Population structure and environmental degradation: Implication for EKC hypothesis

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ABSTRACT

The primary objective of this paper is to test the hypothesis that population age structure could contribute to carbon dioxide emission level (environmental degradation) in Nigeria. Real income (Gross Domestic Product) was used as another determinant of CO₂ emissions to test the EKC hypothesis in this study. Also, autoregressive distributed lag (ARDL) econometric technique was applied in this paper to annual time series data from 1970 to 2018. The results show that age structure's influence on environment is significant. As expected, young adults (LOGYONG, i.e., ages 15-64) and children (LOGCHL, i.e., ages 0-14) are environmentally intensive (due to energy-intensive goods consumed). But the older age group (LOGOLD i.e., ages 65 and above) exert a negative effect. The results of long-term estimation for the population structure-induced EKC hypothesis show that none of the coefficients of economic growth were statistically significant at any of the conventional levels. In other words, this finding did not prove the existence of EKC hypothesis. However, appropriate macroeconomic policies, technological innovations and institutional developments are very important in maintaining a sound environment in Nigeria.

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Introduction

The population of the world keeps increasing, despite at a sluggish speed than at any time since 1950, based on fertility reduction. From approximately 7.7 billion people worldwide in 2019, the medium-variant projection shows the global population sprouting to about 8.5 billion in 2030, 9.7 billion in 2050, and 10.9 billion in 2100 (United Nation, 2019).

However, swift outgrowth of human population is usually established as a key factor behind environmental degradation. Environmental degradation is responsible for irritation and environment in turn affect human beings' social behavior. Even though the problems of population expansion and environmental sustainability predominant in the least developed countries in sub-Sahara Africa and South Asia, the global implications is devastating (Hunter, 2000).

In 1992 when the United Nations Conference on Environment and Development was held in Rio de Janeiro, regenerated stimulus was accorded to the research topic of population growth and the environment (United Nation, 1994). However, this paper focuses on the population age structure effect on environment. This is because changes in the size of populations are definitely culminating in changes in the age-structure of populations. Youthful populations are associated with countries that exhibit high population growth, on the other hand, countries that experience low population growth tend to have an aging population. Changing age structure does not impact on consumption and production only; the balance between returns to and investment in the various factors of production

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are equally influenced. They exert significant influence on labor markets, wages and income distribution, current and future output (Lewis, 1954; Fei and Ranis, 1964) and most definitely environmental condition.

Invariably, including population characteristics aids in clarifying part of the mechanisms through which population influence environmental conditions. Unfortunately, the extent to which attention is paid to this issue is less. Against this background, the main objective of this paper is to empirically examine the effect of population structure on environment degradation. The emphasis is on Nigeria, one of Africa's mostly densely populated countries, with approximately 200 million people in an area of 920,000 km² (360,000 sq mi) (Akinyemi and Isiugo-Abanihe, 2014).

In addition, it is the country with the largest population in Africa (CIA, 2018) and in the world; it has the seventh largest population (CIA, 2019). Nonetheless, humans need to interact with the environment to obtain food, water, fuel, medicines, building materials and many other things. Advances in science and technology have helped to exploit the environment for benefit, but it has also introduced pollution and caused environmental damage. This raises the specific questions research question: does the population age structure (in terms of age-specific consumption of energy-intensive goods) contribute to environmental degradation (carbon dioxide emission level) in Nigeria? In the same vein, it was hypothesized (H_0) in this paper that population age structure does not contribute to environmental degradation in Nigeria. This hypothesis was tested within the Environmental Kuznets Curve (EKC) framework which allows testing the inverted U-shape of the pollution-income relationship.

The plan of this paper is as follows: Section II discusses related literature review; Section III provides an overview of population structure of Nigeria. Econometric methodology including model specification as well as data sources and technique of analysis are discussed in Section IV. The empirical results are presented and discussed in Section V, while the Section VI presents summary, conclusion and suggestions.

