International Journal of Economics and Development Policy (IJEDP)
Vol. 5 No. 2, December, 2022
Print - ISSN: 2651-5644
Online - ISSN: 2651-5644

Renewable Energy Consumption and Sustainable Development in Nigeria

Afolabi Quadri Balogun, Usman Abdullahi & Sameerah Haruna

Department of Economics, Faculty of Arts, Management and Social Sciences, Nigerian Army University, Biu Borno State – Nigeria

Corresponding Author's E – mail: afoobalogun@gmail.com

Abstract

This study examines the relationship between renewable energy consumption and sustainable development in Nigeria over the period 1990-2021. The paper employs Autoregressive Distributed Lag (ARDL) bounds model. The key findings of the study are, that renewable energy consumption was the only variable that significantly impact sustainable development in the long-run, whereas, other variables of interest has insignificant relationship with sustainable development in Nigeria over the observed period. The study also revealed that in the short-run analysis, renewable energy consumption significantly improves sustainable development, while non-renewable energy consumption and population significantly impedes sustainable development. The short-run result also shows that consumer price index do not have a significant relationship with sustainable development in Nigeria. The study recommends the adoption of energy-efficient policies, notably those that encourage Nigerians to use renewable energy sources, and encouraging human capital development to enhance marginal product of human capital resources in the country.

Keywords: Renewable Energy Consumption, Sustainable Development, CO_2 Emissions, Environmental Kuznets Curve

JEL Classification: Q20, Q42, Q43, Q56, F63

Contribution to/Originality Knowledge:
This study contributes to the body of knowledge by providing evidence of a relationship between renewable energy consumption and sustainable development in Nigeria. The originality relies on the data, methodology and results presented.

1.0 Introduction

As Africa countries yearn for development, there has been increase in productive activities which has necessitated an increase in energy consumption. Literature shows different energy sources ranging from the conventional energy like crude oil, coal and gas, to renewables like hydro, solar, wind and geothermal. Several studies have shown negative impact of conventional energy on CO_2 emissions (Boontome et al., 2017; Liu et al., 2017; Lotz & Dogan, 2018; Adu & Denkyirah, 2019). BP energy report (2022) shows that conventional energy from fossil fuel energy sources, accounted for more than 60% of global CO_2 emissions which is contributing to global warming.

There has been increasing debate on reducing global warming, especially on reducing CO_2 emissions. For example, the Paris Agreement of 2016 on climate change aimed at reducing the global temperature to less than 2.0 degree centigrade by 2050. Other international organisations like the International Energy Agency (IEA) and the International Renewable Energy Agency

(IRENA) claimed that renewable energy resources can offer a significant opportunity for the economic development and environmental quality improvement for many countries around the world (Kahia et al., 2017). Recent literatures in Africa are also advocating for increasing use of renewable energy (Maji, 2015; Maji, 2017; Adewuyi & Awoduni, 2020). Study shows that the share of renewable energy consumption from the total energy consumption is 22% globally & 25% in Africa (IEA, 2021). This has further fuelled the agitation for increased renewable energy consumption in total energy mix (Bhattacharya et al., 2016). It was reported that Africa has the highest potential for renewable energy, yet, wind, solar and biomass use in Africa only account for an insignificant portion of the total global renewable energy mix (IEA, 2021).

Moreover, the increasing use of non-renewable energy source which increases CO_2 emissions has environmental consequences and impact future generation (Waziri et al., 2018). This is a catalyst against sustainable development, since sustainable development can only be achieved when the needs of the present generation is fulfilled without depriving that of the future generation. This notion calls for the promotion of renewable energy globally and in Africa. Lee (2019) opined that renewable energy is an effective approach to decrease CO_2 emissions and achieve sustainable development goals (SDGs).

There have been a few studies on the relationship between different energy sources and economic growth in many countries, but we haven't come across a study on the relationship between renewable energy consumption and sustainable development in Nigeria. This study is motivated by the need to identify the extent to which renewable energy consumption stimulates sustainable development in Nigeria. This study aims at evaluating the extent to which renewable energy consumption impact sustainable development in Nigeria over the period of 1990 – 2021. The remaining parts of this study is organized as follows; literature review is presented in Section 2; the methodology is presented in Section 3; Section 4 presents the results and discussion; while Section 5 contains conclusion and policy recommendations.

2.0 Literature Review

2.1 Conceptual Review

While there is a broad consensus among international organizations, government institutions, and regional commissions on what constitutes renewable energy, these groups employ legal or formal definitions that vary slightly in the types of resources included.

