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Research Article

The Exacerbating Role of Population Growth in Carbon Dioxide Emission in Nigeria

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Abstract: *It is commonly believed that rising population increases CO_2 emissions especially in developing countries via increase in human activities. This study therefore, empirically investigates the relationship between population growth and CO_2 emissions in Nigeria from 1986-2022. Using the Autoregressive Distributed Lag Bounds of cointegration, findings reveals that a long-run relationship does not exist among GDP per capita growth rate, the squared GDP per capita growth rate, annual growth rate of the population, fossil energy consumption, financial development, manufacturing value added and carbon dioxide emission over the period under study. The short-run regression result revealed that all the explanatory variables except the squared GDP per capita growth rate and financial development exerted a significant positive relationship with carbon dioxide emissions. Furthermore, the causality results showed the presence of a uni-directional causality running from annual growth rate of the population, fossil energy consumed, financial development and manufacturing value added to carbon dioxide emissions without a feedback effect. In light of the evidences, the study recommended among others, that government, businesses and citizens should diversify into other sources of energy like solar and wind energy which do not harm the environment so as to amplify the sustainability of the environment.*

Keywords: *Population growth, CO_2 emissions, ARDL, TY Granger causality.*

I. INTRODUCTION

Due to its effects on declining environmental quality, global warming is currently one of the most significant problems facing both industrialized and developing nations, including Nigeria. Ali, Law, Lin, Yusop, Chin and Bare (2019) established that ozone layer depletion is attached to carbon dioxide (CO_2) emissions which are the prime cause of global warming. According to Naqvi and Rehm (2014), CO2 emissions have a direct impact on the quality of land and water, which in turn causes extreme floods to occur more frequently and with greater intensity, water uncertainty, high temperatures, soil degradation, and other issues that contribute to global warming and impact a nation 's socio-economic sustainability. An growing frequency of heat waves that are harmful to human health will also put residents at risk due to rising global temperatures.

Population increase is a major component that puts strain on the environment, resulting in excessive emissions of carbon dioxide (CO2). Nigeria is one of the world's fastest developing nations, with an increase in population of 2.4% each year, adding five million people to the population pool (The Cable, 2023). It is also one of the countries with the most energy resources. She is blessed with an abundance of sources of energy, including solar, wind, biomass, crude oil, natural gas, and coal. Current United Nations estimates put Nigeria's population at about 211 million as at 2023, while the growth was projected to reach 400 million by 2050, doubling the current estimate (CIA, 2023). Consequently, this rapid population growth in turn gives rise to air, water and land pollution through the use of unclean technologies. It should be noted that over six decades, the country has been dependent on fossil fuels as a means of energy generation for increased production and consumption activities in order to meet the requirements of her growing population and this exacerbates excessive emissions of carbon dioxide (CO_2) in the environment.

Available statistics from World Bank (WB) 2020 report for Nigeria showed that between 2015 and 2018, Nigeria's per capita CO_2 emission has been rising consistently. In 2015, 2016, 2017 and 2018, it rose to 0.58, 0.59, 0.60 and 0.67 metric tons respectively, showing an increase in the concentration of CO_2 emissions in the atmosphere due to more human and economic activities. Apparently, this resulted in the increase in the annual average temperature to $27^{\circ}C$, thereby making the country vulnerable to the effects of climate change (such as increase in drought and flood that reduced food production, outbreak of diseases and loss of biodiversity). Also, evidence from the National Council on Climate Change report 2023, revealed that Nigeria's total CO_2 emission from the burning of fossil fuels and industrial activities was 127.34 million metric tons in 2019, showing an increase of 21.74 million metric tons from 2018. It further rose to 131.11 million metric tons in 2021, indicating

7.29 million metric tons increase between 2020 and 2021. The image above depicts Nigeria's fast growing population as the driving force behind rising energy demand, expanding agricultural, and increasing urbanization, all of which create environmental degradation.

