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Population Growth and Environmental Quality in Nigeria

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ABSTRACT:
The main objective of this study is to investigate the relationship between population growth and environmental quality in Nigeria. In the course of this investigation, population growth was dissected into two, namely rural and urban population. The data used in this study ranged between 1981 and 2022. Environmental quality (proxied by CO2 Emission) was used as the dependent variable. Variables such as urban population growth, rural population growth, real GDP per capita, and renewable energy consumption were used as independent variables. The Philip-Perron test and the ARDL Bound techniques were employed in the study. From the various findings, rural population growth does not have a significant effect on environmental quality in Nigeria, in both the short-run and long-run. It was also discovered that Environmental Kuznets Hypothesis (EKC) exists in Nigeria, based on available data and the time of this study. From the recommendations given, Nigeria has the potential to improve environmental quality through local investment and consumption of renewable energy resources, population control, and other measures that increase awareness for energy mix transition in Nigeria as a developing country. Creating awareness about the grave importance of energy mix transition in rural area is also paramount in Nigeria at this time.

KEYWORDS: *Population, Environmental quality, EKC, ARDL, Wald Test, Nigeria*

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INTRODUCTION

In the world of technology and climate change, the problem of energy consumption and transition is one of the serious debates in environmental economics. There has been a need for energy transition from non-renewable (fossil, coal) to renewable sources (biofuel, thermal, solar). The fossil fuel consumption, for example, results to the emission of carbon into the atmosphere which, according to Asogwa and Anumudu (2022), necessitates the rationalisation of energy transition as a sustainable source of energy for the reduction of global warming caused by Carbon Dioxide (CO2) emissions and, at the same time, improving the growth of Nigerian economy.

However, urbanization has become a major trend in today's world. According to Nizic and Baresa (2013), a large proportion of the world's population is living in urban centers, and by a projection, the proportion of the global population living in urban centers will grow by 60% by the end of 2030. From 2000 to 2015, the urban population growth rate in Sub-Saharan African countries increased from 24.63% to 67.23%; and

globally speaking, urban population growth is close to 55% of the world population, and this percentage is believed to increase to 68% by the end of 2055 (United Nations, 2018; Alnour *et al.*, 2022). However, the struggle to migrate to cities keeps rising, and the rate is higher in the developing world than in the developed world (Ikporukpo, 2018). Economically speaking, the 50 biggest cities in the world have a joint gross domestic product (GDP) of 9.6 trillion Dollars; this is more than China's GDP and only second to the US economy (World Bank, 2010).
Conversely, the rural population accounts for about 70% of poor people in the developing world (IFAD, 2010). The rural area is a spatial category comprising people and other features that define a place of living related to certain patterns of human activity. However, those relationships are subject to continuous change because of advancements and migrations of people to well-developed regions within and outside their countries. Nearly half of the world's population is estimated to live in rural areas, approximately 3.3 billion people, and 90% live in rural places in developing countries, including Nigeria (Carr & Raholijao, 2014).

Population growth is important in determining the level of CO2 emissions in the environment (Shaari *et al.*, 2021); C02 emissions are less prevalent in rural areas than urban centers. Shaari *et al*. (2021) further discovered that rural population growth does not cause any change in CO2 emissions; this does not mean that rural population does not cause a change in other environmental variables such as forest reserves and energy consumption. According to Yahaya *et al*. (2020), more of the Nigerian population is concentrated in urban areas. However, there is still a need to look at how much impact on the environment is caused by those who remain and grow in rural areas, mainly poor people.

The negative impacts of population growth on the environment continue to evoke serious concern in developing countries, which lack the technical capacity for a proper energy mix transition in the modern times. These negative consequences, as listed by Theodore (2006), include depletion of non-renewable energy sources as a result of high energy consumption (coal, crude oil, etc), land degradation, climate/weather change caused by high CO2 emissions, high rural-urban migration, pollution, etc. Overdependence on non-renewable energy sources in most developing nations of the African continent is part of the reasons for widespread health-related problems and large number of human and animal deaths each year (Edeme and Nnadi, 2018); these deaths are preventable through energy transition from carbon-related to carbon-free energy sources such as solar energy. Regrettably, these green energy sources are not fully adopted in countries like Nigeria where less resources are invested in renewable energy technologies for adoption. Also in Nigeria, the increasing level of urban population has also resulted to a rise in CO2 emissions and the depletion of arable lands for the cultivation of food products for man's survival (Abughlelesha & Lateh, 2013; Sambe *et al*., 2018).