The International Renewable Energy Agency (IRENA) has a statutory definition, ratified by 108 members (107 states and the European Union) as of February 2013: "renewable energy includes all forms of energy produced from renewable sources in a sustainable manner, including bioenergy, geothermal energy, hydropower, ocean energy, solar energy and wind energy." The International Energy Agency (IEA) defines renewable energy as "energy derived from natural processes that are replenished at a faster rate than they are consumed", and mentions solar, wind, geothermal, hydro and biomass as examples of renewable energy (IEA, 2021b). The European Union includes wind, solar, hydro and tidal power, geothermal energy, biofuels and the renewable part of waste as renewable energy in its statistical accounting (Eurostat, 2021); in a recent report, the United Nations Environment Programme follows the same logic (Frankfurt School, 2018).

These definitions vary in the type of sources included and in whether sustainability considerations are explicitly incorporated. These differences illustrate the fact that there is no common or global definition of renewable energy.

Sarkodi and Owusu (2016) view renewable energy as energy sources which replenish themselves naturally without being depleted in the earth. This energy sources according to them include; bioenergy, hydropower, geothermal energy, solar energy, wind energy and ocean (tide and wave) energy. Inglesi-Lotz (2016) perceived renewable energy to be the most viable solutions to improve the environmental status quo of our planet and mitigate and abate the emission of GHG without affecting the countries' economic growth and development. Grabara et al. (2021) opined that renewable energy sources mean sources of energy that can be renewed by natural processes, including solar radiation energy, wind energy, hydrodynamic energy of water, and geothermal energy (heat of soil, groundwater, rivers, and water bodies).

Renewable energies (or renewables) are ways to generate energy from (theoretically) unlimited natural resources. These resources are either available with no time limit or replenish more quickly than the rate at which they are consumed. Renewable energies are generally spoken of as opposed to fossil fuel energies. The fossil fuels' stocks are limited and non-renewable in the human timescale. The most known examples of these resources are coal, oil or natural gas. On the contrary, renewable energies are produced from renewable sources, such as energy coming from solar rays, wind or water cycles – all theoretically unlimited on a human scale time. For the purpose of the study, renewable energy consumption is defined as the consumption of various forms of energy that are replenished naturally and over relatively short periods of time. These energy sources include solar, wind, hydro, bioenergy and geothermal.

Sustainable development is perceived to mean meeting the needs of the present without compromising the ability of the future generations to meet theirs (United Nations [UN], 2007). Engelmen (2013) is of the opinion that sustainable development implies maintaining the capacity of ecological systems, to support and enhance the quality of social systems. In this study, sustainable development is conceptualized as pollution free environment.

This study set out to reveal the extent to which renewable energy consumption promotes sustainable development. It has been noted that renewable energy consumption is an energy source that does not negatively impact the environment, it is therefore imperative to ascertain how renewable energy consumption can enhance sustainable development in Nigeria.

2.2 Theoretical Reviews

The Environmental Kuznets Curve (EKC) is named after Simon Kuznets who proposed that income inequality first rises and then falls as economic development proceeds (Stern, 2018). The EKC framework has been used by many researchers to investigate the relationship between energy consumption, economic growth and CO_2 emissions. The EKC hypothesis argues that there is an inverted U-shaped relationship between economic activity and environmental degradation. The EKC model states that there exists a negative relationship between economic growth and environmental quality until a certain income threshold is attained, beyond which environmental quality starts to improve. The N-shape ensued, such that the inverted U-shape hypothesis holds up to a certain point, beyond which pollution increases again (Alvarez-Herranz et al., 2017), which links a relationship between environmental pollution. In other words, at the initial stage, economic activities increase CO_2 emissions, and then a stage is reached when further economic growth promotes technological advancement which leads to a reduction in CO_2 emissions. A final stage is reached when technology becomes obsolete, and makes CO_2 to increase once again.

The EKC framework explains the inverted U-shaped relationship between economic growth and CO_2 emissions (Pata, 2018). The EKC framework has been used by previous scholars in related field of study to investigate the relationship between renewable energy consumption, economic growth and CO_2 emissions in single country study (Jebli & Youssef, 2015; Dogan, 2016, Cherni & Jouini, 2017; Boontome et al., 2017; Pata, 2018; Sarkodie & Adams, 2018; Lotz and Dogan; 2018) and in multi-country study (Narayan & Doytch, 2017; Belaid & Youssef, 2017; Bhattacharya et al., 2017; Maji, 2017; Sinha & Shahbaz, 2018; Lorente et al., 2018; Silva et al., 2018; Nguyen & Kakinaka, 2019; Destek & Sinha, 2020).

The EKC framework is adopted in this study to explain the relationship between renewable energy consumption and sustainable development in Nigeria.

2.3 Empirical Review

There has been debate on the relationship between renewable energy consumption and economic growth, and the results are inconclusive, but much has not been conducted on renewable energy consumption-sustainable development nexus. Studies on the relationship between different energy sources and other variables started with the work of Kraft and Kraft (1978) who argued that energy is one of the essential drivers of modern growth when they studied the relationship between energy consumption and economic growth in USA. Since then, many other scholars have studied the relationship between energy consumption and other macroeconomic variables.

