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Nexus Between Energy Poverty, Economic Growth, *Ijarah Sukuk*, and Environmental Degradation in Nigeria

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ABSTRACT

Introduction*: Poor energy access leads to environmental degradation among developing countries in Africa. This study investigated the nexus among energy poverty, economic growth, Ijarah Sukuk and environmental degradation in Nigeria based on time series data covering 1981 to 2023. The study intends to explore the effect of energy poverty, Ijarah Sukuk and economic growth on environmental degradation.*

Methods*: The variables used were environmental degradation (dependent variable), energy poverty, Ijarah Sukuk and economic growth (independent variables). Population growth and capital formation were the control variables. Autoregressive Distributive Lag and Vector Error Correction were concurrently applied.*

Results*: The study found a long run relationship based ARDL Bound test which justifies for both long and short run estimations. The result of long run revealed that energy poverty and Ijarah Sukuk are negatively and significantly related to environmental degradation, while economic growth is positively and significantly associated. Also, the short run, result is consistent to its long run estimates even at 10%. This shows that, an increase in current value of energy poverty and Ijarak Sukuk will decrease environmental degradation but increase by an increase in one-year lag value of energy poverty, while a point growth of economy will increase environmental degradation. Finally, the Vector Error Causality result indicates evidence of uni-directional causality from economic growth and energy poverty in the short run. Therefore, the growth of economy which leads to a reduction in energy poverty will result to higher environmental degradation reflecting two-sided blades of the same razor for Nigeria. Study of this nature reveals*

how the interplay among poor energy consumption, economic growth and environmental degradation, and concludes that energy poverty and economic growth have significant effect on environmental degradation for Nigeria.
***Conclusion and suggestion**: Finally, it was recommended that, policymakers should prioritize energy poverty reduction strategy through adopting economic growth and environmentally friendly technology policy framework in Nigeria.*
***Keywords:** Economic Growth, Energy Poverty, Ijarah Sukuk, and Environmental Degradation*

Paper type: Research paper

INTRODUCTION

Consumption of energy for maintaining economic well-being is the principal reason for environmental degradation in both advanced and developing economies of the world. Climate change presents devastating impacts, such as human fatalities, loss of biodiversity, and ecosystem spoilage (Sun et al., 2024). During 2021, 36.3 billion tons of CO_2 were emitted, 6 per cent higher than the previous year (Dong et al., 2023). In this line, climate sponsorship venture is properly utilized. Conference on Parties (COP27) warrants global actions to reduce greenhouse gas emissions to 43% by 2030 and return the world temperature to pre-industrial levels of an average rise of 1.5^0 to sustain human life which according to the International Energy Agency's (IEA) report, requires US$1.3 trillion (World Bank, 2023). In this situation, much remains to be done to tackle global environmental degradation for timely and sensible climate solutions. Therefore, quick actions are indispensable to identify the climate change indicators and agents to global greenhouse emissions.

In an effort to offer solutions to climatic change, the COP27 agreed to fund damages in those countries that are severely vulnerable to climate disasters (UNEP, 2022). While the advanced countries' parties in 2009 pledged to marshal 100 billion USD yearly to developing nations, they have not met that pledge. To meet the target, the multilateral development banks and international monetary bodies were called on to activate climate finance, and therefore, at COP27, the parties settled to set a new quantified goal on climate finance in 2024 by accounting for the necessities and priorities of climate-fragile states (UNFCC, 2022). The dependence on energy aid to use energy services in developing countries also aligns with natural resource utilization-led environmental exploitation. When a country exploits its available natural resources to create economic means instead of investing in its capital, it enhances environmental contamination and faces consequences. Similarly, industrial activities, capital formation, over population and the withdrawal of natural resources enlarge the footprints by considering the ecological capacities. This phenomenon tends to reduce the ecological sustainability of the nation. For instance, the ongoing exploitation of natural resources has resulted in significant environmental degradation, reaching unprecedented levels and jeopardizing the renewable environmental resources' regenerative and replenishment capacities. From 1980 to 2023, developing countries have extracted $24.74 trillion from natural resource rents (Sun, Khan, & Cai, 2024). Likewise, the withdrawal of oil, coal, and gas rose from 6 billion tons to 16 billion tons, while the extraction of biomass harvest climbed from 9 billion tons to 24 billion tons (Bashir et al., 2023).

Nigeria, a nation rich in natural resources, particularly oil and gas, makes a significant contribution to its GDP. The extraction and consumption of this reserve of wealth have resulted in environmental degradation in the hosting communities. Therefore, the country's reliance on fossil fuels for energy production has significantly contributed to pollution, deforestation, and other environmental problems (Dimnwobi, Okere, Onuoha, and Ekesiobi, 2023). Furthermore, the ongoing lack of access to clean energy sources significantly contributes to Nigeria's economic underdevelopment. This is because, without reliable energy sources, industries cannot operate efficiently, hindering productivity, perpetuating economic backwardness, and exacerbating poverty (Mewamba-Chekem and Noumessi, 2021). Additionally, the environmental degradation caused by this reliance on fossil fuels has long-term negative impacts on the economy, including a decrease in agricultural productivity and increased health costs associated with pollution (Afaha & Ifarajimi, 2021; Aigheyisi & Oligbi, 2020). Besides the use of conventional solutions, Islamic teachings have developed ethical ways of addressing social issues, such as environmental damage. Specifically, Sukuk, with its variant forms, has been applied in Islamic finance literature to address similar environmental challenges (Bashir, Ali & Ashraf, 2023). Therefore, this study aims to provide solutions to environmental damage by examining the impact of energy poverty, *Ijarah Sukuk,* and economic growth on environmental degradation, with a focus on Nigeria, spanning the period from 1981 to 2023.