In a bid to reduce CO_2 emissions in the atmosphere and mitigate the multi-dimensional and inter-related effects of climate change in Nigeria, policies to protect the environment from degradation evolved from time to time. The Climate Change Act, which was created by the Nigerian government in 2021, offers a comprehensive regulatory framework for accomplishing the nation's long-term climate goal, which includes environmental and economic accountability, sufficient climate financing, and net-zero carbon emissions by 2060 as well as development of a carbon market framework. Despite this effort, the intensity of oil spillage and gas flaring is still high, thereby leading to consistent increase in CO_2 emissions.

Nevertheless, environmentalists have proved other factors such as economic growth, financial development, urbanization and industrial activities to pose positive impacts on environmental quality. The Environmental Kuznets Curve (EKC) theorizes that during an economy's first growth phase, growth may be achieved by increasing CO2 emissions; as the economy stabilizes economically, sustainable development may be achieved by regulating the emissions (Andreoni & Levinson, 2001; Dasgupta, Laplante & Mamingi, 2001). In addition, some studies revealed how financial development impacts energy consumption in developing countries Sadorsky cited in Baija, Radoine, Abbas, Dakyaga and Chenal (2023). Their assertion is that enhancement in financial operation via increase in access to monetary provisions leads to an increase in CO_2 emission, resulting from rising usage of energy. Conversely, financial growth can increase economic efficiency by reducing financial expenses and capital risk. Additionally, financial development may increase development and research as well as investments in clean technology, which will lessen the total environmental impact of carbon dioxide, by expanding foreign direct investment (FDI) inflows, stock market activities, and banking operations.

Despite interest in the driving force of environmental quality, studies executed in the context of Nigeria failed to recognize manufacturing activities and financial development as essential determinants of environmental quality. Therefore, in-depth knowledge of the roles of the aforementioned variables in promoting or exacerbating environment quality in Nigeria is critical as it will enrich the country's information base for policy formulation aimed at improving environmental quality via promotion of green growth.

The rest of this study is organized as follows: Section two articulates the empirical and theoretical literatures. Section three handles model specification and data sources, while the results and discussion of findings is explained in Section four. The conclusion, recommendation and suggestion for further studies are presented in Section five.

II. LITERATURE REVIEW

A) Empirical Literature

Several studies have employed distinct datasets and methodologies to examine the relationship between population dynamics and environmental quality for numerous developed and developing countries and Nigeria in particular. However, the findings of these studies have been conflicting and contrasting. Some of these empirical studies are:

Begum, Sohag, Abdullah and Jaafar (2015) investigated the dynamic impact of GDP growth, energy consumption and population growth on CO2 emissions of Malaysia during the period of 1970-1980. The findings demonstrated that Malaysia's emissions were not significantly impacted by population growth. Additionally, it showed that per capita GDP and energy consumption both had long-term positive effects on per capita carbon emissions. Adusah-Poku (2016) empirically investigated the relationship between development, population, and CO2 emissions in 45 Sub-Saharan African countries using panel data from 1990–2010 and the pooled mean group (PMG) estimator. The results showed that increase in both urbanization and population significantly drive emissions in the short and long-run in sub-Saharan African countries.

Similar view was shared by Rahman (2017) who employed the panel cointegration test, Granger causality tests, Fully Modified Ordinary Least Square (FMOLS), Dynamic Ordinary Least Squares (DOLS) techniques and panel dataset from 1960 to 2014 to examine the relationship between population density, economic growth, energy use, exports and carbon dioxide (CO2) emissions and discovered that energy use, exports, and the amount of people all have a negative long-term impact on environmental quality. The Granger causality test result revealed long-run bidirectional Granger causality running from population density, energy consumption, GDP and exports to CO2 emissions. In Nigeria, Maji, Rahim, Ndawayo, Ofozor, Basiru and Bin (2017) employed the Autoregressive Distributed Lag (ARDL) technique to investigate the impact of wealth, energy consumption, and population on deforestation and environmental deterioration from 1981 to 2011. The result suggested population growth to be the major cause of deforestation in Nigeria.