Literature Review

Theoretical Review

In the field of population and environment several theories leverage on theoretical presentations from considerable number of fields. In a nutshell, neo-Malthusianism opines that human populations, by reason of their propensity to expand expeditiously if fertility is unrestrained, will eventually surpass Earth's resources, entailing ecological catastrophe. This paradigm has long displayed dominance as far as the field of population and the environment is concern, nonetheless, numerous social scientist have dismissed it due to its underlying biological/ecological underpinnings, treating humans in an undistinguishable approach from other species that extend beyond the local "carrying capacity" (de Sherbinin et al., 2007). Nevertheless, the so-called Boserupian hypothesis, posit that agricultural production enhance population growth due to the heightening of production (greater labor and capital inputs) (de Sherbinin et al., 2007).

Majority of political ecologists recognize population and environment as connected solely inasmuch as they possess conventional root cause, e.g., poverty, and that poverty intrinsically originates from economic disparity between the developed and developing world and in the compass of developing countries themselves (e.g., Gray and Moseley, 2005). Notwithstanding, the intermediate (or mediating) variable theory (Jolly, 1994) or the holistic approach (Chi, 2005) views population's impact on the environment as been arbitrated by social organization, technology, culture, consumption, and values (McNicoll, 1992; Keyfitz, 1991).

Furthermore, the vicious circle model (VCM) seeks to demystify sustained high fertility in spite of dwindling environmental resources (Dasgupta, 1995; O'Neill et al., 2001). The focal point of this model's hypothesis is that there are a number of positive feedback loops that contribute to a descending spiral of population growth, resource depletion, and rising poverty.

It is worth noting that population-environment theories may concurrently run at divergent levels, and thus could all possibly be right.

Empirical Studies

Considerable number of studies have been conducted illustrate how population influence environment. Southgate (1994) examined data from 24 Latin American countries to ascertain the genesis of agricultural frontier expansion and hence of forest clearance. The outcome shows that the enlargement of the agricultural frontier was positively correlated with both population growth and agricultural export growth and negatively related to the growth of agricultural yields.

In 1994, a set of crucial ideas for comprehending population-environment dynamics was presented by Drake. According to him, the complex dynamics of population and the environment should be visualized as a family of transitions. He describes nine different sets of transitions: demographic, epidemiologic, forestry, energy, education, urbanization, agriculture, technology, and toxicity, and recommended that attempts should be made to investigate their interconnectedness in order to comprehend the dynamics of population and the environment.

Cramer (1998) and Cramer and Cheney (2000) investigated the influences of population growth on air pollution in California. The study revealed a positive relation only for some sources of emissions but not for others. Dietz and Rosa (1997) and York, Rosa and Dietz (2003) employing the framework of the IPAT model, evaluated the effect of population on carbon dioxide emissions and energy

use. The results from these studies indicated that the elasticity of CO₂ emissions and energy use with respect to population are close to unity.

Ghanem (2018) established a multi-equation model based on the recursive equation system in order to empirically examine the relationship between population growth and the environment in terms of air pollution portrayed by increased CO₂ emissions, health level proxy by the mortality and morbidity due to air pollution, and labour productivity portrayed by GDP per hour worked, and using a time series data set for Egypt spanning 1950–2010. The findings are as follows: (1) In Egypt, a 1% increase in population raises the CO₂ emissions by 2.4%. (2) An increase in CO₂ emissions by 1% is associated with an increase in deaths due to outdoor air pollution (respiratory and cardiovascular diseases) by 2.5%.

In addition to the above mentioned studies, several studies have discussed and tested the existence of an environmental Kuznets curve (EKC) where the relationship between pollution and income is considered to have an inverted-U shape. Their results differ substantially and are inconclusive (Stern, 2004; Dinda and Coondoo, 2006; Akbostanci et al., 2009; and Narayan and Narayan; 2010; Aboagye, 2017).

Many studies carried out in Nigeria have investigated either the impact of energy consumption exclusively on CO₂ emissions or the influences of energy consumption and economic growth on CO₂ emissions (Akpan and Akpan, 2012; Nnaji et al., 2013; Sulaiman, 2014; Chindo et al., 2015). However, the objective of this paper is to analysis the effect of population structure on environmental degradation (CO₂ emissions). Though an increase in population means an increase in human activities that facilitate CO₂ emissions, there is need to empirically evaluate the channels through which the observed changes in population age structure impact on CO₂ emissions (environmental degradation). No such study has been conducted in Nigeria in recent time. In addition, the investigation is based on environmental Kuznets curve hypothesis.