Cowan, Chang, Inglesi-Lotz and Gupta (2014) explored the causal link between electricity consumption, economic growth and CO_2 emissions in the BRICS countries for the period 1990-2010 using bootstrap panel causality approach. For electricity-GDP nexus, they discovered bidirectional relationship between the variables in Russia, while unidirectional causality running from economic growth to electricity consumption was found in South Africa, and no relationship was discovered among the variables for Brazil, India and China. Regarding the GDP- CO_2 emissions nexus, bidirectional relationship was discovered in Russia, while unidirectional causality running from GDP to CO_2 emissions was found in South Africa, and unidirectional causality running from CO_2 emissions to GDP in Brazil. No causality between the two variables was found in India and China. For electricity-CO_2 emissions nexus, they discovered that electricity consumption affects CO_2 emissions in India, while causality was not found between the two variables in Brazil, Russia, China and South Africa. Their result supports the notion that policies cannot be uniformly implemented across countries as they might have different effects.

Salahuddin and Gow (2014) examined the relationship between CO_2 emissions, economic growth, electricity consumption and financial development in the Gulf Cooperation Council (GCC) countries over the period 1980 – 2012 using DOLS, FMOLS and dynamic fixed effect model (DFE). Electricity consumption and economic growth were discovered to have a positive long run relationship with CO_2 emissions. Additionally, bidirectional causal relationship was discovered between economic growth and CO_2 emissions, with a unidirectional causal relationship running from electricity consumption to CO_2 emissions. Finally, the impulse response and variance decomposition analysis outline forecasted impacts of economic growth and electricity consumption on future CO_2 emissions.

Alvarez-Herranz, Shahbaz and Cantos (2017) investigated the presence of the EKC in 17 OECD countries for the period 1990-2012 using the fixed effects and panel least squared methods. They discovered the existence of N-shaped EKC relationship between economic growth and energy demand. Their study shows that economic growth increases energy demand which increases greenhouse gas emissions. They also discovered that renewable energy sources help to improve environmental quality.

Bhattacharya, Churchill and Paramati (2017) investigated the impact of renewable energy and institutions on economic output and CO_2 emissions across 85 developed and developing countries over the period 1991-2012. Using GMM and FMOLS method they discovered that the growth of REC has a significant positive and negative impact on GDP and CO_2 respectively.

Liu, Zhang and Bae (2017) investigated the renewable energy-agriculture- CO_2 nexus, together with output and non-renewable energy in BRICS countries during 1992-2013 period using FMOLS, DOLS and VECM. Their findings show that GDP and renewable energy consumption have negative impact on CO_2 emissions, while non-renewable energy consumption & agriculture have positive impact on CO_2 emissions. In the short-run, there is feedback hypothetical relationship between of CO_2 emissions and non-renewable energy consumption, unidirectional relationship running from renewable energy consumption to both CO_2 emissions and non-renewable energy consumption, from agriculture to GDP, and from GDP to non-renewable energy consumption. In the long-run, causalities are found from other variables to CO_2 emissions and to non-renewable energy consumption.

Rahman (2017) investigated the relationship between CO_2 emissions, energy use, economic growth, exports and population density for a panel of 11 Asian populous countries over the period 1960-2014. He employed the FMOLS and DOLS methods and discovered that in the long run, energy use, exports and population density increases CO_2 emission, while bidirectional causality was discovered between GDP and population density in both short run and long run. Their findings also show that in the short run, energy consumption, GDP, and exports increases CO_2 emissions, energy consumption and exports increases GDP, exports increases energy consumption, and population density increases exports.

Chen and Lei (2018) evaluated the impact of renewable energy and technological innovation on environment-energy-growth nexus using data of 30 countries over the period 1980-2014. They employed a panel quartile regression method and discovered that for high-emission countries, renewable energy consumption has a limited effect on reducing CO_2 emissions, whereas, technological innovation greatly affects this country category.

Jebli et al. (2019) investigated the dynamic linkage between renewable energy, tourism, CO_2 emissions, economic growth, FDI and trade in 22 Central and South American countries using FMOLS and DOLS method over the period 1995 – 21010. They found out existence of unidirectional causality running from renewable energy consumption to CO_2 emissions and trade openness, from tourism to trade openness and FDI, and from economic growth to renewable energy consumption and tourism.

Kahia et al. (2019) analysed the impact of renewable energy consumption and economic growth on CO_2 emissions in 12 MENA countries using panel VAR over the 1980-2012 period. They discovered that economic growth increases CO_2 emissions while renewable energy consumption, trade openness and FDI reduce CO_2 emissions.

