Renewable Energy Consumption and the Quality of Life in Nigeria: An ARDL Bound Test Approach

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ABSTRACT

This article was aimed at investigating the impact of renewable energy consumption as a source of clean energy on quality of life in Nigeria. The theoretical framework of the study was the Grossman's theory of healthcare demand. The study used the Autoregressive Distributive Lag (ARDL) bounds testing approach. Time series data were sourced from the International Energy Agency (IEA), the Human Development Report of the World Bank and the Central Bank of Nigeria (CBN) for a period of 1990 to 2023. Haven analyzed the data, the study found renewable energy consumption (REC) to be crucial driver of quality of life and also trade openness was found to have mixed effects quality of life which reflected the dual nature of globalization. The study therefore recommends among others that there should be prioritization of renewable energy infrastructure development in Nigeria by all Stakeholders, also there should be a shift from mere enrolment in education to long- term education outcomes by improving teachers' training, upgrading school infrastructure and integrating STEM and vocational training into curricula, and finally stabilize inflation through proactive monetary policies.

Keyword: Quality Of Life, Renewable Energy, Trade openness, Inflation, ECM, ARDL

INTRODUCTION

Energy can be seen as a major life sustainability determinant. It is fundamental in discussing the optimal growth and performance of any economy. The optimal performance of any sector of an economy is hinged on the volume of energy consumed. Energy consumption is crucial to the growth and sustainable development of an economy. There is hardly any productive economic activity that is not either directly or indirectly related to energy consumption (Ishioro, 2015, 2018 and 2019). The importance of energy in economic and human development has gained attention in recent years (Human Development Report, 2007/2008). According to Human Development Report (2007/2008), modern energy is fundamental in driving economic growth, fulfilling social needs and human development.

Energy sources can be disaggregated into renewable and non-renewable. Nonrenewable energy is energy resources that its supply is limited and cannot be replenished once depleted. Nonrenewable energy sources include: coal, natural gas, oil etc. While renewable energy is that energy source which cannot be used up during the period of their consumption. They include: wind, solar, hydropower, geothermal, biomass etc.

Renewable energy including hydropower, biomass, solar, wind, and geothermal accounts for approximately 17% Nigeria's electricity generation and 25% of global electricity generation (EIA, 2019). Hydroelectric power does not involve combustion and is considered safe from a public health perspective, although dams can have major environmental impacts, including obstructing fish migrations, changing water temperature and flow, and flooding natural areas or agricultural lands (IEA, 2019). This energy source can be used to provide energy in some important areas such as water heating/cooling, electricity generation, air and transportation, and rural (off-grid) energy service.

Energy consumption is a fundamental ingredient in accessing the quality of life of the citizenry in an economy. Quality of life, which has gained prominence in social research study since 1970s, is a broad concept

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concerned with overall well-being within the society. Quality of life is synonymous to the standard of living which is measured by human development index in this study.

The Human Development Index (HDI) measures the average achievements in key dimensions of human development, such as health, education, and income. Nigeria's HDI has demonstrated gradual improvement, increasing from 0.465 in 1990 to 0.535 by 2023. Government expends money in infrastructures especially in energy provisions in order to improve the quality of life of her citizens. In Nigeria, the federal government's expenditures are broadly divided into capital and recurrent expenditure (Ashakah, 2023). Although this progress is promising, Nigeria remains classified within the low human development category, underscoring the need for continued investment in education, healthcare, and income equality (United Nations Development Programme [UNDP], 2022).