Population Structure of Nigeria: An overview

According to Demographic Dividend (2019), as of midyear 2016, Nigeria had a population of 186.0 million, annual population growth rate of 2.6%, and 44% of Nigeria's population was under age 15. The Total Fertility Rate, or the average number of children per woman over the course of her lifetime, has dwindled from 6.5 children in 1990 to 5.7 children per woman in 2015. Given Nigeria's high population size and population growth rate, even assuming a decline in fertility to 3.7 children per woman, the population of the country is anticipated to enlarge to over 440 million people by 2050 (Demographic Dividend, 2019).

The population pyramid in Figure 1 demonstrates the country's population age and sex structure.

The horizontal axis reveals the population spread; the left hand side depicts males while females are represented on the right hand side. Furthermore, the population of male and female are broken down into 5-year age groups. These age groups manifest as horizontal bars along the vertical axis. At the bottom are the youngest age groups and the oldest are at the top (0-14 years (children), 15-24 years (early working age), 25-54 years (prime working age), 55-64 years (mature working age), 65 years and over (elderly) (Indexmundi, 2019). It is worth mentioning that population's age structure influences a nation's principal socioeconomic issues. Those countries having young populations (high percentage under age 15) are required to expend more in schools. On the contrary, countries exhibiting older populations (high percentage ages 65 and over) are expected to invest more in the health sector). The structure of the population pyramid progressively unfolds over the years based on fertility, mortality, and international migration trends.

Figure 1: Population Pyramid of Nigeria- 2016; Source: Indexmundi (2019)

Research and Methodology

The methodology of this paper is such that a simple model is specified with annual time series data as against many studies that use cross sectional time series data with so many explanatory variables. This is because of the objective of analyzing the long run effects of population structure on environment. Rather than relying on a single econometric approach, this study employs a range of recent time series data analyzing methods such as Autoregressive Distributed Lag (ARDL) bounds testing approach to cointegration, Fully Modified Ordinary Least Squares (FMOLS) and Conical Cointegration Regression (CCR) to draws more robust results.

Specification of Model

In exiting literature, carbon dioxide is considered the main driver of air pollution and environmental quality. The main aim of this paper is to test the hypothesis that population age structure (in terms of age-specific consumption of energy-intensive goods) could contribute to environmental degradation (carbon dioxide emission level) in Nigeria. From exiting literature, real income as a measure of economic growth is used as another determinant of CO₂ emissions to test the EKC hypothesis which assumes that environmental degradation increases up to a certain level of income; after this level, it decreases.

From this point of view, the following EKC model is presented:

$$CO_2 = f(DCAN, GDP, GDP^2)$$

where CO₂ denotes carbon dioxide emissions (kt), GDP is real income, GDP² is the square of real income, and DCAN is a vector of demographic change variables. The demographic change-induced EKC model in equation (1) can be expressed in logarithmic form to avoid outliers and extremer's and to capture its long-term impacts as shown below:

$$\log CO_{2t} = \pi_0 + \pi_1 \log DCAN_t + \pi_2 \log GDP_t + \pi_3 \log GDP_{2t} + \phi_t$$

where at period t, logCO₂ is the natural log of carbon dioxide emissions, logDCAN is the natural log of vector of population structue variables, logGDP is the natural log of real income, logGDP² is the square of natural log real income, and ϕ_t is the error-disturbance.

Data Source and Technique of Analysis

Data for the variables were from 1970 to 2018 and were sourced from Index Mundi data portal, Knoema.com, the Global Economy.com, and relevant literatures. The rationale behind selecting these periods is the availability of data. In order to avoid spurious regression, this study adopts the Augmented Dickey Fuller Test (ADF) to determine the stationary properties of the variables base on the recommendation of Engle and Granger (1987) that it can be used as a rough guide in applied work. Engle and Granger considered seven test statistics in a simulation study to test cointegration before finally arriving at this conclusion. Next, the ARDL bounds testing was applied.