Nguyen and Kakinaka (2019) investigated the relationship between renewable energy consumption, carbon emissions and development stages of 107 countries. They analysed 1990-2013 data sets and employed FMOLS, and DOLS methods. Their result shows renewable energy consumption has a positive and negative relationship between CO_2 and GDP respectively, for low income countries. For high-income countries, renewable energy consumption is negatively and positively associated with CO_2 and GDP respectively.

Lotz and Dogan (2018) evaluated the role of renewable energy and non-renewable energy on CO_2 emissions in a panel of 10 electricity generating SSA countries. They employed DOLS method over the period 1980-2011 and found that increase in non-renewable energy consumption increases CO_2 emissions, while the opposite is the case for renewable energy consumption. There exist unidirectional causality running from CO_2 emissions, GDP, trade openness and non-renewable energy consumption to renewable energy consumption and CO_2 emissions, and from non-renewable energy consumption to CO_2 emissions, and from CO_2 emissions & non-renewable energy consumption to trade openness.

Sakodie et al. (2020) evaluated the relationship between FDI, renewable energy consumption and CO_2 emissions in 47 SSA countries over the period 1990-2017 using dynamic heterogeneous estimation. They discovered that renewable energy consumption reduces CO_2 emissions in SSA. Their findings contradict the results of Maji et al. (2019) that discovered that renewable energy consumption increases CO_2 emissions in West African countries due to the sub-region reliance on biomass as a major renewable energy source.

Most of the past studies used electricity consumption as a proxy for renewable energy consumption whereas; electricity consumption is only a portion of renewable energy consumption. More so, there hasn't been recent studies on the relationship between renewable energy consumption and sustainable development in Nigeria. This study uses the percentage of total renewable energy consumption from total energy consumption while estimating the impact of renewable energy consumption on sustainable development in Nigeria over the period 1990 – 2021.

3.0 Methodology

3.1 Model Specification

The EKC hypothesis is utilized to investigate the impact of renewable energy consumption on sustainable development in SSA countries, and the EKC model in its general format can be specified as follows:

$$E = F\left(Y,\ Y^2,\ Z\right) \tag{18}$$

where E is an environmental indicator of sustainable development, Y is income and Z is other explanatory variables which may influence environmental degradation (Saboori et al., 2012). The objective of this study is to examine the impact of renewable energy consumption on sustainable development; other explanatory variables including renewable energy consumption, non-renewable energy consumption, population, and consumer price index were included in the model. The model employed in this study is similar to that used by Rahman (2017) in related study as presented below;

$$CO_2 = F\left(REC,\ NREC,\ POP,\ CPI\right) \tag{19}$$

An econometric model can be derived from equation (2) by incorporating intercept (α_0) and disturbance variable (ε) as:

$$CO_{2t} = \alpha_0 + \alpha_1 REC_t + \alpha_2 NREC_t + \alpha_3 POP_t + \alpha_4 CPI_t + \varepsilon_t \tag{20}$$

The estimation model is converted into logarithm linear econometric model in order to reduce skewness in the panel data (Maji, 2015) and is presented below:

$$lnCO2_t = \alpha_0 + \alpha_1 lnREC_t + \alpha_2 lnNREC_t + \alpha_3 lnPOP_t + \alpha_4 lnCPI_t + \varepsilon_t \tag{21}$$

CO_2 represents per capita carbon dioxide emissions in SSA, also as dependent variable of the model, REC, NREC, POP and CPI are renewable energy consumption as percentage of total final energy consumption, non-renewable energy consumption in kg of oil equivalent per capita, population annual growth rate and consumer price index respectively. The subscript *t* represent time period α_0 is constant, while α_1, α_2, α_3, and α_4 are the coefficients of long-run elasticities of CO_2 with respect to renewable energy consumption, non-renewable energy consumption, population growth rate and consumer price index, respectively. And ε is the error term.

Non-renewable energy consumption was included in the model to understand the impact it has on environmental quality. Population has a potential to affect environmental quality in the long run (Rahman, 2017) while CPI, a measure of inflation, is a financial indicator used as a control variable can potentially impact environmental quality.

Data description and Source

The data used in this study is collected from the World Development Indicators (WDI) over the period 1990 – 2021. CO_2 represents per capita carbon dioxide emissions in metric tons, REC is the percentage of renewable energy consumption from total final energy consumption, NREC is the kg of oil equivalent per capita, POP is the annual percentage growth rate of population and CPI is consumer price index taking 2010 as the base year.

Table 1: Variables Description and Sources

Notation	Variable Name	Estimations	Data Source
CO_2	Carbon Dioxide Emissions	metric tons per capita	WDI
REC	Renewable Energy Consumption	% share of total final energy consumption	WDI
NREC	Non Renewable Energy Consumption	kilo ton of oil equivalent per capita	WDI
POP	Population	Population growth rate (annual %)	WDI
CPI	Consumer Price Index	Consumer price index (2010 = 100)	WDI

WDI: Word Development Indicators
Source: Authors' Compilation, 2022.