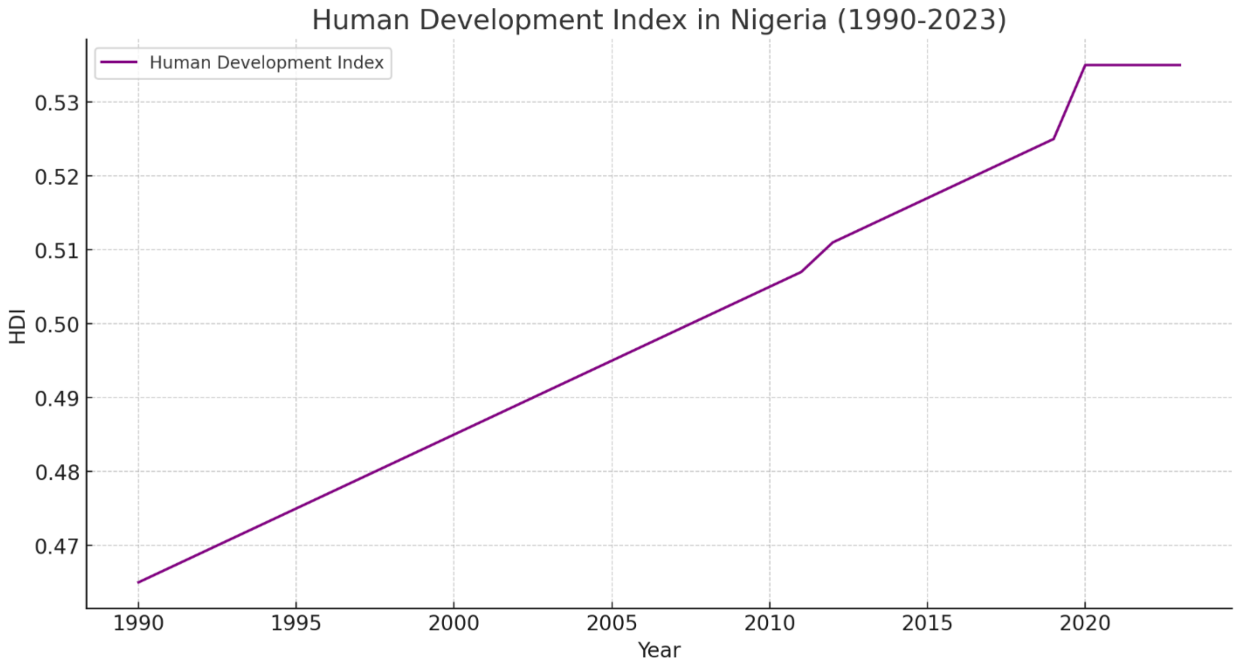

Figure 1.1 Human Development Index in Nigeria (1990 – 2023)

Despite the increase in real GDP, Nigeria's HDI growth has been slow, indicating that economic gains are not equitably translating into improved living standards for its population. This disparity underscores the challenges of addressing both economic and social needs simultaneously, a priority in Nigeria's Vision 2030 Agenda for Sustainable Development (World Bank, 2023).

To this end, the objective of this study is to explore the relationship between renewable energy consumption and the quality of life in Nigeria.

LITERATURE REVIEW

Theoretical Review

Energy Efficiency Theory

Energy efficiency theory, proposed by Cooper and Ross (1985), emphasizes optimizing energy consumption to maximize output while minimizing waste. It highlights the importance of technological innovations, energy-efficient behaviors, and supportive policies to achieve energy efficiency. This theory underscores the role of human behavior and awareness in energy consumption patterns and the need for system-level approaches to optimize energy use across sectors. The idea of energy efficiency holds significance for this research as it offers valuable insights into how renewable energy sources might improve economic development and quality of life by optimizing resource utilization, cutting down on waste, and minimizing expenses. Through the use of cleaner, more dependable energy sources, this optimization promotes more sustainable economic growth and raises living standards. In the end, energy efficiency helps renewable energy become more widely used by making its integration more advantageous for the environment and economically feasible.

Ecological Modernization Theory

Ecological modernization theory, developed by Joseph Hubber and Martion Janicke in the 1980s, posits that economic development and environmental sustainability can coexist through technological innovation and institutional changes. By adopting cleaner and more efficient technologies, societies can reduce their environmental impact and resource consumption, leading to a more sustainable future. The ecological modernization idea highlights how institutional reform and technology advancement can promote both environmental preservation and economic growth. This theory highlights how cutting-edge, environmentally friendly technology and regulations can result in sustainable growth, which is pertinent to the role of renewable energy in improving quality of life and economic development. Societies can advance economically while lessening their negative effects on the environment, hence raising standard of living.

Grossman's Theory of Demand for Healthcare

Grossman's model, introduced in 1972, explores the demand for health and medical care, emphasizing the role of environmental factors in influencing health outcomes. This theory recognizes that environmental quality, including air and water quality, significantly impacts human well-being. This theory is relevant to this study because it connects improved environmental conditions to improved health outcomes. Grossman's Theory of Demand for Healthcare is important to the role of renewable energy in promoting quality of life and economic development. Pollution is decreased by cleaner energy sources, which lowers healthcare costs and boosts productivity. A better quality of life and economic growth are directly impacted by the improvement in public health.

Empirical Review

Wang et al. (2023) examined whether renewable energy improves life expectancy in 121 countries worldwide. They revealed that renewable energy positively affects life expectancy; however, the impact of renewable energy on life expectancy varies across different income levels. Using cross-sectional ARDL, Polcyn et al. (2023) examined whether energy consumption improved life expectancy from 1997 to 2019 in 46 Asian countries. They found that an increase in healthcare spending and energy use results in improved health outcomes in the long run and that CO_2 emissions are detrimental to health. They concluded that increasing health spending, energy consumption, and long-term economic growth will improve health outcomes.

Using the Driscoll-Kraay standard error technique, Ebhota et al. (2023) investigated the impact of renewable energy consumption, air pollution, and economic development on life expectancy in Mexico, Indonesia, Nigeria, and Turkey; they found a positive and significant relationship between renewable energy consumption and life expectancy with a one-way causation – from renewable energy consumption to life expectancy

Pirlogea (2012), using panel data, investigated the relationship between renewable energy and human development in 28 OECD countries, using data from 1990 to 2008. Using regression analysis, the study found a positive relationship between high levels of renewable energy and human development.

Sasmaz et al. (2020) investigated the relationship between renewable energy and human development in 28 Organizations for Economic Cooperation and Development (OECD). Using data from 1990 to 2017 and employing the Westerlund and Edgerton panel cointegration test, and Dumitrescu and Hurlin causality test, renewable energy was found to affect human development positively. In the same study, bidirectional causality was found between renewable energy and human development.