LITERATURE REVIEW

The trend in the literature shows that most studies on environmental degradation have concentrated on Asian countries, collectively African countries, Latin America, Sub-Saharan African countries, and other parts of the world. Examples of such studies include the works of Dimnwobi et al. (2023), Mewamba-Chekem and Noumessi (2021), and Kiani, Ullah, and Muhammad (2020). This indicates that few of this type have been conducted in Nigeria, such as the work of Azeakpono and Lloyd (2020) and Ogwumike and Ozughalu (2015). A study by Hannah et al. (2024), based on cointegration and Granger causality, revealed a positive correlation between environmental degradation and energy poverty. Usman and Badaru (2024) employed the ARDL approach and found that energy consumption and economic growth are positively related to environmental quality. Additionally, Dimnwobi et al. (2023a) used DOLS and found that ecological preservation and energy poverty are directly related in Sub-Saharan Africa. Mewamba-Chekem and Noumessi (2021) applied PCSE and FGLS on SSA nations and established that energy poverty and CO2 emissions were not directly related.

In view of the foregoing, the study on the nexus between energy poverty, economic growth, *Ijara Sukuk* and environmental degradation in Nigeria intends to examine the impact of energy poverty, *Ijara Sukuk* and economic growth on environmental degradation in Nigeria and explore causality among energy poverty, economic growth, *Ijara Sukuk* and environmental degradation, which previous studies had neglected over periods of time. By examining the interplay among environmental degradation, energy poverty, *Ijara Sukuk,* and economic growth in Nigeria. The study provides a comprehensive understanding of the complex dynamics at play, ultimately contributing to the development of sustainable environmental solutions. Additionally, the introduction of *Ijarah Sukuk* marks a new direction in the literature. The research is organized into five sections: Section 2, a literature review; Section 3 outlines the methodology and sources of data; Section 4 presents an analysis and discussion of the results; and Section 5 provides conclusions and policy recommendations.

METHOD

The following flow chart guides an easier understanding of the methodology used in this study:

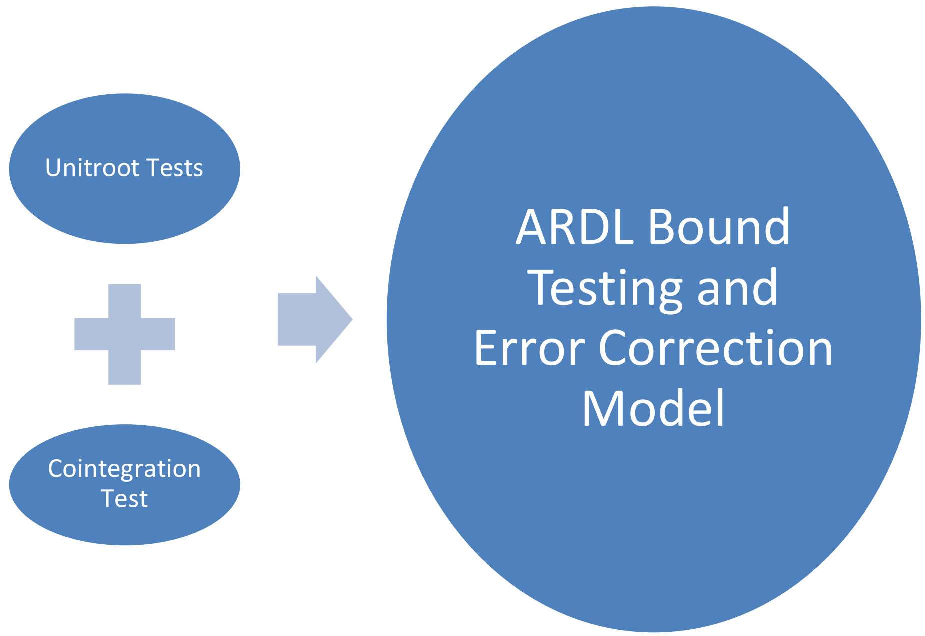

Figure 1. Research Methodology

Theoretical Framework

The Stochastic Impacts by Regression on Population, Affluence and Technology (STIRPAT) Model is used in this study to model the nexus between energy poverty, economic growth, and environmental degradation in Nigeria. The formulation of this relation was derived and conducted using a simple identity based on the Impact, Population, Affluence, Technology (IPAT) formula, as developed by Dietz and Rosa (1997). Where human activities through industrialization served as the essential driving force of emissions in the environment, they divided human activities into four anthropogenic forces that are: population (P), economics activities or affluence (A), and technology (T), describing technical standard of production symbolically given as:

$$I = P * A * T \qquad (3.1)$$

Where;
I represents Environmental Impact, P represents Population changes,
A is affluence and T denotes Technological changes. The STIRPAT model specification is:

$$I_t = \alpha P_t^{\beta}, A_t^{\gamma}, T_t^{\delta}, \varepsilon \qquad (3.2)$$