4.0 Results and Discussion

The variables used in this study are summarized in table 2 below which shows the mean, standard deviation, minimum, maximum values and numbers of observations respectively.

Table 2: ***Summary statistics.***

Variables	$lnCO_2$	lnREC	lnNREC	lnPOP	lnCPI
Mean	-0.389782	4.440586	6.603370	0.945840	3.894854
Std. Dev	0.173108	0.027778	0.027778	0.026162	1.337156
Minimum	-0.695905	4.489995	6.523726	0.911798	0.881247
Maximum	-0.087065	4.485034	6.682898	0.986164	5.589163
Observations	32	32	32	32	32

Source: Authors' computation (2022)

Table 3: ***Stationary test result.***

Variables	ADF		PP	
	Level	First difference	Level	First difference
$lnCO_{2t}$	-1.217265(0.654)	-5.776361(0.000)***	-1.074518(0.713)	-6.778936(0.000)***
$lnREC_t$	-4.894944(0.000)***	-1.896144(0.330)	-4.894944(0.000)***	-2.132789(0.234)
$lnNRE_t$	-1.372743(0.583)	-5.268786(0.000)***	-1.206820(0.659)	-5.942182(0.000)***
$lnPOP_t$	-3.385400(0.012)***	-2.291601(0.181)	-1.234706(0.647)	-2.292891(0.181)
$lnCPI_t$	-4.894944(0.000)***	-1.896144(0.330)	-4.894944(0.000)***	-2.132789(0.234)

*** indicates significance at 1%.

Source: Authors' computation (2022)

Stationarity of the variables were tested using the Augmented Dickey Fuller (ADF) and Phillips Perron (PP). The result of the unit root test is presented in Table 2 and suggested that the variables were stationary at I (0) or I (1). This indicates that the autoregressive distribution lag (ARDL) bound test be conducted.

Table 4: Result of ARDL cointegration test

$lnCO_{2t}= F(lnREC_t, lnNREC_t, lnPOP_t, lnCPI_t)$	Sig. level	Critical values for bound test: Case III	
F-statistics		Lower bounds	Upper bounds
(5.466467)***	1% level	3.29	4.37
Lag length	5% level	2.56	3.49
(1,1,1,0,1)	10% level	2.2	3.09

***Indicates significance at 1%

Source: Authors' computation (2022)

The ARDL bound test position is ascertained by the F-statistic value. If it is greater than the critical value for the upper bound, then cointegration exist which means there exist a long-run relationship among the variables. The ARDL cointegration test result is presented in Table 4 and shows that long-run relationship exists between the dependent variable and independent variables since the F-statistics value (5.466467) is greater than the upper bounds value (4.37) at 1% significance level. It became imperative to conduct the long-run and short-run relationship among the variables using the ARDL and error correction model (ECM).

Table 5: ***Estimated long and short run coefficients.***

Dependent variable = $lnCO_{2t}$				
	Long-run results		Short-run results	
Variables	Coefficient	T-ratio (p values)	Coefficient	T-ratio (p values)
$lnREC_t$	-10.66169	-1.831717(0.027)	-6.690460	-15.20721(0.000)
$lnNREC_t$	9.708656	1.194106(0.286)	1.993726	5.363122(0.003)
$lnPOP_t$	12.45021	0.944891(0.388)	9.179520	4.575637(0.006)
$lnCPI_t$	-0.109138	-1.336983(0.239)	0.034363	0.529275(0.619)
Constant	99.58483	1.498558(0.194)	77.90887	2.358284(0.065)
ECM (-1)			-0.782337	-8.099235(0.001)

Source: Authors' computation (2022)

The long-run and short-run result is presented in Table 5 above. The long-run result shows a significant long run relationship between CO_2 emissions and renewable energy consumption, but an insignificant long-run relationship between CO_2 emissions and other independent variables of non-renewable energy consumption, population growth rate and consumer price index. NREC, POP and CPI. The long-run coefficient of renewable energy consumption and consumer price index are negative, while that of non-renewable energy consumption and population growth rate are positive. The long-run result shows that renewable energy consumption has direct positive relationship with sustainable development in Nigeria, that is, 1% increase in renewable energy consumption enhances sustainability by 10.6617% other determinants of poverty held constant. Furthermore, the coefficient of non-renewable energy consumption and population growth rate are insignificant at 1% level and has a positive long-run relationship with CO_2 emissions in Nigeria. Whereas, the coefficient of consumer price index is insignificant and has negative long-run relationship with CO2 emissions in Nigeria.