Most countries in Africa are still massively imbued into the primitive society, especially the rural population, where agriculture is their maximum source of livelihood. Massive dependence on subsistent agriculture implies a negligence of the necessary renewable technologies to move the country into the green economy, which would reduce the level of CO2 emissions exerted into the atmosphere.

Several studies have made efforts in investigating the relationship between population growth and carbon emission levels in Nigeria and outside. For instance, Shaari *et al* (2021) investigated the impact of energy use, rural population and economic growth on CO2 emissions in nine selected developing nations, using the panel ARDL method. This study found that economic growth and energy use increase CO2 emissions in both the long-run and short-run, while rural population growth does not affect CO2 emissions in the short-run. On the contrary, Yahaya *et al* (2020) discovered that economic growth reduces environmental pollution in Nigeria; energy resources, population density and income growth increases environmental degradation in the short-run. Using a stepwise regression and an error correction (ECM) models, Asogwa and Anumudu (2022) examined the effects of renewable energy use on output growth convergence, and the impacts of renewable energy use for an alternative to the reduction of carbon emission (CO2) levels in sub-Saharan Africa. One of the important contributions made is that adoption of renewable energy is insignificant as a solution to the reduction of CO2 emission in the selected countries under study. Because there is low level of policies guiding the adoption of renewable energy technologies in the region. More so, using the ARDL Bound technique, Purnama *et al.* (2020) found that urbanisation has no significant influence on environmental quality in Indonesia; also, the study found that the Environmental Kuznets Hypothesis does not exist in Indonesia because growth in the country's GDP increases CO2 emission levels in the country, which adds to the environmental debate faced by any country on the verge of growth and advancement. In line with various identified problems, the main objective of this study is to investigate the relationship between population growth and environmental quality in Nigeria, with specific objectives which include the following: (i) Analyse the relationships that exist among rural and urban population growth rates and environmental quality in Nigeria (ii) Investigate the effect of rural population growth on environmental quality in Nigeria (iii) Investigate if there exists a long-run relationship between economic growth and environmental quality in Nigeria.

LITERATURE REVIEW

Theoretical Background

This study adopts the neoclassical model and the Environmental Kuznets Curve (EKC) hypothesis. First, the neoclassical model assumes that population growth increases the level of poverty in a country, especially in a developing country. Scarcity of land and housing facilities motivates poor people to move to ecologically sensitive areas, thereby causing environmental degradation as a result of exploitation of natural resources (Jhingan, 2013). The realities of poor waste disposal and management, as well as local production technology indicate a poor situation of a people and non-implementation of environmental policies in a country (Adejumo, 2020).

The Environmental Kuznets Curve Hypothesis, on the other hand, argues that the quality of the environment is related to GDP per capita in the form of an inverted-U, such that the higher the growth of economic activities in a country, the lower the amount of poor people in the country, in terms of their per capita income (Owolabi *et al*, 2019). Consequently, education, health and poverty, among a variety of economic indicators, are related to GDP per capita. Maintaining a good environment helps to improve these economic actors. From the EKC argument, initially, economic growth worsens environmental quality as growth requires more resources to produce and consume goods and services, which results in more pollution and waste; Kuznets refers to this as a scale effect. As the economy advances in time, it brings a structural change from energy intensive-based activities to less pollutant technology-based activities, replacing the old with green technologies. This new process consequently improves environmental quality, creating an inverted U-shaped relationship between pollution and economic growth (Ulucak & Bilgili, 2018). This is referred to as technical and composition effect.