α represents the constant term; β, γ *and* δ parameters to be estimated, and ε is the error term. A: represents affluence measured by GDP per capita, P: Population is measured by the growth in population, and T: Technology changes' proxies are *Ijarah Sukuk* calculated by the share of the *Sukuk* in total energy efficiency measured by GDP per unit of energy use. The above equation is modified to include energy poverty (P) and capital formation (C) variables. Capital formation enhances investments through industrialization, mechanization and other economic activities that have direct effect on environmental degradation. With energy poverty variable introduced, equation 3.2 becomes;

$$I_t = \alpha P_t^{\beta}, C_t^{\gamma}, A_t^{\gamma}, T_t^{\delta} P_t^{\pi} \qquad (3.3)$$

Where:
$I_t = ENVD, P = POP,\ A = RGDP, T = ISUK,\ P = EPOV \text{ and } C = CAF, \text{expressed}$ in mathematical form, equation 3.3 becomes;

$$ENVD_t = \alpha + EPOV_t^{\beta} +, CAF_t^{\delta} + RGDP_t^{\gamma} +, ISUK_t^{\delta} + POP_t^{\pi} \quad (3.4)$$

Transform 3.4 into econometric model, thus:

$$ENVD_t = \alpha + \beta_1 EPOV_t^{\cdot} +, . +, \beta_3 ISUK_t^{\cdot} + \beta_4 POP_t^{\cdot} +, \varepsilon \quad (3.5)$$

The 3.5 permits a straightforward calculation of environmental impact elasticity according to each explanatory factor. In fact, the STIRPAT model was used to analyze the effect of explanatory variables on the environment.

Model Specification

Pereira et al. (2019) adopted the STIRPAT model, as given in the equation 3.3. With $I_t = ENVD,\ P \text{ represents } POPU,\ A \text{ represents } RGDP,\ \text{and } T \text{ represents } ISUK \text{ expressed}$ in mathematical form. Considering the empirical variables, equation 3.5 was modified to include energy poverty and capital formation variables.

$$ENVD_t = \alpha + \beta_1 EPOV_t^{\cdot} +, \beta_2 CAFO_t^{\cdot} + \beta_3 RGDP_t^{\cdot} +, \beta_4 ISUK_t^{\cdot} + \beta_5 POP_t^{\cdot} +, \varepsilon \quad (3.6)$$

Where:
$ENVD_t$ represent Environmental Degradation (Dependent Variable); $EPOV_t$ represents Energy Poverty; $ISUK_t$ represents *Ijarah Sukuu*; $CAFO_t$ represents Capital Formation; $RGDP_t$ represents Economic growth; $POPU_t$ represent Population growth rate; and ε = Error Term

Thus, β_0 represents a constant, $\beta_1 - \beta_5$ are the coefficients of energy poverty, capital formation, economic growth, technological change, and population growth respectively, and ε_i the error term. Given this specification, the a priori expectation is that energy poverty and economic growth variables are expected to be negatively correlated with environmental degradation variables, while capital formation, population growth, and technological changes are expected to be positively related to environmental degradation. This implies that there are trade-offs between aspiring to achieve environmental quality through reduction in energy poverty level and technological changes.

Technique of Data Analysis

1. **Unit Root Break Point Test**

Detecting the point of integration on each variable is the first conventional process in time series analysis literature. This is because non-stationary series can lead to spurious regression (Danmaraya et al., 2018). For this reason, all the data series on variables in the study i.e., environmental degradation, energy poverty, capital formation, economic growth, technological changes, and population growth rate are subjected to the non-stationary test.

2. **ARDL Bound Test**

Following Pesaran et al. (2001), researchers employ the ARDL bound test in the co-integration approach, considering the numerous advantages associated with the model compared to other methods. ARDL helps to estimate the Error Correction Model (ECM) and determine the equilibrium of long- and short-run dynamics. The issue of endogeneity is addressed by selecting appropriate lag lengths before applying the ARDL model using the Akaike Information Criterion (AIC). Also, Unrestricted Error Correction applied to the ARDL regression, such that each variable is estimated independently in a different equation, so as to capture the coefficient using Ordinary Least Squares (OLS) as used in Ahmed et al. (2019).

ARDL is the only model that can accommodate series with different orders of integration, such as I(0), I(1), or combinations of the two, but it does not allow a series with an integration order of I(2). It also has an advantage over Engle and Granger (1987) due to its unbiased outcome in small sample sizes. The ARDL method can be used to obtain an ECM (Error Correction Model) and to establish the equilibrium between long- and short-run dynamics.

