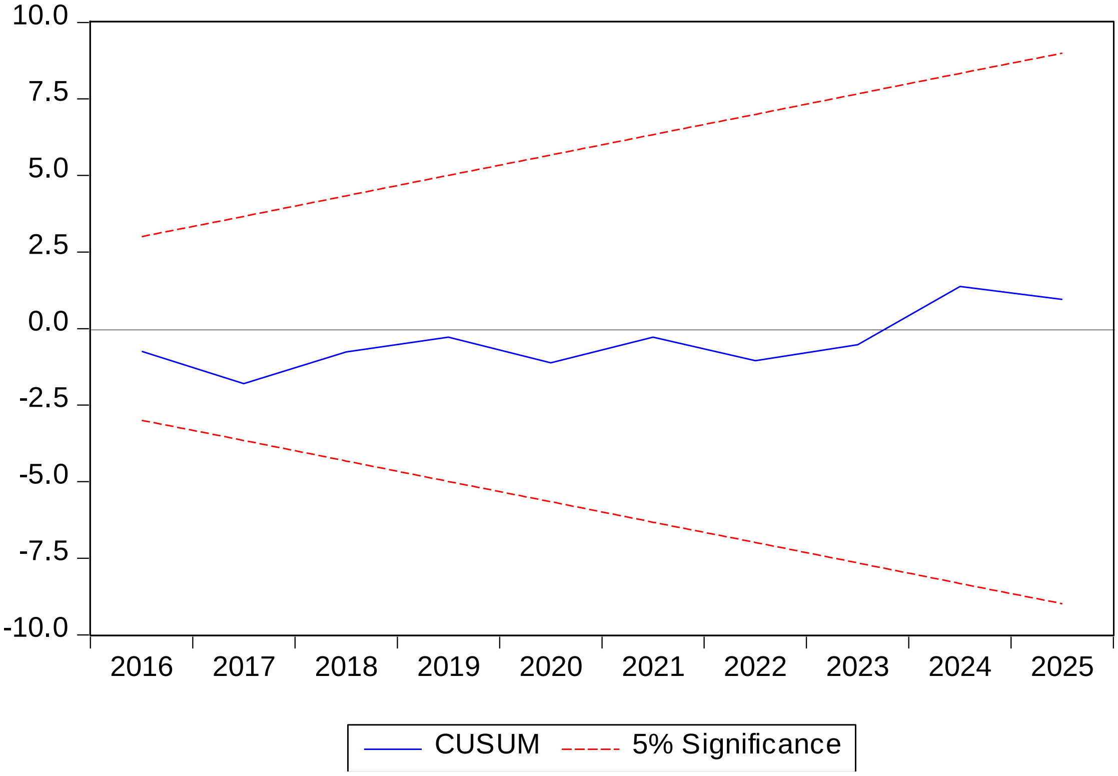
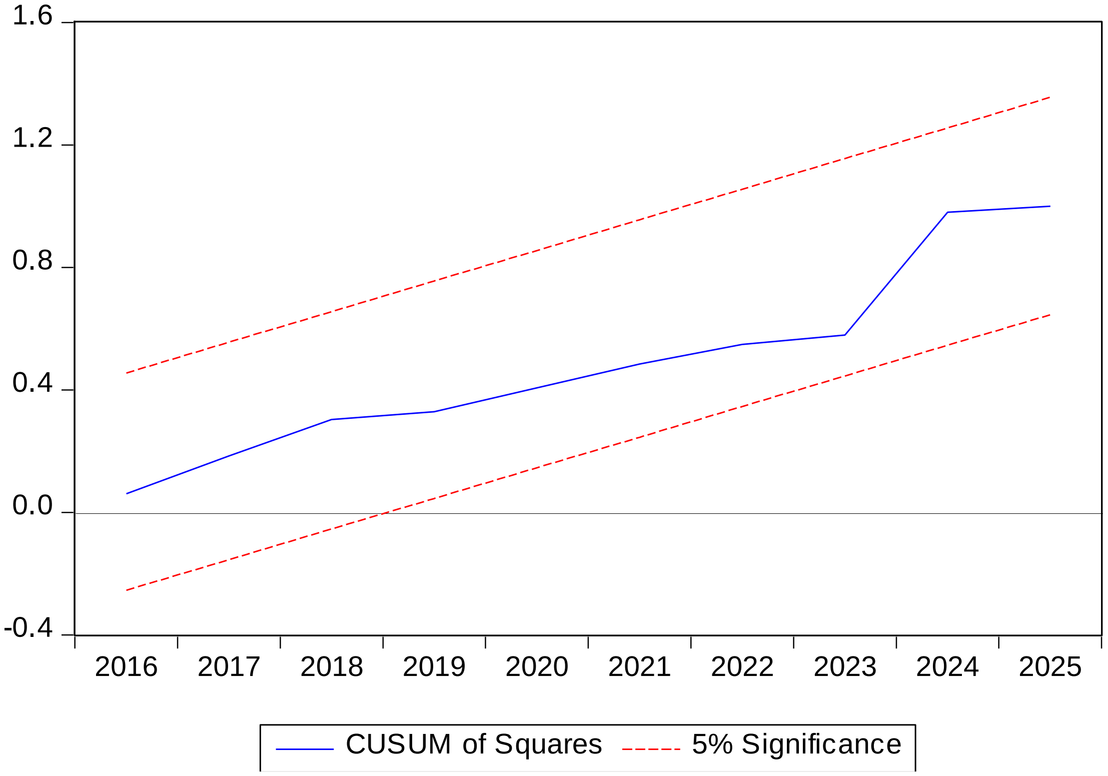