Modern studies confirm that as economic activity rises, the level of environmental damage is corrected. This comes majorly from technical factors rather than a mere reduction in the consumption of environmental resources. Most modern contributions to this theory believe that the EKC should be an N-shaped relationship between environmental quality and economic growth. The latest theoretical development assumes that if innovation potential is fully exhausted, then the technological obsolescence effect might outgrow the scale effect and ultimately damage the environment more drastically, creating an N-shaped Environmental Kuznets Curve (EKC) (Lorente and Alvarez-Herranz, 2016). Relating the EKC hypothesis to population growth, it can be stated that population growth worsens environmental quality due to factors such as higher fossil fuel consumption, contaminated water, carbon dioxide (CO_2) emissions, poor sanitation and so on. The negative consequence of a fall in environmental quality is low level of GDP per capita (Owolabi *et al*, 2022), which results when population growth does not match up with GDP growth.

Edeme and Nnadi (2018) assess the effect of the urban population growth rate on the sustainability of the environment in Nigeria. The study utilizes the Autoregressive Lag estimation technique and found that urban population growth significantly increases renewable energy consumption but causes forest reserves in Nigeria to decrease.Using a sample of 43 sub-Saharan African (SSA) economies from 1995 to 2018, and applying the dynamic panel technique and GMM technique in their study, Rakshit *et al.* (2023) discovered that a rise in the poverty gap and urbanization increases environmental degradation in SSA countries. Alnour *et al*. (2022) utilized the Morlet Wavelet Coherence technique and the SVAR technique to discover that hydropower plays an essential role in the fight against environmental pollution in Sudan.

More so, Ali et al. (2023) assessed the tripartite relationships among agricultural production, economic growth, and environmental pollution in Sub-Saharan African countries. The study utilizes a Panel research design with data ranging between 1997 and 2020. From the model of agricultural production, the result shows that economic growth increases agricultural production when the interaction term between GDP and FDI is included in the model. Amaefule *et al*. (2022) examine climate change's influence on agricultural productivity in Nigeria, with time series data ranging between 1960 and 2019. The study utilized ARDL-bound results and revealed a long-run relationship between climate change and agricultural productivity in Nigeria. This also implies that CO_2 intensity and emissions negatively impact crop and food production in Nigeria in the long run;

Okogor (2022) empirically assesses the impacts of economic growth and environmental quality on human health status in Nigeria. The findings revealed a long-run relationship between health (proxied by life expectancy) and the explanatory variables included. More so, economic growth and the linear combination of access to improved water sources and access to improved sanitary facilities all significantly improve health status in Nigeria; CO2 emissions significantly reduce life expectancy in Nigeria. Ojo and Amassoma (2021) utilized the ARDL bound analysis and discovered that population growth, Agriculture, Forestry, and Fishing positively and significantly impact economic growth in Nigeria. Using primary research design in their study with 700 structured questionnaires, and descriptive and inferential statistical techniques, Ogunbode *et al*. (2023) revealed that 59.3% of both waste/noise management strategies, green economy adoption, and standard of living explain the economic effects of pollution in Iwo. The study moves further to conclude that economic factors that influence pollution in the two metropolises of Ibadan and Iwo differ, and because of this, great efforts should be made towards resolving pollution-related matters using economic indices described and used in the study.

METHODOLOGY

Model Specification

Following from the theories described above, the relationship between population growth and CO2 emissions can be captured thus:

$$\text{CO2 emissions} = f(\text{POP}) \qquad 3.1$$

To examine the non-linear relationship in the EKC hypothesis, the Cobb-Douglas production function is applied. Aside the econometric discussions of non-linear relationships in Gujarati (2013), Asogwa and Anumudu (2022) adopt the Cobb Douglas technique in assessing the effects of renewable energy use on output growth, anchoring their study on the Solow growth model. This production function is one of the varieties commonly used to translate a non-linear relationship between one or more regressors and a regressand. The non-linear model of eqn 3.1 can be stated thus:

$$\text{Log}(Y)_i=\text{Log}[\beta_1 X_{1i}^{\beta_2} X_{2i}^{\beta_3} \varepsilon^{ui} \qquad 3.2$$