Thus:

$$\Delta \text{ENVD}_t = \alpha_0 + \beta_1 ENVD_{t-1} + \beta_2 EPOV_{t-1} + \beta_3 CAFO_{t-1} + \beta_4 RGDP_{t-1} + \beta_5 POPU_{t-1} + \beta_6 \text{ISUK}_{t-1} \sum_{i=1}^{p} \alpha_1 \, \Delta ENVD_{t-1} + \sum_{i=1}^{p} \alpha_2 \, \Delta EPOV_{t-1} + \sum_{i=1}^{p} \alpha_3 \, \Delta CAFO_{t-1} + \sum_{i=1}^{p} \alpha_4 \, \Delta RGDP_{t-1} + \sum_{i=1}^{p} \alpha_5 \, POPU_{t-1} + \sum_{i=1}^{p} \alpha_6 \, \text{ISUK}_{t-1} + du_i T_i + \varepsilon_t \quad (3.7)$$

With reference to equation, Δ is changes in the operator, t is time bias, ε is the error term, β_1- β_6 are the coefficients of the variables ENVD, EPOV, ISUK CAFO, RGDP, and POPU respectively, $du_i T_i$ is the structural breaks and α_1-α_6 are the dynamic error corrections of the variables. To determine the co-integration, the Null Hypothesis $H_0 = \alpha_1 = \alpha_2 = \alpha_3 = \alpha_4 = \alpha_5 = \alpha_6 = 0$ is tested, which shows the absence of co-integration, while alternatively $H_0 \neq \alpha_1 \neq \alpha_2 \neq \alpha_3 \neq \alpha_4 \neq \alpha_5 \neq \alpha_6 \neq 0$ shows the existence of co-integration among the variables.

3. Short Run Specification

$$\Delta ENVD_t = \alpha_0 + \sum_{i=1}^{p1} \alpha_1 \, \Delta ENVD_{t-1} + \sum_{j=0}^{p2} \alpha_2 \, \Delta EPOV_{t-1} + \sum_{j=0}^{p3} \alpha_3 \, \Delta CAFO_{t-1} + \sum_{l=1}^{p4} \alpha_4 \, \Delta RGDP_{t-1} + \sum_{i=1}^{p5} \alpha_5 \, \Delta POPU_{t-1} + \sum_{i=1}^{p6} \alpha_6 \, \text{ISUK}_{t-1} + \delta ECM_{t-1} + \varepsilon_{1t} \quad (3.8)$$

4. Error Correction Model (ECM)

However, the results of the ARDL bounds test are considered to test for the ECM (short and long-run coefficients) with the presence of co-integration in the series. By establishing the short- and long-run positions, the direction of the causal relationship among the variables identified through the error correction model (ECM) (Engle and Granger, 1987) and its policy implications are easily inferred. VECM can be easily run through simple regression, which enables the error correction model (ECM) established using residuals. The statistical significance and negative coefficient of the defined ECM indicate the relationship among the variables under study, while for the short run relationship among the variables; the Wald test statistic can be applied. Where δ signifies the coefficient of the error correction model, and ECM_{t-1} reflects the error correction model, which must be identified in negative form and signifies the long-run relationship and also shows the mechanism for correction which redirects the variables at equilibrium in the long term. The model of the long-run specification:

$$ENVD_t = \alpha_0 + \sum_{i=1}^{p1} \alpha_1 ENVD_{t-1} + \sum_{j=0}^{p2} \alpha_2 EPOV_{t-1} + \sum_{j=0}^{p3} \alpha_3 CAFO_{t-1} + \sum_{l=1}^{p4} \alpha_4 RGDP_{t-1} + \sum_{i=1}^{p5} \alpha_5 POPU_{t-1} + \sum_{i=1}^{p6} \alpha_6 \text{ISUK}_{t-1} + \mu_{1t} \quad (3.9)$$

5. **Post Estimation Test**

Diagnostic tests conducted to determine the health of the model estimated were based on the Breusch-Godfrey test, multicollinearity, White test, Jarque-Bera test, and test of misspecification using the Ramsey RESET test, along with the cumulative sum of recursive residuals (CUSUM) developed by Brown et al. (1975), used in order to test the stability of the estimated model.

RESULT AND ANALYSIS

Descriptive Statistics of the Variables

The descriptive statistics results report the statistical distribution of the mean, median, maximum and minimum value, standard deviation, skewness, kurtosis, and Jarque-Bera test on all the variables used in the study.

Table 1. Descriptive Statistics of the Variables

	ENVD	POPU	EPOV	CAFO	RGDP	ISUK
Mean	5.412	2.577	42.02	2.230	0.418	29.65
Median	4.673	2.579	40.10	2.097	1.068	28.70
Maximum	8.123	2.710	59.90	3.119	12.46	39.25
Minimum	4.185	2.419	20.90	1.896	-15.45	18.17
Std. Dev.	1.306	0.070	9.274	1.082	5.244	5.270
Skewness	0.762	-0.020	-0.327	-0.451	-0.829	-0.130
Kurtosis	2.104	2.101	2.424	2.679	4.691	2.173
Jarque-Bera	5.336	1.384	1.296	2.543	9.573	1.284
Probability	0.069	0.500	0.523	0.098	0.008	0.526
Sum	221.9	105.7	1723	789.0	17.12	1215
Sum Sq Dev.	68.24	0.195	3440	21.12	1100	1110
Observations	43	43	43	43	43	43

Source: Researcher's Computation, 2024.

Table 1 reported the descriptive statistics of the variables used in the model. It can be seen that none of the variables deviated from symmetry, as their results for skewness were within the range of zero. The kurtosis values of ENVD, POPU, EPOV, CAFO and ISUK indicate that the distributions are platykurtic (less than 3), while that of RGDP is leptokurtic (more than 3). The results of the Jarque-Bera statistics indicate that all the series, with exception of RGDP, are found to be normally distributed with a mean of zero and constant variance at 5% level.