The ARDL bounds testing approach is a cointegration method developed by Pesaran et al. (2001) to test presence of the long run relationship between the variables. This procedure, relatively new method, has many advantages over the classical cointegration tests. Firstly, the approach is used irrespective of whether the series are I(0) or I(1). Secondly, unrestricted error correction model (UECM) can be derived from the ARDL bounds testing through a simple linear transformation. This model has both short and long run dynamics. Thirdly, the empirical results show that the approach is superior and provides consistent results for small sample (Global.com, 2019).

Empirical Result and Discussion

Presentation of Results

Table 1: ADF Unit Root Test Result

Variables	Level				First difference			
	Intercept and trend				Intercept and trend			
	t-Statistic	1%	5%	10%	t-Statistic	1%	5%	10%
LOGCHIL	-2.242099	-3.577723	-2.925169	-2.600658	-2.828786	-3.577723	-2.925169	-2.600658
LOGCO ₂	-2.712036	-3.577723	-2.925169	-2.600658	-6.967454	-3.581152	-2.926622	-2.601424
LOGGDP	0.528663	-3.574446	-2.923780	-2.599925	-5.869125	-3.577723	-2.925169	-2.600658
LOGGDP ²	0.528663	-3.574446	-2.923780	-2.599925	-5.869125	-3.577723	-2.925169	-2.600658
LOGOLD	-2.724544	-3.574446	-2.923780	-2.599925	-4.409465	-3.577723	-2.925169	-2.600658
LOGPOPR	-3.433340	-3.592462	-2.931404	-2.603944	-3.868815	-3.592462	-2.931404	-2.603944
LOGYONG	-1.304990	-3.577723	-2.925169	-2.600658	-3.575471	-3.577723	-2.925169	-2.600658

Source: Author's computation using Eviews 9 software

From Table 1, the log of GDP, LOGGDP2, CHIL and YONG became stationary at first difference, while the log of OLD, CO2, POPR were stationary at level. This shows that the model is co-integration of I(1) and I(0). The best model in this case is the Autoregressive Distributive lag. To investigate the long-term relationship between the variables, the bound test for co-integration with ARDL modeling approach is adopted.

In the bound test, max lag was 1 for both dependent and independent variables, Akaike info criterion (AIC) was the default, constant was chosen for fixed regressors trend specification. From Table 2, the calculated F-statistic (3.933274) falls between the lower and upper bounds, the test is inconclusive. But anyway, the long-run equilibrium relationship between the variables was estimated. Before the ARDL modeling approach was applied, attempt was made to figure out an adequate lag length among the explanatory variables in order to remove any serial correlation. The output in Table 3 shows that the optimal lag length for the model is 1 (based on the vector autoregressive (VAR) of LR, FPE, AIC, SC and HQ) and the best criterion to adopt for the model is FPE (given the lowest value among the criteria). However, Schwartz criterion (SC) was chosen because the variables are more than 4. The relationship between the variables was investigated as the lag length has been established. Table 4 shows the ARDL model long run coefficients results. Tables 4, 5, 6 and 7 show the results of long-term estimation for population structure and environmental degradation.

Table 2: Bounds Test

Test Statistic	Value	k
F-statistic	3.381249	7

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	2.03	3.13
5%	2.32	3.5
2.5%	2.6	3.84
1%	2.96	4.26

Source: Author's computation using Eviews 9 software

Table 3: Lag length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	18.03013	NA	0.035952	-0.490228	-0.209192	-0.385461
1	25.07602	11.58657*	0.027516*	-0.758934*	-0.437750*	-0.639200*
2	25.15150	0.120761	0.028717	-0.717844	-0.356512	-0.583143
3	25.31073	0.247693	0.029873	-0.680477	-0.278996	-0.530809
4	25.75767	0.675382	0.030695	-0.655896	-0.214268	-0.491262

Source: Author's computation using Eviews 9 software

* indicates lag order selected by the criterion

LR: sequential modified LR test statistic (each test at 5% level)