Where Y is output; X_{1i} is labour; X_{2i} is capital.
βsare parameters in the model.
Taking the natural log of both sides of eqn 3.2 in order to linearize the model, disaggregating the population variable in eqn 3.1, and introducing other control variables, eqn 3.2 can be condensed as follows:

$$\text{InCo2}_t = \text{in}\beta_1 + \beta_2\text{InRUR}_t + \beta_3\text{InURB}_t + \beta_4\text{InRGDPPC}_t + \beta_5\text{InREN}_t + u_t \qquad 3.3$$

Where CO2 = Carbon emissions from gaseous fuel consumption;
RUR = Rural population Growth; URB = Urban population growth; RGDPPC = Real GDP per capita; and REN = Renewable energy consumption.
If we let $\alpha = \text{in}\beta_1$, eqn 3.3 is transformed into a log-log model such as eqn 3.4 below.

$$\text{InCo2}_t = \alpha + \beta_2\text{InRUR}_t + \beta_3\text{InURB}_t + \beta_4\text{InRGDPPC}_t + \beta_5\text{InREN}_t + u_t \qquad 3.4$$

Objective One

Estimating eqn 3.4 gives the parameter estimates and the overall joint influence of the coefficients of the regressor on CO2 emissions. From objective one, we carry out some restrictions on the short-run and long-run coefficients of rural and urban population growth rates to understand how they influence the dependent variable in the short-run, such that

$$\beta_i = 0; \beta_j = 0 \qquad 3.5$$

i for rural population parameter estimates; j for urban population parameter estimates.
The results of the above null hypotheses reveal the population growth and environmental quality nexus in a disaggregated form. In these hypotheses, we also understand which variable impacts more on the environment than the other between rural and urban population growth rates. In order to achieve this purpose, we use the ARDL Wald Test, which is discussed in the estimation techniques below.

Objective Two & Three

To understand the long-run and short-run effects of rural population growth on environmental quality in Nigeria, we estimate equation 3.4 using the ARDL technique. The ARDL model is adapted from Asogwa and Anumudu (2022).

$$\Delta InY_t = \alpha + \sum^{p}_{i-1}\beta\Delta_i InY_{t-i} + \sum^{q}_{i-1}\beta_i\Delta InX_{t-i} + ECM(-1) + u_t \qquad 3.6$$

Eqn 3.6 shows a mix of current and previous values of the dependent and independent variables, which defines the dynamic nature of the ARDL (p, q) model. P stands for the autoregressive nature of the regressand, while p stands for the distributive nature of the regressors included in the model. The ECM(-1) stands for the Error Correction Term which defines the short-run dynamics of the model.

Y = CO2; X = Rural population growth, urban population growth, real GDP per capita, and renewable energy consumption.

RESULTS AND DISCUSSIONS

Philip-Perron unit root test carried out in this study revealed that data for CO2 emission and renewable energy consumption are stationary at levels, 1(0), real GDP per capita is stationary at first difference, 1(1), while rural and urban population are stationary at second difference, 1(2). Stationarity at 2nd difference, more interestingly, is not a new discovery in economics. According to literature, the issue of structural break on time series data is one of the weaknesses of the commonly used Augmented Dickey Fuller and the PP tests in checking for unit root in a variable (Siddha et al, 2020). When there is structural break in the data, the ADF and the PP procedures have low power in detecting for unit roots in the data; it becomes difficult to reject the null hypothesis of non-stationarity of the variables involved while using the two methods. The ADF and PP unit root tests assume only one unit root in a variable. According to Gujarati (2013), data integrated of order two, 1(2), implies that there is more than one unit root in data, and the commonly used ADF and PP tests are not suitable in investigating the stationarity of the data. Despite the recommendation of a Toda Yamamoto VAR analysis by Siddha et al (2020) in cases of stationary at 2nd difference, there is high possibility of structural breaks on the rural and urban population data used in this study, which could be solved using a stronger stationarity test other than the ADF and the Philip-Perron (PP) tests. This investigation is outside the scope of this study.