Correlation Matrix

The correlation matrix results report the link between and among the dependent variables (ENVD) and the set of independent or explanatory variables (POPU, EPOV, CAPO, RGDP and ISUK)

Table 2. Correlation Matrix

Correlation t-Statistic Probability	ENVD	POPU	EPOV	CAFO	RGDP	ISUK
ENVD	1.000					
POPU	0.459 3.225 (0.003)***	1.000				
EPOV	-0.155 -0.978 (0.334)	-0.593 -4.602 (0.000)***	1.000			
CAFO	0.782 0.457 (0.001)**	0.980 0.210 (0.000)***	-0.681 -0.123 (0.023)*	1.000		
RGDP	0.121 0.761 (0.451)	0.024 0.153 (0.877)	0.327 2.160 (0.037)**	0.870 0.562 (0.003)***	1.000	
ISUK	-0.651 -5.349 (0.000)***	-0.391 -2.655 (0.011)**	0.302 1.980 (0.055)**	0.543 0.232 (0.000)**	-0.369 -2.478 (0.018)**	1.000

Note: ***, ** and * implies significance at 1%, 5% and 10% respectively.
Source: Researcher's Computation, 2024.

Table 2 reported the correlation matrix of the variables used in the model. The coefficient indicated that only POPU and CAFO are positively and significantly related to the ENVD; RGDP is positively but insignificantly related to ENVD; EPOV is negatively and insignificantly related to ENVD while ISUK is negatively but significantly related to ENVD. EPOV and ISUK are found to be negatively but significantly related to POPU while RGDP is found to be positively but insignificantly related to POPU. RGDP and ISUK are all found to be positively and significantly related to EPOV. Lastly, ISUK is found to be negatively but significantly related to RGDP.

Unit Root Test Results

The result of the unit root test in Table 3 reports the order of integration of the variables based on the Augmented Dickey-Fuller (ADF) and Phillip-Perron (PP) frameworks. It also ensures that none of the variable is I(2) which is necessary for the applicability of the ARDL.

Table 3. Unit Root Test Results

	LEVEL					
	Augmented Dickey-Fuller (ADF)			**Phillip Perron (PP)**		
	Constant	**Constant &Trend**	**None**	**Constant**	**Constant &Trend**	None
ENVD	1.229	-1.470	2.757	1.287	-1.334	2.614
POPU	-1.620	-1.374	-0.953	-2.398	-2.646	-0.800
EPOV	-2.041	-2.031	0.805	-2.118	-2.100	0.762
CAFO	-2.923	-2.818	-2.567	-2.671	-2.320	-2.012
RGDP	-3.165**	-2.759	-3.000***	-4.305***	-4.129**	-4.222***
ISUK	-1.664	-1.664	-0.640	-2.363	-2.520	-0.974

FIRST DIFFERENCE						
ENVD	-6.047***	-7.057***	-0.750*	-6.068***	-7.411***	-5.403***
POPU	-4.248***	-3.221*	-4.335***	-5.394***	-5.228***	-5.486***
EPOV	-5.725***	-5.606***	-5.621***	-5.730***	-5.613***	-5.630***
CAFO	-3.012	-3.120*	2.980**	-3.232*	-3.679***	-3.014***
RGDP	-10.369***	-10.575***	-10.437***	-10.731***	-12.020***	-10.754***
ISUK	-6.128***	-6.193***	-6.197***	-7.527***	-8.591***	-7.213***

Note: ***, ** and * implies significance at 1%, 5% and 10% respectively.
Source: Researcher's Computation, 2024.

Table 3 presents the unit root test results for each of the variables used in this study. The ADF results indicate that all variables are non-stationary at the level, with the exception of RGDP, which was found to be stationary with both constant and no constant and trend. Additionally, all variables were found to be stationary at the first difference. The PP results indicate that all variables were found to be non-stationary at the level, with the exception of RGDP, which was found to be stationary at the level with a constant, constant and trend, and with no constant and trend. Additionally, all variables were found to be stationary at their first difference. Therefore, while RGDP is an I(0) process, all other variables are I(1) processes. The assumption of the ARDL bounds testing is that the regressors should be integrated at I(0) or I(1), or both.

Table 4. Unit Root Test with Breaks Results

Variable	Model	ADF Test	Kmax	K* max	Breakpoint	P Value	Remark
ENVD	AO	First Diff.	9	2	2002	0.010	I(1)
POPU	IO	Level	9	9	2000	0.014	I(0)
EPOV	AO	Level	9	0	1995	0.012	I(0)
CAFO	IO	First Diff.	9	2	1999	0.000	I(1)
RGDP	IO	First Diff.	9	0	2003	0.010	I(1)
ISUK	AO	Level	9	1	2001	0.020	I(0)

Source: Researcher's Computation, 2024.