FPE: Final prediction error

AIC: Akaike information criterion

SC: Schwarz information criterion

Table 4: ARDL Long Run Coefficients (without economic growth variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPR	-2.213640	1.456120	-1.520232	0.1359
LOGYONG	9.188899	2.989036	3.074202	0.0037
LOGCHIL	12.552812	5.639948	2.225697	0.0315
LOGOLD	-21.931115	6.011928	-3.647934	0.0007
C	-45.456713	12.362681	-3.676930	0.0007

Source: Author's computation using Eviews 9 software

Table 5: ARDL Long Run Coefficients (with economic growth variables)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPR	-0.085772	1.201408	-0.071393	0.9435
LOGYONG	11.882374	4.217846	2.817167	0.0077
LOGCHIL	13.580391	5.376701	2.525785	0.0160
LOGOLD	-24.103194	7.565843	-3.185791	0.0029
LOGGDP	-22.629995	22.053282	-1.026151	0.3115
LOGGDP ²	0.412150	0.415370	0.992247	0.3275
C	228.115990	278.778387	0.818270	0.4184

Source: Author's computation using Eviews 9 software

Table 6: FMOLS estimation

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPR	-1.320291	0.868284	-1.520576	0.1360
LOGYONG	7.489253	3.014578	2.484345	0.0172
LOGCHIL	22.26263	3.587426	6.205740	0.0000
LOGOLD	-29.37967	5.045339	-5.823131	0.0000
LOGGDP	10.77381	14.97923	0.719250	0.4761
LOGGDP ²	-0.216057	0.282294	-0.765362	0.4484
C	-210.5134	189.4262	-1.111322	0.2729

Source: Author's computation using Eviews 9 software

Table 7: CCR estimations

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOGPOPR	-1.166465	0.829553	-1.406138	0.1672
LOGYONG	7.441503	2.696645	2.759541	0.0086
LOGCHIL	22.68581	4.073809	5.568698	0.0000
LOGOLD	-29.69774	5.444657	-5.454474	0.0000
LOGGDP	10.40781	14.08816	0.738763	0.4643
LOGGDP ²	-0.209771	0.265206	-0.790974	0.4335
C	-207.2815	178.3352	-1.162314	0.2518

Source: Author's computation using Eviews 9 software

Discussion

According to the results of long-term estimation for population structure and environmental degradation in Tables 4, 5, 6 and 7, age structure's influence on environment is significant and in some cases reasonably large. Table 4 depicts the ARDL Long Run Coefficients, as expected, young adults (LOGYONG, i.e., ages 15-64) and children (LOGCHIL, i.e., ages 0-14) are environmentally intensive (due to energy-intensive goods and services consumed, e.g., emissions from the combustion of fuel from all transport activity and residential electricity consumption in the use of cooling and heating machines, water heater, washer and dryer, lighting, refrigerator, electric oven, Television and DVD player, dishwasher, microwave, computer, etc. Note, the working population is found mid-way in the age bracket of 15-64. Increasing working population means more money and there is likelihood that it will be spent on electronic gadgets and motor vehicles. No doubt, this has directly influenced air pollution and the use of high energy). But the older age group (LOGOLD i.e., ages 65 and above) exert a negative effect—implying that population aging will have a slightly improving environmental effect. That is because older age group do not drive vehicle much as such emissions from the combustion of fuel from all transport activity by this group is less.

In particular, Table 5 shows the results of long-term estimation for the population structure-induced EKC hypothesis. Population age structure's influence on environmental degradation (CO₂ emission) has an inverse U-shaped pattern, with the children (LOGCHIL, i.e., ages 0-14) and young adults (LOGYONG, i.e., ages 15-64) age groups having positive elasticity coefficients and the older (LOGOLD i.e., ages 65 and above) group having negative coefficient. This inverted U-shaped relationship is also exhibited by economic growth. Nonetheless, none of the coefficients of economic growth were statistically significant at any of the conventional levels. In other words, this does not confirm the hypothesis of the existence of an EKC. Invariably, economic growth seems not to be the main driver of environmental degradation in Nigeria. However, Mabogunje (1995) pinpointed three elements that vigorously escalate the menace of environmental degradation in sub-Saharan Africa (Nigeria inclusive): its demographics, its substantial burden of foreign debt, and the non-existence of democracy. All over the region, a monumental extension of social services, basically in the areas of education and health care at the end of the colonial era. This gave rise to abrupt plunge in infant mortality and to a instantaneous population escalation.