The unit root test result did not show whether or not long-run equilibrium relationships exist in the equation system, which necessitated carrying out a con-integration test. Before carrying the co-integration test, we determined the maximum lag length for our model using the Akaike Information Criteria (AIC). A maximum lag length of two is better for time series data, as recommended by Pesaran et al (2001). The Akaike Information Criteria (AIC) is mostly used in determining the lag length. Determining the lag length in small sample size, the Schwarz Bayesian Information Criterion (SBIC) is superior (Lutkepohl, 2005); the smaller the lag length, the better the model results.In this study, the AICimplied that a lag length of 6 is optimal. This is supported by Hannan-Quinn and FPE criteria. As a result, the study's maximum lag length is 6. This study employed a lag length of 2 in estimating the ARDL models.

From the co-integration result, the F-statistic (8.4895) is greater than the lower and upper bounds at both 1%, 5%, and 10% levels of significance. This is a strong statistical/econometric evidence for a co-integrating equation system. We concluded that, using each of the variables as a dependent variable and the rest as independent variables, the equations formed depict a long-run equilibrium relationship in the system. From here, we estimated both the long-run and the short-run ECM forms of the ARDL Model as showed below.

Short-run and Long-run Results

Rural Population: The coefficient of rural population (-0.4781) shows that rural population has a negative relationship with CO2 emissions in the long-run, which means that the higher the growth of rural population, the lower the rate of emissions. This result does not conform to a priori, as we expected a positive relationship between the two variable. More importantly, this coefficient is statistically insignificant (p-value=0.5526), implying that rural population growth does not have a long-run statistical impact on CO2 emissions.The first impression from the ECM result is that rural population does not have a short-run impact on CO2 emissions in Nigeria, which also implies that rural population growth is not a significant factor in determining the level of emissions in Nigeria, in both short-run and long-run periods. Also, renewable energy consumption does not have a short-run impact on emission level, as confirmed on the ECM result. Consumption of green energy in Nigeria is insignificant in determining emission levels in both the short-run and long-run.

Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LRUR	-0.478158	0.794302	-0.601986	0.5526
LURB	2.772864	0.652907	4.246949	0.0003
LRGDPPC	-0.848564	0.226475	-3.746839	0.0009
LREN	2.569642	1.287988	1.995082	0.0570
Short-run ECM Regression result				
D(LURB)	19.76821	7.764955	2.545824	0.0174
D(LURB(-1))	-1.555448	10.51374	-0.147944	0.8836
D(LURB(-2))	20.77516	8.153693	2.547945	0.0174
D(LRGDPPC)	-2.216331	0.507064	-4.370910	0.0002
D(LRGDPPC(-1))	0.942865	0.568394	1.658821	0.1096
D(LRGDPPC(-2))	1.524223	0.519046	2.936587	0.0070
D(LRGDPPC(-3))	1.119409	0.498613	2.245046	0.0339
CointEq(-1)	-1.341158	0.171543	-7.818218	0.0000
R-squared	0.777448	Mean dependent var		0.021015
Adjusted R-squared	0.725519	S.D. dependent var		0.079628
S.E. of regression	0.041718	Akaike info criterion		-3.331112
Sum squared resid	0.052211	Schwarz criterion		-2.986357
Log likelihood	71.29114	Hannan-Quinn criter.		-3.208451
		Durbin-Watson stat		2.213894

Table 1.*Source: Author's Computation using E-Views 12*

Urban Population: The coefficient of urban population (2.7728) shows that urban population has a positive relationship with CO2 emission in the long-run, which also means that if population of people in urban centres rises by 1%, CO2 emission levels in Nigeria will more than double (2.77%) in the long-run. This estimated coefficient is statistically significant at 5% level, meaning that urban population growth has a long-run statistical impact on CO2 emission level in Nigeria, and this relationship conforms to a priori expectation. The coefficients of urban population reveal that the growth of urban population in the previous year causes emission levels to drop by 1.56% in the current year; in the previous two years, growth of urban population causes emission level to rise by 20.78% in the current year. It is still being expected that population growth in many past years would cause emissions to rise because of the non-popularity of the alternative sources of energy many years back. Recent changes in urban population is expected to have a negative effect of CO2 emissions due to massive awareness of green energy technologies, despite their scarce use in Nigeria due to the developing nature of the society.