Yunashev et al., (2020) investigated the impact of quality and volume of renewable energy consumption on human development, using sample countries for the period of 1985 to 2018. Using three-stage least squares, and HDI as a proxy for human development, energy consumption and renewable energy as proxies for energy consumption, the study found the share of clean energy consumption to have a positive impact on human development.

Ray et al. (2016) investigated the impact of energy on the Human Development Index using bio-mass energy for the period of 1990-2014. Correlation analysis was used. Using long-term field studies, in rural areas of different geographical locations, the study found output and emission intensity to have direct input on HDI through health, education and income generation. A switch from raw bio-mass energy sources to solar energy was found to provide positive development to the villagers.

Table: 2.1. Methodological review of renewable energy consumption and quality of life

Author/Year	Variables	Model
Jabbin & Adebisi, (2023)	Renewable energy consumption was proxied by Alternative and Nuclear Energy (ANE), Per Capita Electricity Consumption (CPN) and Fossil Fuel Energy Consumption (FEN), while Life expectancy is proxied by life expectancy at birth. Trade openness was used as control variable.	$LEX= \beta_0+ \beta_1 ANE +\beta_2 EPN + \beta_3 FEN+\beta_4 PCI+\beta_5 TOP+ \mu$
Balogun, A. Q. & Oloja-Ojabo, E. D. (2023)	Poverty proxied by human development index (HDI), public capital expenditure (PCE), renewable energy consumption (REC), gross domestic product (GDP) and quality of governance (QG), respectively.	$Pov_t = F (REC_t, PCE_t, GDP_t, QG_t)$……….(1) $Pov_t = \alpha_0 + \alpha_1 REC_t + \alpha_2 PCE_t + \alpha_3 GDP_t + \alpha_4 QG_t + \varepsilon$…………..(2) $Pov_t = \alpha_0 + \alpha_1 lnPCE_t + \alpha_2 lnREC_t + \alpha_3 lnGDP_t + \alpha_4 lnQG_t + \varepsilon$…….(3)
Ekone F. A & Amaghionyeodiwe L.(2020).	Real gross domestic product (RGDP) and Renewable energy consumption (REC).	$lnRGDP_t = \beta_0 + \beta_{1ln} REC_t + \varepsilon_t$…(1)
Ekpobodo R. O. , Yuri C., Oleg Y. K. , Dmitrii N. E. , Sinivie P. O. , Bashir A. Y.(2019).	Gross domestic product (GDP), Solar energy (SE), wind(WE), hydro(HE), biogas(BIOE), Gross fixed capital formation(GFCF) and labour force(LAF)	$RGDP_t = \alpha_0 + \alpha_1 Gfcf_t + \alpha_2 Laf_t + \alpha_3 SE_t + \alpha_4 WE_t + \alpha_5 HE_t + \alpha_6 BIOGE_t + \mu_t$
Majeed Muhammad Tariq, Tania Luni, & Gulreen Zaka (2021).	Life expectancy at birth (LE), infant mortality rate(MR), and incidence of tuberculosis(TR) are used as proxies for human health. Renewable energy consumption (RE), Gross domestic product per capita(GDP), trade, female education (FS)and urbanization (UR).	$LE_{it} = \alpha_0 + \alpha_1\ lRE_{it} + \alpha_2\ lGDP_{it} + \alpha_3\ lTR_{it} + \alpha_4 UR_{it} + Z_i + u_t + v_i + \varepsilon_i$…….(1) $MR_{it} = \alpha_0 + \alpha_1\ lRE_{it} + \alpha_2\ lGDP_{it} +\alpha_3\ lTR_{it} + \alpha_4 UR_{it} +\alpha_5 FS_{it} +Z_i + u_t +v_i + \varepsilon_{it}$…….(2) $lTC_{it} = \alpha_0 + \alpha_1\ lRE_{it} + \alpha_2\ lGDP_{it} +\alpha_3\ lTR_{it} + \alpha_4 UR_{it} +Z_i + u_t +v_i + \varepsilon_{it}$……(3)
Samour, A.; Baskaya, M.M.; Tursoy, T. (2022).	Renewable energy consumption(REC) Gross domestic product (GDP), bank credit (FD) and foreign direct investment(FDI)	$lnREC_{it}= \beta_0 + \gamma_1 lnEG_{it} + \beta_2 lnFD\ I_{it} + \beta_3\ lnFD_{it} + \varepsilon_t$

Source: Author's computation, 2025.

MATERIALS AND METHODS

Theoretical framework

The renewable energy consumption–quality of life nexus has been investigated through the framework of Grossman's theory of healthcare demand. In this model, health is viewed as a form of capital in which individuals can invest. Health capital is accumulated through investments in factors, such as medical care, preventive measures, and a healthy lifestyle. The theoretical foundation of this study is Grossman's theory of healthcare demand. The theory is relevant in optimizing health outcomes through the allocation of resources.

The Model

The model is stated as follows:

$$H = F(X_t) \qquad (3.1)$$

Where:

H represents health outcome, and X is a vector of individual inputs in the health production function (i.e. renewable energy consumption, GDP per capita, educational level).