Figure 1



5. Conclusion and Recommendation

This study used Autoregressive Distributed Lags (ARDL) to estimate the impact of energy consumption and power transmission losses on environmental degradation in Nigeria for the period of 1990-2025. To model the relationship, the model the relationships between the variable

(Energy Consumption, Power Transmission Losses) and Carbon oxide (CO_2) emissions, a proxy for environmental degradation while economic growth and population growth were used as control variables. Base on the findings of the study, the Bound Cointegration test revealed that there exist a long run relationship between energy consumption, power transmission losses and environmental degradation in Nigeria. The empirical analysis revealed distinct short-run and long-run dynamics.

The long-run results indicate that energy consumption, economic growth, and population growth exert positive effects on environmental degradation, while electric power transmission and distribution losses have a negative effect. However, none of these long-run relationships is statistically significant, suggesting that the selected macroeconomic variables do not independently explain long-run changes in carbon dioxide emissions over the study period.

In contrast, the short-run (ECM) results show that energy consumption significantly increases environmental degradation contemporaneously, although some lagged effects are negative. Economic growth exhibits a statistically significant negative short-run relationship with environmental degradation, while population growth has a significant negative contemporaneous effect but a positive first-lag effect. Electric power transmission and distribution losses display a negative contemporaneous effect but positive and statistically significant lagged effects, indicating that the environmental consequences of transmission inefficiencies emerge over time rather than immediately.

Based on the findings, the following recommendations are proposed

(1) Since energy consumption significantly increases environmental degradation in the short run, government should expand investments in renewable energy technologies, improve energy efficiency standards, and encourage households and industries to adopt cleaner energy sources to reduce carbon emissions.

(2) The significant lagged effects of transmission and distribution losses indicate that inefficiencies in the electricity network have lasting environmental consequences. Government should prioritize rehabilitation of transmission lines, deployment of smart-grid technologies, and regular maintenance to reduce technical losses and improve electricity reliability.

(3) Regulatory institutions should improve enforcement of emission standards, promote compliance with environmental regulations, and provide incentives for firms investing in environmentally friendly technologies.

(4) Expanding renewable electricity generation, improving electricity access, and reducing dependence on petrol and diesel generators will simultaneously enhance energy security and reduce greenhouse gas emissions.

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