Turning to the second factor, in the attempts to industrialize and supply its swiftly expanding population with modern social services, Nigeria like other countries in sub-Saharan Africa sustained substantial foreign debts. However, the challenge that transpired was more of the region's degenerating capacity to service the debt than the rising level of the debt. Sub-Saharan African countries (including Nigeria) were left vulnerable to the extended commodity prices fall that started in the 1970s all because of high dependence on the export of primary products. Not surprisingly, Nigeria just like other sub-Saharan African countries had to undergo fundamental structural adjustments. Besides involving a severe compression of imports and acute devaluation of national currencies, it also included laying off a huge part of the wage- and salary-earning population. A great number of people turned to survival agriculture as living conditions worsened in urban as well as rural area. Meanwhile, swiftly increasing prices for imported energy products pushed numerous families to fall back on wood and charcoal for their domestic energy needs. Clearly, these developments put acute strain on the environment everywhere in the region.

Thirdly, a very severe issue is the failure of majority of African governments in executing the reforms required to improve their economies. Shortly after independence, the international community spent years rationalizing (and sometimes applauding) the need for authoritarian one-party or military rule. In the course of time, these regimes turned out excessively corrupt and transparency and accountability were not regarded in the management of the countries' economies. In several countries in sub-Saharan Africa (including Nigeria), the outcome is high level of political instability and social alienation that has impaired both development activities and environmental protection.

In addition to the results of the ARDL estimation, FMOLS and CCR estimations are also presented to check the robustness of results in Table 4. In the FMOLS estimation in Table 6, population age structure's influence on CO₂ emission has an inverted U-shaped pattern, with the children (LOGCHIL, i.e., ages 0-14) and young adults (LOGYONG, i.e., ages 15-64) age groups having positive elasticity coefficients and the older (LOGOLD i.e., ages 65 and above) ones having negative coefficients. Nonetheless, none of the coefficients of economic growth were statistically significant. Hence, the EKC does not hold for this model in this case.

The results for the CCR estimations in Table 7 are quite similar in magnitude to those reported in FMOLS estimation. The bottom line is that there is no significant relationship between environmental degradation (CO₂ denotes carbon dioxide emissions (kt)), real income (GDP), the square of real income (GDP²). This conforms again the non-existence of EKC hypothesis in Nigeria.

Conclusions

The main objective of this paper is to empirically examine the effect of population age structure on carbon dioxide emission level (environmental degradation) in Nigeria. Real GDP was used as additional determinant of CO₂ emissions to test the EKC hypothesis in this paper. For this purpose, annual time-series data were analyzed for Nigeria over the period 1970-2018 with the autoregressive distributed lag (ARDL) framework.

The ARDL Long Run Coefficients (without economic growth variables) shows that young adults and children are environmentally intensive (due to energy-intensive goods consumed). But the older age group exert a negative effect—implying that population aging will have a slightly improving environmental effect. This result is also reflected in the results of long-term estimation for the population structure-induced EKC hypothesis. Population age structure's influence on environmental degradation (CO₂ emission) has an inverse U-shaped pattern, with the children and young adults age groups having positive elasticity coefficients and the older group having negative coefficient. This inverted U-shaped relationship is also exhibited by economic growth. However, none of the coefficients of economic growth were statistically significant at any of the conventional levels. That means the findings do not support the existence of EKC hypothesis.

Even though the result of this study shows that young adults and children are environmentally intensive, the environmental challenges in Nigeria are more complex than the simple model linking environmental degradation to population structure. Because of this complexity, no easy solutions are available. However, appropriate macroeconomic policies, technological innovations and institutional developments are more important in maintaining a sound environment. Therefore, this paper suggests that:

Nigeria should embrace policy steps in rendering education and advocacy for sustainable consumption to lessen environmental constrain and to complement benefits attained via improved technology and production processes. In the same vein, it should execute development programmes that support moderate population expansion by investing more in developing human capital, gender equality and education, in particular for girls — this will cause fertility curtailment.