This study used annual time series data from 1990 to 2023 which was sourced from the publications of Central Bank of Nigeria Statistical Bulletin, the International Energy Agency (IEA) and Human Development Reports of the United Nations. The study used human development index as proxy for quality of life ((see Morote, 2010 Quedrago, 2013; Sani & Sabo, 2017; Eras et al, 2022; Ishioro, 2023).

Renewable energy consumption was used to examine the impact of clean energy on quality of life. Other factors determining quality of life includes educational level, gross domestic product per capita, inflation and trade openness. The model constructed to describe the impact of renewable energy on quality of life is given below:

$$HDI = \gamma_1 + \gamma_1 Ren + \gamma_2 Gdp + \gamma_3 Inf + \gamma_4 Top + \gamma_5 Edl + Ut \qquad (3.2)$$

The Autoregressive Distributed Lag Model (ARDL) was employed in data analysis as used by Ashakah, (2023).The Autoregressive Distributive Lag (ARDL) bound model of equation 3.2 above can be specified as:

$$HDI = \sum_{i=1}^{p} \gamma_{1i}\, \Delta HDI_{t-1} + \sum_{i=0}^{q} \gamma_{2i}\, \Delta REC_{t=1} + \sum_{i=0}^{q} \gamma_{3i}\, \Delta EDU_{t-1} + \sum_{i=0}^{q} \gamma_{4i}\, \Delta GDP_{t-1} + \sum_{i=0}^{q} \gamma_{5i}\, \Delta IFR_{t-1} + \sum_{i=0}^{q} \gamma_{6i}\, \Delta TOP_{t-1} + \pi_1 HDI_{t-1} + \pi_2 REC_{t-1} + \pi_3 EDU_{t-1} + \pi_4 GDP_{t-1} + \pi_5 IFR_{t-1} + \pi_6 TOP_{t-1} + \mu_{1t} \qquad (3.3)$$

Table: 3.1 . Variable Descriptions and Sources

S/N	Variable	Symbol	Measurement	Source
1	Renewable energy consumption	REC	Wind and solar-generated electricity measured in terawatt hour.	IEA
2	Human development index	HDI		HDR
3	Educational level	EDL	Gross primary school enrolment	HDR

4	Trade openness	TOP	Exports plus imports divided by GDP	CBN
5	Inflation rate	IFL	Consumer price index	CBN
6	Real gross domestic product	RGDP	Measured at constant 2010 prices.	CBN

Source: Author's computation, 2025.

Analysis And Interpretation

In this section, the results of the model estimation were presented and discussed starting with the descriptive statistics before moving to the regression technique.

Table 4.1 Descriptive Statistics

	HDI	REC	INFL	TOP	EDL	GDPPC
Mean	0.441441	84.26298	18.56534	332.1866	88.63235	1584.432
Median	0.477000	84.50000	12.10000	336.9009	88.07757	1767.901
Maximum	0.548000	88.60000	76.75887	550.2128	100.1878	3088.721
Minimum	0.254000	79.90000	0.223606	178.5611	68.30000	480.6694
Std. Dev.	0.095886	2.736862	16.63585	85.06415	7.217707	772.3024
Skewness	-0.764541	-0.149367	2.138833	0.265644	-0.364101	-0.029709
Kurtosis	2.143278	1.667809	6.965416	2.814828	3.282207	1.873928
Jarque-Bera	4.352095	2.640632	48.19918	0.448452	0.864052	1.801389
Probability	0.113489	0.267051	0.000000	0.799134	0.649192	0.406287
Sum	15.00900	2864.941	631.2216	11294.34	3013.500	53870.70
Sum Sq. Dev.	0.303406	247.1837	9132.800	238785.0	1719.145	19682883
Observations	34	34	34	34	34	34

Source: Author's Computation (2025)

The descriptive statistics presented in Table 4.1 shows that The Human Development Index (HDI) has a mean value of 0.441, indicating moderate levels of human development. However, the wide range (0.254 to 0.548) and left-skewed distribution (skewness of -0.765) suggest significant disparities in life expectancy, education, and income levels.

Renewable Energy Consumption (REC) shows a high mean value of 84.26%, with a narrow range (79.90% to 88.60%) and low standard deviation (2.74), indicating a strong and stable reliance on renewable energy sources. This reflects a commitment to sustainable energy practice; however, the near-maximum values suggest limited room for further growth in renewable energy adoption, highlighting the need for diversification into other sustainable practices and technologies.

The Inflation Rate (INFL) presents a concerning picture, with a mean of 18.57%, a right-skewed distribution (skewness of 2.14) and high standard deviation (16.64) which indicated periods of extreme inflation with a maximum value reaching 76.76%.

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Trade Openness (TOP) is relatively high, with a mean of 332.19, reflecting significant integration into the global economy. The moderate standard deviation (85.06) and narrow range (178.56 to 550.21) suggest consistent trade activity.

The Education Level (EDL), measured by gross primary school enrolment, has a high mean value of 88.63% indicating strong access to basic education. The slight left skew (-0.36) and low standard deviation (7.22) suggest consistency in educational attainment.