Aiyetan and Olomola (2017) in another study for Nigeria used autoregressive distributed lag (ARDL) bounds testing approach for cointegration, Toda-Yamamoto non-granger causality test methodology and annual data from 1980 to 2012 to analyze the relationship between population growth, economic growth, energy consumption and CO2 emissions. The findings demonstrated that energy consumption and population expansion had a large and positive impact on CO2 emissions in both the long and short run, whereas economic growth had a weak and negative impact in the short term. Furthermore, the result of the Granger causality test revealed a positive unidirectional causality running from CO2 emissions, energy consumption and economic growth to population growth. Similarly, Mansoor and Sultana (2018) used the autoregressive distributed lag (ARDL) bounds testing approach for cointegration using data from 1975 to 2016 to investigate the relationship between population increase, energy use, economic growth, and carbon emissions in Pakistan. They discovered that population expansion and energy use increase emissions, but economic growth has a negative impact.

Furthermore, Weber and Sciubba (2018) used panel regressions, spatial econometric models, propensity score matching and panel dataset of 1062 regions within 22 European countries from 1990 to 2006 to critically examine the impact of population expansion on CO2 emissions and urban land use change. The study discovered a significant impact of regional population growth on carbon dioxide (CO2) emissions and urban land use in Western Europe. Equally, Abdelfattah et al. (2018) utilized panel data from 1990 to 2014, the autoregressive distributed lag (ARDL) technique and error correction mechanism (ECM) to investigate the relationship between population dynamics and CO2 emissions in the Arab countries. The result submits that population boosts emission in the Arab regions.

The work of Dong, Hochman, Zhang, Sun, Li, and Liao (2018) supports the opinion of Abdelfattah et al as they disclosed that population size and economic growth positively and significantly influence CO2 emission levels at both the global and regional levels. The results of panel causality test further provided evidence of varied causality links among the variables across regions. Sulaiman and Abdul-Rahim (2018) in another study for Nigeria used the Autoregressive Distributed Lag (ARDL) technique and VECM Granger causality test to examine the effect of population growth on CO2 emissions from 1971-2000, 1971-2005, and 1971-2010 recursively. The study found that population growth does not stimulate emissions. Furthermore, the causality result revealed significant causality from economic growth to CO2 emissions in the long-run, while causality was detected in economic growth, population growth and CO2 emissions in the short-run.

In addition, Mesagan and Nwachukwu (2018) employed the Autoregressive Distributed Lag (ARDL) model technique to cointegration and annual data from 1981 to 2016 to examine the determinants of environmental quality in Nigeria with a specific focus on the role of financial development and found that income, financial development, energy consumption and trade significantly cause environmental degradation. The result also showed that there is a bi-directional flow of causality between energy consumption and environmental degradation, whereas a one-way causality among urbanization, income and environmental degradation was found. Time series data from 1981 to 2017 and ARDL technique was used by Edeme and Chibuzo (2018) to access the relationship between urban population growth and environmental sustainability in Nigeria. The finding revealed that urban population growth increases renewable energy consumption but decreases forest reserves.

In Pakistan, Anser (2019) examined The impact of fossil fuel usage, nonrenewable usage of energy, population, income, and poverty on carbon emissions is examined using annual time series data from 1972 to 2014. The findings revealed that fossil fuel usage, population expansion, rising prosperity, and urbanization all contribute to Pakistan’s high carbon emissions. Saidi and Zaidi (2019) in a study for Tunisia assessed the impact of population growth on GDP and environmental quality using panel data from 1980 to 2013 and under the framework of the generalized moments in system method (GMM). The finding showed that population growth had a positive and significant impact on economic growth (GDP) and CO2 across the countries analyzed. Also, urbanization was found to be negatively and significantly impacting on CO2.

Egbetokun, Osabuohien, Akinbobola, Onanuga, Gershon and Okafor (2019) in their research on the nexus between environmental pollution, economic growth, and institutional quality in Nigeria for the period 1970 to 2017 utilized the Autoregressive Distributed Lag (ARDL) technique and disclosed the presence of an Environmental Kuznets Curve (EKC) for carbon dioxide (CO2) and suspended particulate matters (SPM) in Nigeria. In addition, it showed that other environmental pollution indicators such as nitrous oxide (N2O), rainfall, temperature, and total greenhouse gas emissions (TGH) did not exert significant influence on economic growth within the study period. In the same vein, Ogundipe, Okwara, and Ogundipe (2020) examined the effect of fossil fuel consumption on environmental quality in Nigeria from 1970 to 2017 using annual time series data sourced from World Development Indicators of World Bank. The result revealed that fossil fuel consumption, income and population stimulate carbon emission. In addition, education did not meaningfully influence carbon emission.