Table 4 presents the unit root test results with structural breaks for each variable using the modified Augmented Dickey-Fuller (ADF) test. The results of unit-root test revealed that ENVD, CAFO, and RGDP are stationary of order one under the Innovational Outlier Model 3 and Additive Outlier Model 3, respectively. The truncation lag lengths of k*= 2 and 0 were selected using the F-sig approach. The p-value for the RGDP unit-root test is different from that of the ENVD unit-root test. This indicates that the Additive Outlier Model has relative equal power with the Innovation Outlier Model 1 on these series. The remaining series, i.e., POPU, EPOV, and ISUK, are stationary at a level under, Innovational Outlier Models 1, Additive Outlier Model 2, and both. The k*= 9 for population, 0 for poverty level and k* = 1 for technology and were chosen using the t-sig recursive technique. The breakpoint dates correspond to significant periods of global economic and Nigerian government policy change shocks. Which were selected to maximize the t-statistics. In the first place, early 2000s of Olusegun Obasanjo's administration witnessed a 70% increase in poverty among 130 million Nigerians and its effect is observed in the same years with a high dependency ratio across the country. In 1992, Nigeria's Real GDP increased by exactly 2 percent, resulting in a corresponding decline in real per capita consumption nationwide in 1995 and a corresponding rise in the country's poverty rate. In 2003, Nigeria experienced a significant decline in GDP per capita, dropping from $780 in 2002 to $731 in 2003, a decrease of $49. This marked a notable shift in the country's growth trend. The role of science and technology, and its translation into innovation as an engine of development, began to feature prominently in the economic reform agenda during the period between 1999 and the early 2000s, resulting in significant improvements in industrial activities and subsequent ecological concerns in 2001.

Co-integration Test

The co-integration bounds testing reports the co-integration result, indicating whether a long-run relationship exists among ENVD, EPOV, CAFO, RGDP, ISUK, and POPU.

Table 5. Result for ARDL Bounds Test for Co-integration

Test Statistic	Value	K
F-Statistic	**4.972258**	**5**
Critical Value Bounds		
Significance	I(0)	I(1)
10%	2.2	3.09
5%	2.56	3.49
1%	3.29	4.37

Source: Researcher's Computation, 2024.

Table 5 reports the co-integration result based on the Bounds test. The result indicates that the computed F-Statistics (4.972) are greater than the upper critical bounds by Pesaran, Shin and Smith (2001) at 1%, 2.5%, 5% and 10%, which are suitable for a relatively small data set. This ARDL Bound testing result validated the existence of long-run relationship between ENVD, EPOV, CAFO, RGDP, ISUK and POPU, and this has equally informed the justification for estimation of the long-run relationship.

ARDL Estimation Results

ARDL result reports the estimated coefficient of the long-run and short-run ARDL relationship, along with their effects on the variables used in the study.

Table 6. Long Run and Short Run ARDL Estimates (ARDL 1, 1, 2, 1, 1, 4)

		Long Run Coefficient Estimates (B)		
		Co-integrating Form		
EPOV	-0.239	0.061	-0.633	0.053
ISUK	-0.381	0.086	-4.424	0.000
RGDP	0.411	0.134	0.894	0.031
C	28.778	18.065	1.593	0.001
		Short Run Coefficients (A)		
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
D(EPOV)	0.124	0.005	1.179	0.021
D(EPOV (-1))	0.241	0.005	2.822	0.001
D(RGDP)	0.320	0.005	5.609	0.000
D(ISUK)	-0.187	-0.009	-2.928	0.008
CointEq(-1)	-0.307	0.017	-7.128	0.000

R-Squared = 0.9 Adjusted R-Squared = 0.98 Durbin-Watson Stat. = 1.9 F-Statistic = 362.5175 Prob. (F-Statistic) = 0.000000

Source: Researcher's Computation, 2024.

Table 6 presents the results of the short and long-run coefficients of the optimal ARDL (1, 1, 2, 1, 1, 4). It comprises of two panels (A & B). Panel A reported the long-run coefficients, while panel B reported the short-run coefficients. The results from panel A show that the energy poverty (EPOV) has a significant impact on explaining environmental degradation (ENVD). A 1% increase in EPOV results in approximately a 23.9% decrease in ENVD, all other factors being equal. *Ijarah Sukuk* (ISUK) has a significant effect in predicting environmental degradation. A 1% increase in ISUK decreases environmental degradation (ENVD) by a 38%. Additionally, economic growth (RGDP) has significant impact in explaining environmental degradation (ENVD). A 1% increase in RGDP leads to approximately 41.1% increase in ENVD, assuming all other factors remain equal. This result suggests that population growth, energy poverty, capital formation, economic growth, and technological changes have a significantly greater impact on environmental degradation in Nigeria than the energy poverty.

Table 6 further reports the estimates of short-run relationship among the variables. The current value of energy poverty (EPOV) is positively and significantly related to environmental degradation (ENVD) and rightly signed. A 1%-point increase in current value of EPOV probably through over population, will increase ENVD by 12.4%. One year lag value of energy poverty (EPOV(-1)) is positively and significantly related to environmental degradation (ENVD) and rightly signed. A 1%-point increase in current value of EPOV probably through over population, will increase environmental degradation (ENVD) by 24.1%. This implies that, an increase in EPOV will result into too much pressure on the environment. This result supports the conclusion of Afaha and Ifarajimi (2021). *Ijarah Sukuk* (ISUK) has a significant effect on environmental degradation. A 1% increase in ISUK results in an approximately 19% reduction in ENVD.