Finally, GDP Per Capita (GDPPC) has a mean value of $1,584.43, reflecting a relatively low standard of living. The wide range ($480.67to $3,088.72) and high standard deviation ($772.30) shows significant income inequality and economic disparities.

Since the study intends to use an autoregressive distributed lag (ARDL) model, we perform the group unit root test and bounds co-integration test before estimating the model.

Table 4.2 Unit Root Test

Group unit root test: Summary				
Series: HDI, REC, EDL, INFL, TOP, GDPPC				
Sample: 1990 2023				
Newey-West automatic bandwidth selection and Bartlett kernel				
			Cross-	
Method	Statistic	Prob.**	sections	Obs
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-4.20039	0.0000	6	191
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	-2.64378	0.0041	6	191
ADF - Fisher Chi-square	29.2028	0.0037	6	191
PP - Fisher Chi-square	19.0324	0.0077	6	198
** Probabilities for Fisher tests are computed using an asymptotic Chi				
-square distribution. All other tests assume asymptotic normality.				

Source: Author's Computation (2025)

Table 4.2 shows the result of the unit root test for both common unit root and individual unit root processes. The table shows that the Levin, Lin & Chu t test* have a p-value of 0.0000 which is less than 5% level of significance, therefore, we can infer that there is no common unit root process. Also, the Im, Pesaran and Shin W-stat test both provide strong evidence against the presence of a unit root, implying that the series are likely stationary.

The ADF - Fisher Chi-square test and the PP - Fisher Chi-square test also support this conclusion, with a significant result indicating stationarity of the variables as their p-values are well below 5% level of significance.

The Bounds test for co-integration tests for long-run relationship between the variables and it is presented below.

Table 4.3 ARDL Bounds Co-integration Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	5.430619	10%	2.2	3.09
K	4	5%	2.56	3.49
		2.5%	2.88	3.87
		1%	3.29	4.37
Actual Sample Size	32		Finite Sample: n=35	
		10%	2.46	3.46
		5%	2.947	4.088
		1%	4.093	5.532
			Finite Sample: n=30	
		10%	2.525	3.56
		5%	3.058	4.223
		1%	4.28	5.84

Source: Author’s Computation (2025)

The results of the ARDL Bounds Co-integration in Table 4.3examines whether there is a levels relationship (co-integration) among the variables, which is essential for validating the use of the ARDL model. The F-statistic calculated for the test is 5.430619, which serves as the key metric for determining co-integration.

For the asymptotic sample, the critical values for the lower bound I(0) and upper bound I(1) at the 5% significance level are 2.56 and 3.49, respectively. For the finite sample size of 35, these values are slightly higher at 2.947 (I(0)) and 4.088 (I(1)). Similarly, for the finite sample size of 30, the critical values are 3.058 (I(0)) and 4.223 (I(1)) at the 5% significance level.

The calculated F-statistic of 5.430619 exceeds all the upper-bound critical values (I(1)) across both asymptotic and finite sample sizes at all significance levels. For instance, at the 5% significance level for the finite sample size of 35, the F-statistic (5.430619) is greater than the upper-bound critical value of 4.088. This indicates strong evidence to reject the null hypothesis of no levels relationship. In other words, the results confirm the presence of a long-run co-integration relationship among the variables in the model.

This finding is significant because it validates the use of the ARDL framework for analyzing the long-run dynamics between the variables. It suggests that the variables move together in the long run, despite potential short-term fluctuations. Next, we estimate the ARDL model as follows.

Table 4.4 Autoregressive Distributed Lag Model

Dependent Variable: LOG(HDI)		
Method: ARDL		
Sample (adjusted): 1992 2023		
Included observations: 32 after adjustments		
Maximum dependent lags: 2 (Automatic selection)		

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Model selection method: Akaike info criterion (AIC) **Dynamic regressors (2 lags, automatic): LOG(REC) LOG(EDL) LOG(INFL) LOG(TOP)** **Fixed regressors: C** **Number of models evalulated: 162** **Selected Model: ARDL(2, 1, 1, 2, 2)**				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	4.809909	2.145520	2.241838	0.0371
LOG(HDI(-1))	0.480700	0.127500	3.770196	0.0013
LOG(HDI(-2))	0.360960	0.114896	3.141633	0.0054
LOG(REC)	0.852072	0.061207	13.921061	0.0000
LOG(REC(-1))	1.878103	0.738250	2.543993	0.0198
LOG(EDL)	0.096313	0.142606	0.675374	0.5076
LOG(EDL(-1))	0.349022	0.166191	2.100131	0.0493
LOG(INFL)	-0.022093	0.009700	-2.277524	0.0345
LOG(INFL(-1))	0.005633	0.011537	0.488229	0.6310
LOG(INFL(-2))	-0.016014	0.009170	-1.746378	0.0969
LOG(TOP)	0.046660	0.053535	0.871587	0.3943
LOG(TOP(-1))	-0.133128	0.042938	-3.100498	0.0059
LOG(TOP(-2))	0.234778	0.044210	5.310482	0.0000