Similarly, Nigeria should further strengthen its institutions and frameworks in a way that it would incorporate population structure in both state and federal policy planning. As such, it should shift its focus of development from mere economic growth to eliminating the prevailing poverty. That way, the people as a whole can play a more crucial responsibility, not only in turning the economic wealth of the country around but also in reinforcing the environmental standard.

Environmental degradation is caused by natural phenomenon as well as by certain activities of human beings. However, this paper only focused on population age structure (in terms of age-specific consumption of energy-intensive goods). Also, the area of concern of this paper in terms of environmental degradation is CO₂ carbon dioxide emission level (air pollution). However, there are other environmental degradation problems like deforestation, flood, erosion, etc., but were left out.

Future research could explore the relationships among a full range of population dynamics (e.g., population density, and sex composition, migration, urbanization, vital rates, etc.) and environmental changes in Nigeria. Also, poverty and food insecurity link in connection to environmental degradation in Nigeria could be examined.

References

- Aboagye, S. (2017). Economic expansion and environmental sustainability nexus in Ghana, *African Development Review*, 29(2), 155–168.
- Akbostanci, E., Türlüt-Asik, S., and Tunc, I.G. (2009). The relationship between income and environment in Turkey: is there an Environmental Kuznets Curve? *Energy Policy*, 37 (2), 861-867. <http://dx.doi.org/10.1016/j.enpol.2008.09.088>
- Akinyemi, A., and Isiugo-Abanihe, U. C. (2014). Demographic dynamics and development in Nigeria, *African Population Studies*. 27(2), 239–248.
- Akpan, G. E., and Akpan, U. F. (2012). Electricity consumption, carbon emissions and economic growth in Nigeria, *International Journal of Energy Economics and Policy*, 2(1), 292-306.
- Chi, G. (2005). Debates on population and the environment, *Popul.-Environ. Res. Netw. (PERN) Cyberseminar Popul. MDG7*; 5–16 Sept.
- Chindo, S., Abdulrahim, A., Waziri, S. I., Huong, W. M., and Ahmad, A. A. (2015). Energy consumption, CO2 emissions and GDP in Nigeria. *Geo Journal*, 80 (1), 315-322.
- CIA (2018). The World Factbook — Central Intelligence Agency. www.cia.gov.
- CIA (2019). Nigeria: people, CIA World Factbook, 2018. <https://www.cia.gov/library/publications/the-world-factbook/geos/ni.html>
- Cramer, C.J. (1998). Population growth and air quality in California, *Demography*, 35(1), 45-56.
- Cramer, J. C., and Cheney, R. P. (2000). Lost in the ozone: population growth and ozone in California, *Population and Environment* 21, (3), 315-337.
- Dasgupta, P.S. (1995). Population, poverty, and the local environment. *Sci Am.*, 272(1), 40–46.
- De Sherbinin, A., Carr, D., Cassels, S., and Jiang, L. (2007). Population and environment, *Annu Rev Environ Resour.*, 32(1), 345–373.
- Demographic Dividend (2019). Nigeria. http://www.demographicdividend.org/country_highlights/nigeria/
- Dietz, T., and Rosa, E. A. (1997). Effects of population and affluence on CO2 emissions, *Proceedings of the National Academy of Sciences USA* 94, 175-179.
- Dinda, S., & Coondoo, D. (2006). Income and emission: a panel data-based cointegration analysis, *Ecological Economics*, 57, 167-181. <http://dx.doi.org/10.1016/j.ecolecon.2005.03.028>
- Drake, W. D. (1984). Towards building a theory of population-environment dynamics: a family of transitions. In G.D. Ness and H. Ando, eds., *the land is shrinking: population planning in Asia*. Baltimore, MD: Johns Hopkins University Press.
- Engle, R.F., and Granger, C.W.J. (1987). Co-integration and error correction: rep-resentation, estimation, and testing. *Econometrica*, 55(2), 251-276.
- Fei, J., and Ranis, G. (1964). *Development of the labor surplus economy*, Homewood, Irwin, IL.
- Ghanem, S. K. (2018). The relationship between population and the environment and its impact on sustainable development in Egypt using a multi-equation model, environment, development and sustainability: a multidisciplinary approach to the theory and practice of sustainable development, Springer, vol. 20(1), pages 305-342, February. DOI: 10.1007/s10668-016-9882-8
- Global.com (2019). What is ARDL bounds testing. <https://www.igi-global.com/dictionary/ardl-bounds-testing/47420>
- Gray, L.C., and Moseley, W.G. (2005). A geographical perspective on poverty-environment interactions, *Geogr J.*, 171(1), 9–23.
- Hunter, L. M. (2000). The environmental implications of population dynamics. https://www.rand.org/content/dam/rand/pubs/monograph_reports/2000/MR1191.pdf
- Indexmundi (2019). Population pyramid of Nigeria- 2016. https://www.indexmundi.com/nigeria/age_structure.html
- Jolly, C.L. (1994). Four theories of population change and the environment, *Popul Environ.*, 16(1), 61–90.
- Keyfitz, N. (1991). Population and development within the Ecophere: one view of the literature, *Popul Index*, 57(1), 5–22.
- Lantz, V., and Feng, Q. (2006.) Assessing income, population, and technology impacts on CO2 emissions in Canada: where's the EKC? *Ecological Economics* 57(1), 229–238.
- Lewis, W.A. (1954). *Economic development with unlimited supplies of labor*, The Manchester School.
- Mabogunje, A. L. (1995). The environmental challenges in Sub Saharan Africa, *Environment*, 37(4), 4. <http://web.mit.edu/africantech/www/articles/EnvChall.htm>
- McNicoll, G. (1992). Mediating factors linking population and the environment, presented at UN Expert Group Meet. *Popul., Environ. Dev.*; New York. 20–24, Jan.
- Narayan, P.K., and Narayan, S. (2010). Carbon dioxide emissions and economic growth: panel data evidence from developing countries, *Energy Policy*, 38(1), 661-666. <http://dx.doi.org/10.1016/j.enpol.2009.09.005>
- Nnaji, C. E., Chukwu, J. O., Nnaji, M. (2013). Electricity supply, fossil fuel consumption, CO2 emissions and economic growth: implications and policy options for sustainable development in Nigeria, *International Journal of Energy Economics and Policy*, 3(1), 262-271.
- O'Neill, .BC., MacKellar, F.L., and Lutz, W. (2001). *Population and climate change*, New York: Cambridge Univ. Press.