Additionally, economic growth (RGDP) is positively and significantly related to environmental degradation (ENVD). A 1%-point increase in the RGDP variable, likely due to opennes and poor environmental regulatory policies, willresult in a 32% increase in ENVD. This Implies that as the economy develops, likely through industrialization, infrastructure development, mining or the excavation of mineral resources, as in the case of the Niger Delta region of Nigeria, the environment is negatively affected, resulting in an increase in an environmental degradation in the country. However, the short-run error correction model ECM (-1) is the adjustment mechanism that stabilizes the equilibrium in the model. It is correctly signed with a weak coefficient value of -0.3071, and it is also statistically significant and negative at 1% level. This implies a fairly low speed of adjustment, indicating that anomalies will take a moderately low speed, at 31%, to converge to long-run equilibrium from the short run. The joint explanatory power of all independent variables is remarkable, with an R-square of 99% and an adjusted R-square of 98%, and is statistically significant at 1% level. This implies that 98% of the variation in the dependent variable (ENVD) is explained by changes in the independent variables (energy poverty, economic growth, population growth, and technological changes), with only 2% of the variation that could not be explained by the model. This also implies that the model will not be affected by a misspecification test. These results differed from those of Azeakpono and Lloyd (2020).

Diagnostic Tests

In this study, post estimations conducted were summarized and presented in Table 7.

Table 7. Diagnostic Tests

Test Statistics	F-statistics	Probability
Autocorrelation	1.276	0.288
Normality	1.847	0.397
Heteroscedasticity	12.296	0.200
Specification Error	5.339	0.022

Source: Researcher's Computation, 2024.

The diagnostic test results, as shown in Table 4.6, indicated that the model passed the Autocorrelation, Normality, and Heteroscedasticity tests, and their respective Null hypotheses could not be rejected, with insignificance probability values of 0.288, 0.397, and 0.200.

DISCUSSION

Energy poverty has a significant impact on explaining environmental degradation. This implies that an increase in energy insecurity will result in too much pressure on the environment, leading to environmental degradation. The Environmental Justice Theory (EJT) is in opposition to the findings of this study. Additionally, economic growth is positively and significantly related to environmental degradation. This implies that as economy develops, often through industrialization, infrastructural development, mining or excavation of mineral resources, as in the case of the Niger Delta region of Nigeria, the environment is negatively impacted, resulting in an increase in environmental degradation within the country. This result supports the Green Growth Theory, which proposes that economic growth can be achieved by reducing environmental degradation. However, contrary to McDonough (2020), environmental sustainability can also be attained through design and business innovations.

This study provides evidence of the complex interconnections between energy poverty, economic growth, *Ijarah Sukuk* financing, and environmental degradation in Nigeria. The results confirm that energy poverty remains one of the most significant obstacles to sustainable development. Limited access to affordable and modern energy services not only restricts industrial productivity and business competitiveness but also undermines human capital development, leading to poor health, limited education, and reduced social welfare. The findings further indicate that economic growth in Nigeria exhibits a paradoxical nature. On the one hand, growth contributes positively to infrastructure expansion, job creation, and improved welfare outcomes. On the other hand, such growth, largely driven by fossil fuel extraction and consumption, has accelerated environmental degradation. The evidence suggests that without a transition to cleaner energy sources, Nigeria's growth trajectory may exacerbate pollution levels, deforestation, and carbon emissions. This dynamic is consistent with the Environmental Kuznets Curve (EKC) hypothesis, which suggests that environmental quality tends to deteriorate in the early stages of growth before improving to a sustainable level (Jama & Abdi, 2025).

Against this background, *Ijarah Sukuk* emerges as a crucial Islamic financial instrument with potential to address these intertwined challenges. By mobilizing Shariah-compliant investment for renewable energy projects, green infrastructure, and environmentally sustainable development initiative (Sarkodie & Adams, 2020). *Ijarah Sukuk* can fill Nigeria's financing gap in tackling energy poverty while simultaneously reducing environmental stress. Unlike conventional debt financing, Sukuk offers risk-sharing mechanisms that align with ethical investment principles, making it particularly suitable for funding projects that support long-term sustainability. The interplay among these variables highlights an important policy lesson: focusing solely on short-term economic growth while neglecting energy accessibility and environmental protection may create deeper structural problems. To break this cycle, Nigeria must adopt an integrated development strategy that balances economic expansion with sustainable energy investment and environmental preservation. In this respect, Ijarah Sukuk represents a strategic financial innovation that can support Nigeria in achieving inclusive growth while advancing its commitments to the Sustainable Development Goals (Jawaid & Waheed, 2017).

In summary, the nexus between energy poverty, economic growth, *Ijarah Sukuk*, and environmental degradation underscores the need for a multidimensional policy approach. Addressing energy poverty through renewable energy development financed by *Sukuk* instruments can drive inclusive economic growth while mitigating environmental challenges (Siswantoro, 2022). Such a framework not only strengthens Nigeria's resilience but also contributes to the global transition toward sustainable and green economies.

Energy Poverty and Economic Growth

Energy poverty is identified as a significant barrier to Nigeria's development agenda. Access to reliable and affordable energy is a prerequisite for industrialization, agricultural modernization, and improved service delivery. In Nigeria, however, the persistence of energy poverty, as evidenced by limited grid access, a heavy reliance on biomass, and frequent power outages, reduces productivity across all sectors of the economy. Small and medium enterprises (SMEs), which form the backbone of employment generation, are particularly constrained by high energy costs and unreliable electricity (Chingiz et al., 2025). The findings confirm the theoretical proposition that energy is both a driver and outcome of economic growth. Countries with inadequate energy access often experience "low growth traps," where insufficient energy supply restricts growth opportunities, and in turn, slow economic performance prevents large-scale energy infrastructure investments. Nigeria's situation exemplifies this vicious cycle, highlighting the urgency of breaking it through innovative financing and policy reforms (Najia et al., 2025).