The estimated short-run relationship was also presented alongside the long-run estimates in Table 5. The coefficient of all variables but CPI are significant at 1% level. The result revealed that all variables except renewable energy consumption are negatively related to sustainable development in the short-run in Nigeria. The short-run coefficient of renewable energy consumption is -6.69046 which implies that 1% increase in renewable energy consumption increases sustainability by 6.69046%. The short-run result also shows that 1% increase in non-renewable energy reduces sustainable development by 1.99373%, while 1% increase in population growth rate also reduces sustainable development by 9.17952%. In addition, the coefficient of the ECM is negative, less than one and significant. The ECM result shows that there is high speed of adjustment from the short run to the long run. And that if there is any disequilibrium in the system it takes an average speed of approximately 78.23% to adjust back from the short run to the long run.

4.2 Reliability and Stability Tests Results

After estimating the long-run and short-run relationship between the dependent variable and independent variables, diagnostic tests were conducted to check the reliability and stability of our results. The reliability of the model was tested by conducting tests for serial correlation, normality and heteroscedasticity. The result of the diagnostic test is presented in Table 6 and shows that the model passes the three diagnostic checks with the *p* values higher than 0.05. The stability of the model was tested by conducting the cumulative sum of recursive residuals and cumulative sum of square of recursive residuals which is presented in Fig. 1 and Fig. 2. As depicted in Fig 1 and 2, the plots of the statistics fall within the critical bounds at 5% level of significance, this reveals that the model is stable and consistent.

Table 6: Diagnostic tests results.

	F-statistics	*P* values
Normality	0.569523	(0.7522)
Serial correlation	0.679713	(0.4560)
Heteroscedasticity	1.220162	(0.4512)

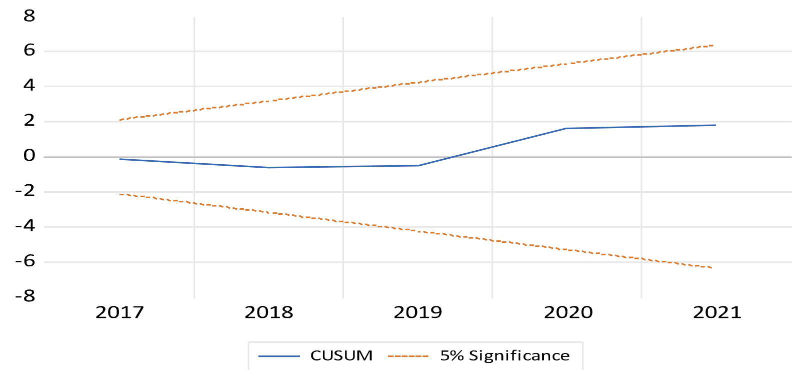

Fig. 1: Plot of cumulative sum of recursive residuals

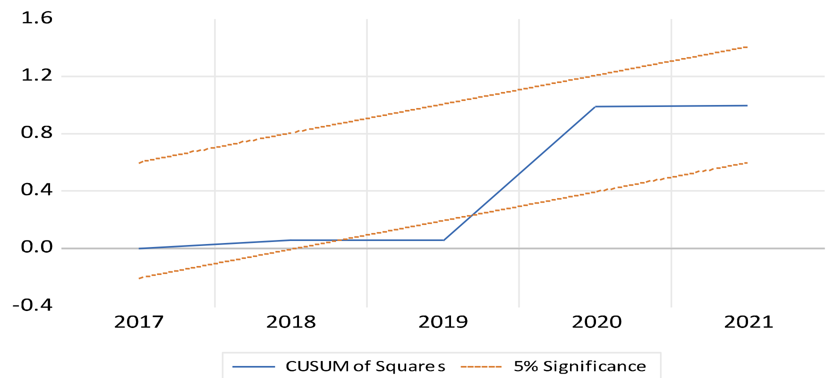

Fig. 2: Plot of cumulative sum of squares of recursive residuals

5.0 Conclusions and Policy Recommendations

This study examined the relationship between renewable energy consumption and sustainable development in Nigeria from 1990 to 2021. The unit root test results revealed that some variables were stationary at level while others were stationary at first difference which necessitates the conduct of the autoregressive distributed lag (ARDL) bound test. More so, the ARDL bound tests revealed that longrun cointegration exist among the variables, and makes it imperative to conduct the long-run and short-run relationship between the dependent and independent variables using the ARDL and error correction model (ECM) estimation technique.

The long run result revealed that renewable energy consumption significantly increases sustainable development, while non-renewable energy and population reduces is but insignificantly, whereas consumer price index also improves sustainable development in the long-run but insignificantly. In addition, public capital expenditure does not significantly impact poverty rate in Nigeria in the long run. The short run result revealed that renewable energy consumption has a significant positive relationship with sustainable development, non-renewable energy consumption and population has a significant negative relationship with sustainable development, while consumer price index has a negative insignificant impact on sustainable development in Nigeria.