On the ECM, the coefficients of urban population reveal that the growth of urban population in the previous year causes emission levels to drop by 1.56% in the current year; in the previous two years, growth of urban population causes emission level to rise by 20.78% in the current year. It is still being expected that population growth in many past years would cause emissions to rise because of the non-popularity of the alternative sources of energy many years back. Recent changes in urban population is expected to have a negative effect of CO2 emissions due to massive awareness of green energy technologies, despite their scarce use in Nigeria due to the developing nature of the society.

Real GDP per capita: The Coefficient of economic improvement in Nigeria (-0.8485) shows that real GDP per capita has a negative relationship with CO2 emissions in the long-run, and this relationship is statistically significant at 5% level. If GDP per capita increases by 1% in the long-run, emission level will drop by 0.85%. Based on A priori, the relationship between CO2 emissions and real GDP per capita conforms to what is expected from the EKC hypothesis which states that, initially, growth of economic activities causes the CO2 level to increase up to a certain point, when it starts dropping as per capita income of people and technology switching keep rising. Hence, for us to have the inverted U shape of the EKC, this relationship is expected to be positive in the short-run. Real GDP per capita in the previous times, however, conform to a priori expectation. In the short-run, growth of economic activities in Nigeria leads to growth of emission level in both the first, second, and third-year lags (0.94%, 1.52% and 1.12%); the short-run and long-run results confirm the application of the EKC hypothesis for Nigeria, using available.

Wald Test Result

Wald Test:
Equation: Untitled

Test Statistic	Value	df	Probability
F-statistic	1.941904	(3, 25)	0.1487
Chi-square	5.825712	3	0.1204

Null Hypothesis: C(1)=C(2)=C(3)=0

Table 2. *Source: E-Views Result*

A restriction was placed on the short-run coefficient of the urban population. The table 2 above shows that the three coefficients of urban population are jointly insignificant, which implies that, in the short-run, urban population growth in the previous periods does not have a joint significant impact on emission levels in Nigeria. The probability value of the F-statistic is greater than 0.05 level of significance.

CONCLUSIONS

Among the basic findings in this study, the following conclusions were reached:

1. Rural population has a negative effect on CO2 emission in the long-run and this relationship is insignificant. Migration is one of the factors that bring about this negative effect; from rural areas, Nigerians migrate to cities where they utilise more fossil energy sources, thereby emitting more carbon into the atmosphere. In investigating the effects of rural population growth on environmental quality, such factors need to considered such as, ecological footprint, forest cultivation, and other harmful emissions into the atmosphere.

2. The positive significant effect of urban population growth on CO2 emission level in Nigeria is more than double. A 2.78% growth of emission levels caused by urban growth implies that urbanisation is a huge factor that increases carbon emission level in Nigeria and possibly in other developing nations who depend so much on fossil energy resources for survival.

3. The ECM result has shown that urban population in the previous year improves environmental quality due to the negative relationship with CO2 emission level; the previous two to three years cause environmental quality to fall due to their positive relationship with emission levels.

4. The ARDL resultsalso showed the existence of the EKC in Nigeria. First, the short-run result revealed that the growth of real GDP per capita within the three years lag all have positive relationships with emission level, which implies a reduction environmental quality in the short-run. In the long-run, the relationship between real GDP per capital and CO2 emission turns downward (-0.8485), showing a negative relationship, which also implies that environmental quality improves as economic activities continue to grow in the future.

5. There is a long-run positive relationship (2.57%) between renewable energy consumption and CO2 emissions in Nigeria. Explaining further, Nigeria has the potential to improve environmental quality through massive local investment and consumption, adoption of government policies on renewable energy technologies, population control, and other measures that increase awareness for energy mix transition.

6. The long-run result has shown that urban population has a significant impact on CO2 emission; rural population does not. In the short-run, rural population has no significant impact on emission levels, while urban population at different stages has a no joint significant effect on emission levels in Nigeria. Hence, we conclude that urban population growth has more significant effect on CO2 emissions than rural population growth in Nigeria. According to Shaari *et al.* (2021), C02 emissions are less prevalent in rural areas than in urban centres. This conclusion is expected due to the fact that CO2 emissions are more popular in urban centres than rural centres. This does not imply that environmental quality is better protected in rural areas than urban. Just as observed in cities, a great number of Nigerians in the rural areas are still using traditional sources of cooking, occupying agricultural lands, cutting down trees and making charcoals for cooking. Sources of biomass energy in small settlements and villages are charcoal, fuelwood, and agro-wastes such as palm Kernel shell, palm fruit fiber.