Finally, Dimnwobi et al. (2021) employed panel data from 1990-2019 and a Cross-Sectionally Augmented Autoregressive Distributed Lag (CS-ARDL) econometric technique to test the nexus between population dynamics and environmental quality in Africa (DR Congo, Ethiopia, Nigeria, South Africa, and Tanzania). The empirical findings showed that trade openness, energy consumption, population density, age distribution of the population, per capita GDP growth rate, and population growth rate all contribute to environmental degradation. Furthermore, the study found that in the chosen African nations, the rate of urban population expansion had no discernible impact on environmental degradation.

It is evident from the review of the empirical literature that studies executed in the context of developed and developing countries are with mixed results. Most studies (Adusah-Poku, 2016; Maji et al., 2017; Aiyetan & Olomola, 2017; Mansoor & Sultana, 2018; Weber & Sciubba, 2018; Abdelfattah et al., 2018; Dong et al., 2018; Edeme & Chibuzo, 2018; Anser, 2019; Saidi & Zaidi, 2019; Ogundipe et al., 2020; Dimnwobi et al. 2021) concluded that population growth exerts a strong positive impact on carbon dioxide (CO2) emissions. Other studies were of the view that population growth adversely affect carbon dioxide (CO2) emissions (Begum et al., 2015; Rahman, 2017; Sulaiman & Abdul-Rahim, 2018; Mesagan & Nwachukwu, 2018). This seeming mixed and inconclusive evidence in the empirical literature regarding the nexus between population growth and environmental quality calls for further studies.

In addition to the foregoing, the majority of the previous studies on this topic have relied on total energy use measured in kilotons of oil equivalent as a proxy for energy consumption. Using this proxy has the effect of combining traditional and commercial energy sources into one category. Both commercial energy sources, such as fossil fuels (natural gas, coal, and petroleum), nuclear, renewable energy, and conventional energy sources, such as waste and traditional biomass, are included in the EIA's classification of total energy usage. It will be challenging to distinguish the distinct effects of the various energy sources on environmental quality if we solely focus on overall energy consumption. Therefore, initiatives to lower CO2 emissions may overlook significant energy consumption sources like fossil fuels as an explanatory variable if the nature of the relationship between environmental degradation and commercial energy use is not properly understood. However, it is clear that fossil fuels are essential to the functioning of contemporary businesses in Nigeria and other emerging nations. Furthermore, depending solely on total energy consumption for a topic of this kind will not demonstrate the true impact of fossil fuel consumption on environmental deterioration because it results in the production of carbon dioxide, which is the cause of environmental degradation. This study is set to fill in the gap by limiting energy consumption to the utilization of commercial energy source (fossil fuel) by households and industrial sectors of the economy.

Besides, studies executed in the context of Nigeria did not recognize manufacturing activities and financial development as essential determinants of environmental quality. The aforementioned factors were included on the basis that a nation's manufacturing and economic development are significant and practical predictors of its likelihood of environmental harm. Hence, this study intends to bridge this knowledge gaps by incorporating the aforementioned variables to deepen our understanding on the basis of environmental quality in Nigeria in isolation.

B) Theoretical Framework

Many theories have been created to give the empirical examination of the relationship between environmental quality and population dynamics a theoretical basis. These theories are the environmental Kuznets theory, the Malthusian theory of population and the demographic transition theory. But this study will adopt the environmental Kuznets theory as a working theoretical framework.