R-squared	0.976378	Mean dependent var	-0.815700
Adjusted R-squared	0.961458	S.D. dependent var	0.222267
S.E. of regression	0.043635	Akaike info criterion	-3.134690
Sum squared resid	0.036177	Schwarz criterion	-2.539234
Log likelihood	63.15503	Hannan-Quinn criter.	-2.937313
F-statistic	65.44379	Durbin-Watson stat	2.034233
Prob(F-statistic)	0.000000		

Source: Author’s Computation (2025)

The Autoregressive Distributed Lag (ARDL) model presented in Table 4.4 provides a detailed analysis of the factors influencing the Human Development Index (HDI) in Nigeria using annual data from 1992 to 2023. The model, selected via the Akaike Information Criterion (AIC), employs a lag structure of ARDL (2, 1, 1, 2, 2), capturing both short-run dynamics and long-run relationships between HDI and renewable energy consumption (REC), education level (EDL), inflation rate (INFL), and trade openness (TOP).

The model shows the persistence of HDI as evidenced by the positive and statistically significant coefficients of its lagged terms (LOG(HDI(-1)) and LOG(HDI(-2))). This suggests that improvements in human development are path-dependent, with past gains strongly influencing current outcomes. Approximately 84% of prior HDI improvements carry forward, emphasizing the need for sustained and consistent development efforts.

Renewable energy consumption (REC) emerges as a powerful driver of HDI, with both current and lagged terms showing significant positive effects. The immediate impact of REC is substantial, while its lagged effect is even stronger, indicating that renewable energy adoption not only boosts human development in the short run but also amplifies its benefits over time. The coefficient for LOG(REC) is 0.852, meaning that a 1% increase in renewable energy consumption leads to an immediate 0.85% increase in HDI. The lagged term, LOG(REC(-1)) has an even stronger coefficient of 1.878 implying that a 1% increase in renewable energy consumption in the previous year results in a 1.88% increase in the current year's HDI. The cumulative long-run impact of REC on HDI is 2.73%, showing the transformative role of clean energy in improving quality of life through enhanced energy access, reduced pollution, and economic opportunities in green sectors.

Education level (EDL) exhibits a delayed but positive impact on HDI. While the current period's education level (LOG(EDL) shows no significant effect (coefficient = 0.096, p = 0.508), its first lag (LOG(EDL(-1)) has a coefficient of 0.349, indicating that a 1% increase in education level in the previous year leads to a 0.35% increase in the current year's HDI. This suggests that investments in education take time to translate into measurable improvements in human development, reinforcing the importance of sustained educational policies, such as curriculum reforms and teacher training, to ensure that enrolment gains lead to tangible outcomes like a skilled labor force and higher incomes.

Inflation, on the other hand, poses a significant threat to human development. The current inflation rate (LOG(INFL)) has a coefficient of -0.022, meaning that a 1% increase in inflation leads to an immediate 0.022% decline in HDI. The second lag of inflation (LOG(INFL(-2)) also shows a delayed negative effect (coefficient = -0.016), suggesting that a 1% increase in inflation two years prior results in a 0.016% decline in the current year's HDI.

Trade openness (TOP) displays a mixed relationship with HDI. While the current term (LOG(TOP)) is insignificant, its first lag (LOG(TOP(-1)) has a coefficient of -0.133, indicating that a 1% increase in trade openness in the previous year leads to a 0.13% decline in the current year's HDI. This may reflect short-term disruptions, such as job losses in uncompetitive sectors. However, the second lag (LOG(TOP(-2)) has a positive coefficient of 0.235, meaning that a 1% increase in trade openness two years prior results in a 0.24% increase in the current year's HDI. The net long-run effect of trade openness on HDI is 0.102%, stressing the importance of patience and complementary policies such as retraining programs for displaced workers to maximize the benefits of trade liberalization.

The model demonstrates strong explanatory power, with an R-squared of 0.976 and Adjusted R-squared of 0.961, indicating that 96% of the variation in HDI is explained by the variables. The F-statistic of 65.44 confirms the overall significance of the model, while the Durbin-Watson statistic of 2.03 suggests no autocorrelation in residuals. These diagnostics affirm the robustness of the results.

Model Diagnostics

The serial correlation and Heteroskedasticity tests were carried out and presented in the table below.

Table 4.5 Diagnostic Tests

Test	Breusch-Godfrey Serial Correlation LM Test	Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null Hypothesis	**No serial correlation at up to 2 lags**	**Homoskedasticity**
F-statistic	0.890118	2.204278
Prob. F	0.4289	0.0598
Obs*R-squared	3.033379	18.62306
Prob. Chi-Square	0.2194	0.0980
Scaled Explained SS	-	3.621577
Prob. Chi-Square (Scaled Explained SS)	-	0.9893

Source: Author's Computation (2025)

Table 4.3 above shows two diagnostic tests, first, the Breusch-Godfrey Serial Correlation LM test has an F-statistic of 0.890118, an Obs*R-squared of 3.033379 with p-values of 0.4289 and 0.2194respectively. Since these p-values are greater than 0.05, we fail to reject the null hypothesis, indicating no evidence of serial correlation in the residuals at up to 2 lags.