Economic Growth and Environmental Degradation

The analysis also reveals the dualistic impact of economic growth on the environment. On the one hand, growth has generated improvements in infrastructure, healthcare, and employment. On the other hand, Nigeria's growth model is predominantly fossil-fuel-based, which intensifies carbon emissions, land degradation, and deforestation. Such outcomes align with the Environmental Kuznets Curve (EKC) framework, which suggests that environmental conditions deteriorate at early stages of growth but may improve when economies transition to cleaner technologies and stronger environmental regulation. However, Nigeria's case suggests that the EKC turning point may not materialize without deliberate policy interventions. Continued reliance on oil exports and inefficient energy consumption patterns may lock the country into a "pollution-intensive growth path." This highlights the importance of integrating environmental considerations into economic planning rather than assuming that growth alone will eventually lead to sustainability (Venghaus et al., 2019).

Role of *Ijarah Sukuk*

In this nexus, *Ijarah Sukuk* emerges as a promising instrument for financing sustainable development. As an asset-backed, Shariah-compliant financial instrument, *Ijarah Sukuk* can mobilize domestic and international capital for infrastructure projects that directly address energy poverty. By channeling funds into renewable energy generation, solar electrification of rural areas, and environmentally friendly infrastructure, Sukuk can simultaneously promote inclusive growth and environmental sustainability (Syamsuri et al., 2021). Unlike conventional debt, *Sukuk* is based on risk-sharing and asset utilization, which ensures that funds are tied to real economic activities. This structure reduces the likelihood of speculative bubbles and increases accountability in project implementation. Moreover, *Sukuk* financing aligns with ethical and socially responsible investment principles, making it an attractive option for investors seeking impact-driven opportunities. For Nigeria, a country with a significant Muslim population and growing interest in Islamic finance, *Sukuk* provides both a cultural fit and a strategic financial innovation (Kronenberg & Fuchs, 2021).

Policy Integration and the Nexus Approach

The interaction among these variables highlights the danger of treating them in isolation. Policies that prioritize economic growth over addressing energy poverty may exacerbate inequality, as only wealthier households and firms can afford alternative energy sources. Similarly, pursuing growth without addressing environmental concerns may undermine long-term development by depleting natural resources and increasing vulnerability to climate change (Najia et al., 2025). Thus, Nigeria requires an integrated policy framework that simultaneously addresses energy access, expanding renewable and decentralized energy systems to reduce dependence on fossil fuels. Green growth encourages structural transformation toward industries and services that are less resource-intensive. Innovative finance leveraging *Ijarah Sukuk* to bridge funding gaps for sustainable infrastructure and energy transition. Environmental safeguards strengthen regulatory frameworks to ensure that growth does not compromise ecological balance (Yuan et al., 2020).

Implications for Sustainable Development

The nexus between energy poverty, growth, *Sukuk*, and the environment has direct implications for Nigeria's ability to achieve the Sustainable Development Goals (SDGs), particularly Goal 7 (Affordable and Clean Energy), Goal 8 (Decent Work and Economic Growth), Goal 12 (Responsible Consumption and Production), and Goal 13 (Climate Action). By strategically deploying *Ijarah Sukuk* to fund renewable energy projects, Nigeria can create a win-win scenario: reducing poverty and inequality while transitioning to a greener economy.

CONCLUSION

The study investigated the link between Energy poverty, economic growth, and environmental degradation in Nigeria, covering the period between 1981 to 2023. The STIRPAT model was applied by incorporating the energy poverty, capital formation, economic growth, population growth, technological changes, and environmental degradation. ADF and PP tests were applied to test the stationarity property of the series. The ARDL bounds testing approach is applied to examine the long-run relationship among the variables, and Pairwise Granger Causality was used to establish a causal long-run relationship between energy poverty, economic growth, and environmental degradation. In the short run, the current value of energy poverty is positively and significantly related to environmental degradation. One-year lag value of energy poverty is positively and significantly related to environmental degradation. Economic growth, on the other hand, is positively and significantly related to environmental degradation. However, the short-run error correction model ECM (-1) implies a fairly low speed of adjustment, indicating that anomalies will take a moderately low speed to converge to long-run equilibrium from the short run.

The long-run results revealed that energy poverty and *Ijarah Sukuk* have a significant impact in explaining environmental degradation. Also, economic growth has a significant impact in explaining environmental degradation. Therefore, this result suggests that energy poverty, *Ijarah Sukuk* and economic growth have a significant impact on environmental degradation and economic growth have greater significant impact on environmental degradation for Nigeria, justifying the STIRPAT model in which human activities through industrialization served as the essential driving force of emissions in the environment for Nigeria. Therefore, policymakers should prioritize on environmentally friendly economic growth policies that integrate Islamic innovations to enhance sustainable environment through imposing an appropriate Pay as You Pollute tax system to reduce human effects on the natural environmental. Finally, this study is limited by its restrictive use of ecological footprints as an environmental measure. Hence, future research should carry out aggregate study.

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