It is therefore recommended that the Nigerian government adopt policies aimed at promoting modern renewable energy sources through investment in renewable energy technologies and partnership with private stakeholders. In addition, the government should put in place birth control policies and capacity building programmes for the development of the human capital resources, with the intention of equipping the manpower needed to man renewable energy technology plants in the country. Furthermore, renewable-resources actors and government should invest massively in public education that will enhance consumer and policy choices.

References

Adewuyi, A.O. & Awodumi, O.B. (2020). Environmental pollution, energy import, and economic growth: evidence of sustainable growth in South Africa and Nigeria. Environmental Science and Pollution Research 1–35.

Adu, D., & Denkyirah, E. (2019). Economic growth and environmental pollution in West Africa: Testing the environmental Kuznets curve hypothesis. *Kasetsart Journal of Social Sciences,* 40(2), 281-288.

Alvarez-Herranz, A., Shahbaz, M. & Cantos, J. M. (2017). Energy innovation and renewable energy consumption on the correction of air pollution levels, *Energy Policy, 105,* 386-397.

Belaid, F. & Youssef, M. (2017). Environmental degradation, renewable and non-renewable electricity consumption, and economic growth: Assessing the evidence from Algeria. *Energy Policy,* 102, 277-287.

Bhattacharya, M., Churchill, A. A. & Paramati, S. (2017). The dynamic impact of renewable energy and institutions on economic output and CO2 emissions across regions. *Renewable Energy, 111,* 157-167.

Bhattacharya, M., Paramati, S.R., Ozturk, I. & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy, 162,* 733-741.

Boontome, P., Therdyothin, A. & Chontanawat, J. (2017). Investigating the causal relationship between non-renewable and renewable energy consumption, CO2 emissions and economic growth in Thailand. *Energy Procedia, 138,* 925-930.

BP p.l.c., *bp Energy Outlook, London, United Kingdom*, 2022

Chen, W. & Lei, Y. (2018). The impacts of f renewable energy and technological innovation on environment-energy-growth nexus: New evidence from a panel quantile regression. *Renewable Energy, 123,* 1-14.

Cowan, W. N., Chang, T., Inglesi-Lotz, R., & Gupta, R. (2014). The nexus of electricity consumption, economic growth and CO2 emissions in the BRICS countries. *Energy Policy*, *66*, 359-368.

Cherni, A. & Jouini, E. S. (2017). An ARDL approach to the CO2 emissions, renewable energy and economic growth nexus: Tunisian evidence. *International Journal of Hydrogen Energy, 42(*48), 29056-29066.

Destek, M. & Sinha, A. (2020). Renewable, non-renewable energy consumption, economic growth, trade openness and ecological footprint: Evidence from organisation for economic Co-operation and development countries. *Journal of Cleaner Production, 242,* 118537.

Dogan, E. (2016). Analyzing the linkage between renewable and non-renewable energy consumption and economic growth by considering structural break in time-series data. *Renewable Energy, 99,* 1126-1136.

Engelman, R. (2013). Beyond Sustainable Instate of the World: Is Sustainability Still Possible? Washington DC: Island Press.

Eurostat (2021) Renewable energy statistics, Eurostat statistics explained. Web resource. http://ec.europa.eu/eurostat/statistics-explained/index.php/Renewable_energy_statistics

Frankfurt School (2018) Global Trends in Renewable Energy Investment 2018, Frankfurt School – UNEP Collaborating Centre, Frankfurt School of Finance & Management, Frankfurt. https://drive.google.com/file/d/1SmhaI-WAcmEMqR8R9oL5Fxn0cZ0kfY8Z/view

Grabara, J., Tleppayev, A., Dabylova, M., Mihardjo, L. W. W. & Dacko-Pikiewicz, Z. (2021). Empirical Research on the Relationship amongst Renewable Energy Consumption, Economic Growth and Foreign Direct Investment in Kazakhstan and Uzbekistan. *Energies, 14,* 332.

IEA (2021a) Addressing climate change - Policies and measures database. https://www.iea.org/policiesandmeasures/climatechange/

IEA (2021b) IEA FAQ on Renewable energy. https://www.iea.org/about/faqs/renewableenergy/

Inglesi-Lotz, R. (2016). The impact of renewable energy consumption to economic growth: A panel data application. Energy Economics 53, 58–63.

Jebli, M. B. & Youssef, S. B. (2015). The environmental Kuznets curve, economic growth, renewable and non-renewable energy, and trade in Tunisia. *Renewable and Sustainable Eenrgy Reviews, 47,* 173-185.

Jebli. M. B., Youssef, S. B. & Apergis, N. (2019). The dynamic linkage between renewable energy, tourism, CO2 emissions, economic growth, foreign direct investment, and trade. *Latin American Economic Review, 28*(2).