The Environmental Curve hypothesis as propounded by Simon Kuznets (1955) suggests that there is an inverse U-shaped relationship between environmental degradation and economic development as indicated by per capita income. According to the theory, increasing income causes environmental pollution to rise at the beginning of growth, but as income rises further, a threshold will be reached at which investments in cleaner technologies and environmental regulations will cause environmental pollution to decline. This shows an inverted U-shaped curve, which suggests that pollution is causing the economy to flourish. It gained popularity in Grossman and Krueger's publications that analyze the relationship between pollutants and income (1995). However, Ehrlich and Holden (1971) presented an alternative method for examining the relationship between economic development and environmental pollution long before EKC was used in pollutant-income analysis. IPAT is the name of this method. According to O'Neill and Chen (2002), IPAT is a method for evaluating how human activity affects the environment (I) as a function of three variables: population size (P), affluence (A), and technology (T). The incapacity of this IPAT approach to consider numerous additional aspects that have an indirect impact on the environment has drawn criticism (Shaw, 1989; Harrison, 1994). According to O'Neill and Chen (2002), this IPAT technique weakness renders it unsuitable for micro-level investigations. As a result, the outcomes are likewise not reliable. On the contrary EKC has been used to evaluate the impact of a wide range of factors, such as population density, urbanization, income inequality, trade openness, literacy (Cole, 2003).

When it comes to biodiversity conservation, some natural resource use, and other pollutants, the EKC model is controversial. Yandle, Bhattarai, and Vijayaraghavan (2002), for instance, contend that the EKC has not been found to apply to carbon since most pollutants cause localized issues, such as lead and sulfur, and that cleaning up these pollutants is more urgent. As a nation grows, the marginal benefit of eliminating these pollutants directly raises the standard of living for its people. The motivation to clean things up, on the other hand, comes solely from the selfless desire to improve the environment worldwide because lowering carbon dioxide emissions does not have a significant effect locally. Everyone is worse off as a result of this tragedy of the commons, where it is most effective for everyone to pollute and for no one to clean up (Hardin, 1968). As a result, carbon emissions are not falling in line with the EKC, even in a wealthy nation like the US. However, as CO2 is a worldwide pollutant that has not yet demonstrated its validity inside Kuznets' Curve, there appears to be little agreement over whether EKC is created with reference to CO2 emissions (Uchiyama, 2016). Yandle et al. (2002) similarly came to the conclusion that economic restructuring, price reform, and trade liberalization—all measures that promote growth—should benefit the environment.

Arrow, Bolin, Costanza, Dasgupta, Folke, Holling and Jansson (1995) argued that If pollution rises again at the end because of increased income and consumption by the general populace, the pollution-income progression from rural communities (clean) to industrial economies (pollution intensive) to service economies (cleaner) would seem to be a myth. As a result, the environmental Kuznets curve (EKC) hypothesis is used as the working theoretical framework in this investigation.

III. METHODOLOGY

The study followed a succession of approaches that guided the achievement of the objectives of the paper. This study proceeded first by conducting a unit root test in other to ascertain the other of integration of the series. In doing this, the technique of Augmented Dickey-Fuller (ADF) and Philips-Perron (PP) unit root tests was employed. The unit root test results of 1(0) and 1(1) exhibited by the variables indicated that the bounds testing approach to cointegration is more appropriate. Since the existence of cointegration among the variables in the model was not established, the study estimated only the short-run coefficients of the growth equation through the ARDL cointegration method. Thereafter, the Toda and Yamamoto (1995) causality test was employed to determine the direction of causality among the variables. The performance of the estimated model was finally verified through the diagnostic test.

A) Model Specification

The model is built around the Environmental Kuznets Curve (EKC) theory which this study reviewed (see page 8). Kuznets suggested that environmental quality initially deteriorates with economic growth as societies prioritize industrialization and resource extraction. However, expenditures in cleaner technology and environmental legislation start to enhance environmental quality after a particular income threshold. This shows an inverse U-shaped correlation between pollution and economic development. Based on this, the basic EKC in quadratic form is specified as follows:

$$CO_2 = f(Y_t, Y_t^2) \qquad 3.1$$

The specification in Equation (3.1) assumes environmental pollution (CO2) as a function of income (Yt) and the squared of income (Yt). Income is used to capture the nature of the pollution-income relationship at initial stage of development, while the squared of income test for the validity of the EKC by illustrating whether a turning point had occurred or not. However, the basic EKC is augmented in the works of Grossman and Krueger (1995) and Cole (2003) that used the approach to assess the environmental impact of human activities as the product of a wide range of demographic factors such as population growth. Hence, Equation (3.1) is modified as:

$$CO_2 = f(Y_t, Y_t^2, POP_t) \qquad 3.2$$

Meanwhile, based on the insight provided by Dimnwobi et al. (2021) which incorporated other factors that may have a substantial impact on the relationship between pollution and population growth in Nigeria were included in this study in addition to the basic EKC as previously mentioned. These factors include population growth rate, population density, urban population growth rate, age distribution of the population, per capita GDP growth rate, energy consumption, and trade openness. The variables added were manufacturing value added and financial development. The variables discarded were population density, urban population growth rate, age structure of the population and trade openness. But for this study, Y and Y2 were measured as GDP per capita and Equation (3.2) is transformed to:

$$CO_2 = f(GDPPCGR, GDPPCGR^2, AGRPOP, FOSC, FD, MVA) \qquad 3.3$$

Equations (3.3) can be put in econometric form as follows:

$$CO_{2(t)} = \beta_0 + \beta_1 GDPPCGR_t + \beta_2 GDPPCGR_t^2 + \beta_3 AGRPOP_t + \beta_4 FOSC_t + \beta_5 FD_t + \beta_6 MVA_t + \varepsilon_t \qquad 3.4$$

The theoretical expectation of the above equation is as follows:

$$\beta_2, \beta_5 < 0; \beta_1, \beta_3, \beta_4, \beta_6 > 0$$

Restating Equation (3.4) as an ARDL model in line with the framework of Pesaran et al. (2001), we have:

$$\Delta CO_{2t} = \beta_0 + \sum_{i=1}^{n}\beta_{1,i}\Delta CO_{2t-1} + \sum_{i=1}^{n}\beta_{2,i}\Delta GDPPCGR_{t-1} + \sum_{i=1}^{n}\beta_{3,i}\Delta GDPPCGR^2{}_{t-1}$$
$$+ \sum_{i=1}^{n}\beta_{4,i}\Delta AGRPOP_{t-1} + \sum_{i=1}^{n}\beta_{5,i}\Delta FOSC_{t-1} + \sum_{i=1}^{n}\beta_{6,i}\Delta FD_{t-1}$$
$$+ \sum_{i=1}^{n}\beta_{7,i}\Delta MVA_{t-1} + \beta_8 CO_{2t-1} + \beta_9 GDPPCGR_{t-1} + \beta_{10} GDPPCGR^2{}_{t-1}$$
$$+ \beta_{11} AGRPOP_{t-1} + \beta_{12} FOSC_{t-1} + \beta_{13} FD_{t-1} + \beta_{14} MVA_{t-1} + \varepsilon_t \quad 3.5$$

Where: CO_2 = Carbon dioxide emissions which capture environmental pollution, $GDPPCGR =$ GDP per capita growth rate, $AGRPOP =$ Annual growth rate of the population, $FOSC =$ Fossil fuel energy consumption, $FD =$ Financial development, $MVA =$ Manufacturing value added, n, Δ, β_0, ε_t, $\beta_1 - \beta_7$ and $\beta_8 - \beta_{14}$ denote the lag length, difference operator, the drift, disturbance term, parameters of the short-run dynamics and the parameters of the long-run relationship respectively. The decision concerning the existence of cointegration is guided by the following hypotheses:

$H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5 = \beta_6 = 0$ (absence of cointegration among the variables)

$H_0 : \beta_1 \neq \beta_2 \neq \beta_3 \neq \beta_4 \neq \beta_5 \neq \beta_6 \neq 0$ (presence of cointegration among the variables)

Testing for cointegration involves comparing the computed F-statistic with the critical bounds proposed first by Pesaran and Shin (1999) and advocated by Pesaran, Smith and Shin (2001). In conducting the test, the F-statistic was compared with both the upper 1(1) and lower 1(0) critical values at the 5% level. If the calculated F-statistic is more than the upper critical bound 1(1), the series are co-integrated; if it is less than the lower critical bound 1(0), the series are not. The outcome is unclear, nevertheless, if the calculated F-statistic lies between the lower and higher critical bound values. However, as cointegration among the variables in the model was not proved, the short-run coefficients were calculated using OLS as shown:

$$\Delta CO_{2t} = \beta_0 + \sum_{i=1}^{n}\beta_{1,i}\Delta CO_{2t-1} + \sum_{i=1}^{n}\beta_{2,i}\Delta GDPPCGR_{t-1} + \sum_{i=1}^{n}\beta_{3,i}\Delta GDPPCGR^2{}_{t-1}$$
$$+ \sum_{i=1}^{n}\beta_{4,i}\Delta AGRPOP_{t-1} + \sum_{i=1}^{n}\beta_{5,i}\Delta FOSC_{t-1} + \sum_{i=1}^{n}\beta_{6,i}\Delta FD_{t-1}$$
$$+ \sum_{i=1}^{n}\beta_{7,i}\Delta MVA_{t-1} + \Psi ECM_{t-1} + \varepsilon_t \quad 3.6$$

Where: Ψ is the coefficient of the error correction model and ECM_{t-1} is the error correction term which shows how disequilibrium in output can be adjusted in the short-run. Other variables are as defined earlier.

The study also investigated the direction of causality among the variables using the Toda and Yamamoto test for Granger non-causality. The following TY multivariate model guided this study:

$$CO_{2t} = \lambda_1$$
$$+ \sum_{i=1}^{k+d\max}\alpha_{1i} CO_{2t-1} + \sum_{i=1}^{k+dmas}\alpha_{1i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max}\alpha_{1i} GDPPCGR^2{}_{t-1}$$
$$+ \sum_{i=1}^{k+d\max}\alpha_{1i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max}\alpha_{1i} FOSC_{t-1} + \sum_{i=1}^{k+d\max}\alpha_{1i} FD_{t-1}$$
$$+ \sum_{i=1}^{k+d\max}\alpha_{1i} MVA_{t-1} + \varepsilon_{1t} \quad 3.7$$

$$GDPPCGR_t = \lambda_2 + \sum_{i=1}^{k+d\max} \alpha_{2i} CO_{2t-1} + \sum_{i=1}^{k+dmas} \alpha_{2i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{2i} GDPPCGR^2{}_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{2i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{2i} FOSC_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{2i} FD_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{2i} MVA_{t-1} + \varepsilon_{2t} \quad 3.8$$

$$GDPPCGR^2{}_t = \lambda_3 + \sum_{i=1}^{k+d\max} \alpha_{3i} CO_{2t-1} + \sum_{i=1}^{k+dmas} \alpha_{3i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{3i} GDPPCGR^2{}_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{3i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{3i} FOSC_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{3i} FD_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{3i} MVA_{t-1} + \varepsilon_{3t} \quad 3.9$$

$$AGRPOP_t = \lambda_4 + \sum_{i=1}^{k+d\max} \alpha_{4i} CO_{2t-1} + \sum_{i=1}^{k+dmas} \alpha_{4i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{4i} GDPPCGR^2{}_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{4i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{4i} FOSC_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{4i} FD_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{4i} MVA_{t-1} + \varepsilon_{4t} \quad 3.10$$

$$FOSC_t = \lambda_5 + \sum_{i=1}^{k+d\max} \alpha_{5i} CO_{2t-1} + \sum_{i=1}^{k+dmas} \alpha_{5i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{5i} GDPPCGR^2{}_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{5i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{5i} FOSC_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{5i} FD_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{5i} MVA_{t-1} + \varepsilon_{5t} \quad 3.11$$

$$FD_t = \lambda_6 + \sum_{i=1}^{k+d\max} \alpha_{6i} CO_{2t-1} + \sum_{i=1}^{k+dmas} \alpha_{6i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{6i} GDPPCGR^2{}_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{6i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{6i} FOSC_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{6i} FD_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{6i} MVA_{t-1} + \varepsilon_{6t} \quad 3.12$$

$$MVA_t = \lambda_7 + \sum_{i=1}^{k+d\max} \alpha_{7i} CO_{2t-1} + \sum_{i=1}^{k+dmas} \alpha_{7i} GDPPCGR_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{7i} GDPPCGR^2{}_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{7i} AGRPOP_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{7i} FOSC_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{7i} FD_{t-1} + \sum_{i=1}^{k+d\max} \alpha_{7i} MVA_{t-1} + \varepsilon_{7t} \quad 3.13$$