Policy Implications

The main objective of this study is to examine the relationship between population growth and environmental quality in Nigeria, disaggregating population into rural and urban growth. It was found that rural population has a negative effect on CO2 emission in the long-run and this relationship is insignificant. The implication of this relationship could be viewed from the angle of rural-urban migration. Migration to cities is very popular in the world, and this could also be a good reason why urban population growth has more significant effect on emission levels. The negative impact of rural population implies that rural population growth brings about reduction in CO2 emissions, which is an improvement in environmental quality. Migration is one of the factors that bring about this result, as people migrate to cities where they utilise fossil energy, thereby emitting more carbon into the atmosphere. This result does not mean that rural population has no effect on other variables attributed to rural areas, which are commonly used to define environmental quality; such variables include, ecological footprint, forest cultivation, and other harmful emissions into the atmosphere.

The statistical significance of urban population growth has a double effect on environmental quality in Nigeria. This is because, according to literature, urban population growth is known to have more effect on environmental quality. A 2.78% growth of emission levels caused by urban growth implies that urbanisation is a huge factor that increases carbon emission level in Nigeria and possibly in other developing nations who depend so much on fossil energy resources for survival. This is in line with the findings from Asogwa and Anumudu (2022). Poor adoption of renewable energy policies is one of the reasons why urban growth causes the environment to depreciate in quality. The realities of poor waste disposal and management in both urban and rural areas, as well as local production technology, indicate a poor situation of a people and non-implementation of environmental policies in a country (Adejumo, 2020). This is the case in Nigerian cities and local areas. The ECM result has shown that urban population in the previous year improves environmental quality due to the negative relationship with CO2 emission level; the previous years cause environmental quality to fall, and this is expected because the concept of renewable energy was not so popular in the past years than what is obtainable in recent times. The short-run result also implies that continuous adoption of alternative sources of energy would continue to improve environmental quality, especially in urban centres where energy is massively in use for economic growth and technological advancement.

Environmental Kuznets Hypothesis is one of the theories used to back up the model for this study. According to the theory, environmental quality is related to GDP per capita in the form of an inverted-U, such that the higher the growth of economic activities in a country, the higher the GDP per capita, the lower the amount of poor people in the country in terms of their per capita income (Owolabi et al, 2019). Initially, economic growth worsens environmental quality as growth requires more resources to produce and consume goods and services, which results in more pollution and waste; Kuznets refers to this as a scale effect. As the economy advances in time, it brings a structural change from energy intensive-based activities to less pollutant technology-based activities, replacing the old with green technologies. This new process consequently improves environmental quality, creating an inverted U-shaped relationship between pollution and economic growth (Ulucak and Bilgili, 2018). The ECM result also showed that the EKC exists in Nigeria. First, the short-run result revealed that the growth of real GDP per capita within the three years lag all have positive relationships with emission level, which implies a reduction environmental quality in the short-run. In the long-run, the relationship between real GDP per capital and CO2 emission turns downward (-0.8485), showing a negative relationship, which also implies that environmental quality improves as economic activities continue to rise in the future. And Nigeria has the potential to tap from renewable energy sources by investing in the right technologies for massive growth and socio-cultural advancements.

Generally speaking, population growth in Nigeria seems uncontrollable. Nigeria has the potential to improve environmental quality through massive investment and local consumption, population control and other measures that would increase awareness for energy mix transition. This argument is supported by the long-run positive relationship (2.57%) between renewable energy consumption and CO2 emissions in Nigeria. This positive relationship implies that, until Nigerians begin to adopt renewable energy policies, these alternative sources of energy may not solve the emission problem in Nigeria. Supporting this claim, renewable energy consumption has no short-run effect on emission in Nigeria, which reveals that the adoption of renewable energy sources only have a long-run positive effect on environmental quality if energy policies are fully adopted, especially in the process of tapping from local endowments, which are cheaper than the imported technologies.

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