For the heteroskedasticity test, the Breusch-Pagan-Godfrey with test coefficients: F-statistic (2.204278), Obs*R-squared (18.62306) and Scaled Explained SS (3.621577) all have p-values greater than 0.05 (0.0598, 0.0980 and 0.9893 respectively), therefore we fail to reject the null hypothesis indicating no evidence of heteroskedasticity in the residuals.

Essentially, the results confirm that the model residuals are free from serial correlation and heteroskedasticity which supports the reliability and validity of the regression estimates, and this ensures that the statistical inferences drawn from the model are robust and trustworthy.

DISCUSSION OF FINDINGS

The persistence of HDI observed in the model corroborates prior studies emphasizing the cumulative nature of human development. For instance, Morote (2010) highlighted that human development outcomes are inherently path-dependent, requiring sustained investments in health, education, and income to drive long-term progress.

Renewable energy consumption was seen to be a critical driver of quality of life in Nigeria which is consistent with global and regional evidence. Balogun and Oloja-Ojabo (2023) demonstrated that renewable energy adoption in Nigeria reduces poverty by enhancing energy access and stimulating economic opportunities in rural and urban areas. Similarly, Ekone and Amaghionyeodiwe (2020) identified a bidirectional causality between renewable energy use and economic growth, suggesting that clean energy investments not only improve living standards but also create a feedback loop for sustained development. The delayed yet amplified impact of renewable energy aligns with Wang et al. (2023), who found that renewable energy adoption correlates with improved life expectancy over time, as reduced pollution and better healthcare access mitigate long-term health risks. Furthermore, Majeed et al. (2021) noted that renewable energy consumption globally reduces respiratory diseases, indirectly supporting the model's inference on HDI improvements through health outcomes.

The delayed positive impact of education on quality of life in Nigeria resonates with Quedraogo (2013) who argued that education's benefits such as higher productivity and innovation manifest after a lag, as skills acquired today translate into economic contributions tomorrow. This aligns with Eras et al. (2022), who emphasized that education policies must prioritize quality and retention to realize long-term human capital gains. The insignificance of immediate educational impacts underscores the need for patience in policy implementation as enrolment alone may not suffice without complementary investments in infrastructure and teacher training.

Inflation's detrimental effect on the quality of life in Nigeria is consistent with monetary economics theories that associate rising prices to reduced household purchasing power and increased poverty rates. Jebbin and Adebisi (2023) further demonstrated that inflation exacerbates health disparities by limiting access to nutrition and healthcare, directly undermining life expectancy; a key component of Human Development Index. The prolonged negative effects of inflation stress the urgency of stabilizing macroeconomic conditions to safeguard human development gains, particularly for vulnerable populations.

Trade openness's mixed effects on the quality of life in Nigeria reflect the dual nature of globalization. While initial disruptions, such as job losses in uncompetitive sectors, may temporarily hinder development, the long-term benefits of technology transfer and market access align with Samour et al. (2022) who noted that strategic trade policies in the UAE fostered sustainable growth through renewable energy partnerships. Similarly, Ishioro (2022) highlighted that Nigeria's reliance on oil exports exposes the economy to volatility, underscoring the need to diversify trade activities and invest in resilient sectors. Maku and Ishioro (2023) further emphasized that macroeconomic stability is pivotal to maximizing trade benefits, advocating for policies that cushion short-term shocks while promoting inclusive growth.

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study offers a detailed look at how renewable energy consumption, socio-economic factors, and human development interact in Nigeria, shedding light on both the drivers of progress and the challenges that still exist. Using an ARDL model, the research examines how renewable energy consumption, education, inflation, trade openness, and quality of life in Nigeria are connected, showing both short-term and long-term effects. The results highlight the key role of renewable energy in improving quality of life, the gradual but crucial impact of education on human development, the negative effects of inflation, and the complex influence of trade openness. These findings not only support what previous studies have found, but also add new insights to the growing knowledge on sustainable development.

From a broader perspective, the study emphasizes the need for a well-rounded approach to development that considers economic, social, and environmental factors. Over the past few decades, Nigeria has faced challenges like rapid population growth and limited resources, which have slowed progress in human development. However, the findings of this research offer hope, showing that by investing strategically in renewable energy, education, and economic stability, Nigeria can achieve significant improvements. Renewable energy, in particular, stands out as a powerful tool for change. As the world shifts toward more sustainable energy, Nigeria could greatly benefit from its renewable resources, not just to meet its energy demands, but also to stimulate economic growth and raise living standards.

Looking forward, the field of renewable energy and human development will become even more important. The global push for sustainability and the urgent need to tackle climate change create both challenges and opportunities for Nigeria. Policymakers need to take advantage of this moment to make policies that encourage renewable energy consumption, improve education, control inflation, and use trade to foster inclusive growth. Additionally, future research should look into regional differences in the quality of life, how renewable energy affects specific sectors, and how innovation can drive progress. This will help us gain a deeper understanding of development paths and guide more effective interventions.