Kahia, M., Kadria, M., Aissa, M. S. B., & Lanouar, C., (2017). Modelling the treatment effect of renewable energy policies on economic growth: evaluation from MENA countries. *Journal of Cleaner Production*, 149, 845–855.

Kahia, M., Jebli, M. B. & Belloumi, M. (2019). Analysis of the impact of renewable energy consumption and economic growth on carbon dioxide emissions in 12 MENA countries. *Clean Technologies and Environmental Policy, 21*(1).

Kraft, J. & Kraft, A. (1978). On the relationship between energy and GNP. *Journal of Energy Development, 3*, 401–413.

IRENA (2020), Renewable Energy Statistics 2020. The International Renewable Energy Agency, Abu Dhabi.

Lee, J. W., (2019). Long-run dynamics of renewable energy consumption on carbon emissions and economic growth in the European Union. *Journal of Sustainable Development & World Ecology,* 26, 69-78.

Liu, X., Zhang, S., & Bae, J., (2017). The impact of renewable energy and agriculture on carbons dioxide emissions: Investigating the environmental Kuznets curve in four selected ASEAN countries. *Journal of Clean. Prod.* 164, 1239-1247.

Lorente, D. B., Shahbaz, M. Roubaud, D. & Ferhani S. (2018). How economic growth, renewable electricity and natural resources contribute to CO2 emissions? *Energy Policy, 113,* 356-367.

Lotz, R., & Dogan, E. (2018). The role of renewable versus non-renewable energy to the level of CO2 emissions a panel analysis of sub- Saharan Africa's Big 10 electricity generators. *Renewable Energy,* 123, 36-43.

Maji, I. (2015). Does clean energy contribute to economic growth? Evidence from Nigeria. *Energy Reports, 1,* 145-150.

Maji, I. (2017). The link between trade openness and deforestation for environmental quality in Nigeria. *GeoJournal, 82 (*1), 131-138.

Maji, I., Sulaiman, C. & Abdul-Rahim A. (2019). Renewable energy consumption and economic growth nexus: A fresh evidence from West Africa. *Energy Reports, 5,* 384-392.

Narayan, S. & Doytch, N. (2017). An investigation of renewable and non-renewable energy consumption and economic growth nexus using industrial and residential energy consumption. *Energy Economics, 68,* 160-176.

Nguyen, K. H. & Kakinaka, M. (2019). Renewable energy consumption, carbon emissions, and development stages: Some evidence from panel cointegration analysis. *Renewable Energy, 132,* 1049-1057.

Pata, U. K. (2018). Renewable energy consumption, urbanization, financial development, income and CO2 emissions in Turkey: Testing EKC hypothesis with structural breaks. *Cleaner Production, 187,* 770-779.

Raman, M. (2017). Do population density, economic growth, energy use and exports adversely affect environmental quality in Asian populous countries? *Renewable and Sustainable Energy Reviews, 77,* 506-514.

Saboori, B., Sulaiman, J. & Mohammad S. (2012). Economic growth and CO2 emissions in Malaysia: A cointegration analysis of the Environmental Kuznets Curve, *Energy Policy, 51,* 184-191.

Salahuddin, M. & Gow, J. (2014). Economic growth, energy consumption and CO2 emissions in Gulf Cooperation Council Countries. *Energy, 73*, 44–58.

Sarkodie A. S. & Owusu, P.A. (2016). Carbon dioxide emissions, GDP, energy use, and population growth: a multivariate and causality analysis for Ghana, 1971–2013. *Environ. Sci. Pollut. Res.*

Sarkodie, S. A., Adams, S. & Lervik, T. (2020). Foreign direct investment and renewable energy in climate change mitigation: Does governance matter? *Journal of Cleaner Production, 263,* 121262.

Sarkodie, A. S. & Adams, S. (2018). Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa. *Science of the Total Environment, 643*, 1590-1601.

Silva, P.P., Cerqueira, P.A. & Ogbe, W. (2018). Determinants of renewable energy growth in Sub-Saharan Africa: Evidence from panel ARDL. *Energy, 156,* 45-54.

Sinha, A. & Shahbaz, M. (2018). Estimation of Environmental Kuznets Curve for CO2 emission: Role of renewable energy generation in India. *Renewable Energy*, *119*, 703-711.

Stern, D I. (2018). The Environmental Kuznets Curve, Reference Module in Earth Systems and Environmental Sciences, *Elsevier.*

UN Commission on Sustainable Development (2007). *Report on the Fifteen Session, Economic and Social Council Official Records,* Supplement No. 9.

Waziri, S. I., Mohamed-Nor, N., Hook, L.S. & Hassan, A. (2018). Access to safe drinking water, good sanitation, occurrence of under-five mortality and standard of living in developing countries: System GMM approach. *J. Ekon. Malaysia, 52* (2), 1–13.

World Bank, Data and Statistics. World Development Indicators (WDI), Retrieved November 2022.