- Pesaran, M.H., Smith R.J., and Shin, Y. (2001). Bounds testing approaches to the analysis of level relationships, *Journal of Applied Econometrics*, 16(1), 289-326.
- Rothman, D.S., and De Bruyn, S.M. (1998). Probing into the Environmental Kuznets Curve Hypothesis, *Ecological Economics*, 25(1), 143–145.
- Southgate, D. (1994). Tropical deforestation and agricultural development in Latin America, In: The causes of tropical deforestation: the economic and statistical analysis of factors giving rise to the loss of tropical forests, edited by K. Brown and D. Pearce. London: University College London Press.
- Stern, D.I. (2004). The rise and fall of the Environmental Kuznets Curve. *World Development*, 32, 1419–1438. <http://dx.doi.org/10.1016/j.worlddev.2004.03.004>
- Sulaiman, C. (2014). The causality between energy consumption, CO2 emissions and economic growth in Nigeria: an application of Toda and Yamamoto procedure, *Advances in Natural Applied Sciences*, 8(1), 75-81.
- United Nation (1994). Population and the environment in developing countries (ESA/P/WP.123). <https://www.un.org/popin/books/wp1.html>
- York, R., Rosa, E.A., and Dietz, T. (2003). STIRPAT, IPAT and ImPACT: Analytic tools for unpacking the driving forces of environmental impacts, *Ecological Economics* 46 (3), 351-365.