Recommendation

Based on the findings of the study, the following recommendations are proffered:

1. **Prioritize Renewable Energy Infrastructure Development:** Enhance energy access in underserved areas by expanding decentralized renewable systems such as solar mini-grids and off-grid solutions, while partnering with private stakeholders and offering incentives like tax rebates and low-interest loans to drive investments and replicate successful models from initiatives like the Nigeria Electrification Project.
2. **Strengthen Educational Quality and Retention:** Shift focus from mere enrolment to long-term educational outcomes by improving teacher training, upgrading school infrastructure, and integrating STEM and vocational training into curricula, alongside implementing supportive measures such as conditional cash transfers and school feeding programs to reduce dropout rates and ensure quality education.
3. **Stabilize Inflation Through Proactive Monetary Policies:** Address hyperinflation's threat to human development by adopting a hybrid inflation-targeting framework, using monetary tools like interest rate adjustments and open market operations to control liquidity, and temporarily subsidizing essential commodities to protect low-income households from rising living costs.
4. **Optimize Trade Policies for Inclusive Growth:** Mitigate short-term trade shocks by establishing retraining programs and social safety nets for workers affected by import competition, while promoting export diversification by incentivizing renewable energy technology and value-added agricultural products, thereby reducing over-reliance on oil and fostering broader economic growth.
5. **Strengthen Data-Driven Policy Formulation:** Develop a comprehensive national monitoring framework to regularly track HDI sub-indices at local levels and establish a centralized database for renewable energy metrics, ensuring that policymakers can leverage accurate, real-time data to identify disparities and tailor interventions effectively in collaboration with international organizations.

REFERENCES

1. Ashaka O. F (2025). Government Expenditure, Tax Revenue, and Economic Growth: Empirical Evidence from Nigeria. Jalingo Journal of Social and Management Sciences Volume 5, Number 1, October 2023. 263
2. Ashaka O. F (2025). Impact of Energy Consumption on Economic Growth in Nigeria: An ARDL Estimation Approach. Jalingo Journal of Social and Management Sciences Volume 6, Number 2, Page 254-266
3. Balogun, A. Q., Oloja-Ojabo, E. D. (2023). The Impact of Renewable Energy Consumption and Public Capital Expenditure on Poverty Reduction in Nigeria. International Journal of Business, Management, and Economics, 4(3). 212 – 230. DOI: https://doi.org/10.47747/ijbme.v4i3.1139
4. Central Bank of Nigeria. (2022). Inflation and Monetary Policy Report. Retrieved from CBN Official Website.
5. Central Bank of Nigeria. (2023). Energy Consumption and Economic Growth Report. Retrieved from CBN Official Website
6. EIA (Energy Inf. Adm.). 2019. What is U.S. electricity generation by energy source? Energy Information Administration Frequently Asked Questions. https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
7. Ekone F. A & Amaghionyeodiwe L.(2020). Renewable energy consumption and economic growth in Nigeria: any causal relationship. The Business and Management Review, Volume 11 Number 1
8. Eras, J.J.C., Fandino, J.M.M., & Gutierrez, A.S. (2022) Assessing the causality relationship and time series model for electricity consumption per capita and human development. Energy Reports,8, 10464-10477.
9. IEA. (2020). Defining Energy Access. p.2. Available from: https://www.iea.org/articles/defining-energy-access-2020- methodology [Last accessed on 2024 Sep 30].
10. Jebbin, M.F., & Adebisi, S.A. (2023). Energy consumption and life expectancy in Nigeria. International Journal of Advanced Studies in Economics and Public Sector Management, 11(2):49-63.
11. Ishioro(2022): Crude oil and economic growth in Nigeria: a simplified pairwise causality test. at: Journal of academic research in economics https://www.researchgate.net/publication/365770052

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12. Majeed M, Tania Luni, & Gulreen Zaka (2021). Renewable Energy Consumption and Health Outcomes: Evidence from Global Panel Data Analysis. Pakistan Journal of Commerce and Social Sciences 2021, Vol. 15 (1), 58-93
13. Maku, O.A., & Ishioro, B.O. (2023) Empirics of the Relationships among Macroeconomic Fundamentals in Nigeria. Innovations, 72, Series (05),1011-1021.
14. Morote, E. (2010) "The Impact of Human Development on the Gross Domestic Product in Latin American Emerging Markets" El Portal Educativo de las Américas www.educoea.org/portal/laeducacion.
15. Quedraogo, N.S. (2013). Energy consumption and human development: evidence from a panel cointegration and error correction model. Energy, 63, 28-41 (15 December)
16. Samour, A.; Baskaya, M.M.; Tursoy, T. (2022).The Impact of Financial Development and FDI on Renewable Energy in the UAE: A Path towards Sustainable Development. Sustainability 2022, 14, 1208. https:// doi.org/10.3390/su14031208
17. Wang, Q., Wang, L., & Li, R. (2023). Does renewable energy help increase life expectancy? Insight from the linking renewable energy, economic growth, and life expectancy in 121 countries. Energy Strategy Reviews, 50:101185. https://doi.org/10.1016/j.esr.2023.1011854