B) Data and their Sources

The study employed the annual time series data over the period of 1986 - 2022. All the data were sourced from World Development Indicators 2022. Carbon dioxide (CO_2) is used to capture environmental quality and is measured in metric tons per capita, GDP per capita growth rate is measured as the annual percentage change in the ratio of GDP to population (%), annual growth rate of the population is measured in annual population growth rate (%), fossil fuel energy consumption is measured in kilogram (kg) of oil equivalent per capita, financial development is proxied by domestic credit to the private sector (% of GDP) and manufacturing value added is measured as the percentage of GDP.

IV. RESULTS AND DISCUSSION OF FINDINGS

The descriptive statistics results in Table 1 indicate that carbon dioxide (CO_2) records an annual average of 0.68% and a mean value of 0.67%. The maximum value of 0.92 indicates that the highest per capita carbon dioxide emission was 0.92% and this was recorded in 1992, while the minimum value is 0.46% which was achieved in 1989. Meanwhile, fossil fuel energy consumption has the highest mean and median values of 19.27% and 18.83% respectively. It was also found that the variable that exhibited the highest dispersion is the squared of GDP per capita growth rate solid mineral exports as its range is the highest (29.07). The results further revealed that the means and medians of the other variables (GDPPCGR, AGRPOP, FOSC, FD, MVA) are very close, indicating that the variable have high tendency to be normally distributed.

Another important statistics reported in Table 1 is Jarque-Bera test which compares the shape of a given distribution (skewness and kurtosis) to that of a normal distribution. Meanwhile, we accept the null hypothesis that the residuals of a series are normally distributed when the probability associated with the JB test is significantly larger than the usual criterion of 0.05. On this note, the JB result of this study suggests that the variables are normally distributed. . The skewness result obtained reveals that the squared of GDP per capita growth rate ($GDPPCGR^2$) was positively skewed, which means that the distribution is skewed to the right. Equally, annual growth rate of the population (AGRPOP) and manufacturing value added (MVA) were negatively skewed, meaning that the distribution is skewed to the left while carbon dioxide (CO^2), GDP per capita growth rate (GDPPCGR), fossil fuel energy consumption (FOSC) and financial development (FD) has no skew, thus revealing that the distribution is symmetrical on both sides of the tail. Finally, the kurtosis statistics show that GDPPCGR, $GDPPCGR^2$, FOSC and FD were leptokurtic, revealing that their distributions were peaked relative to normal distribution while CO_2, AGRPOP and MVA were platykurtic, suggesting that their distributions were flat relative to normal distribution.

Table 1 Result of Estimated Descriptive Statistics of the Indicators

Statistics	**CO_2**	**GDPPCGR**	**$GDPPCGR^2$**	**AGRPOP**	**FOSC**	**FD**	**MVA**
Mean	0.6799	1.4894	11.7403	2.5691	19.2689	9.7971	13.2764
Median	0.6740	1.4035	5.3721	2.5790	18.8292	8.4510	12.6673
Maximum	0.9164	12.2761	150.7036	2.6777	22.8448	19.6035	21.0196
Minimum	0.4574	-4.5071	-20.3144	2.3800	15.8541	4.9480	1.0611
Std. Dev.	0.1255	3.6956	29.0712	0.0769	1.4676	3.5086	5.1584
Skewness	0.2105	0.5256	3.3280	-0.4136	0.5244	0.8985	-0.0903
Kurtosis	1.8431	3.5432	3.8584	2.4799	3.2693	3.5767	2.0536
Jarque-Bera	2.3368	2.1586	323.1972	1.4716	1.8081	5.4910	1.4311
Observations	37	37	37	37	37	37	37

Source: *Researcher's Compilation (2024) using E-Views 9.*

The correlational analysis findings are shown in Table 2. A statistical technique for assessing the degree of association between two quantitative variables is correlation analysis. A weak correlation indicates that there is little to no association between the variables, whereas a high correlation indicates that two or more variables have a strong relationship. In econometrics, correlational analysis has applications. Woodridge (2001) asserts that correlational analysis is a measure of the interdependence of variables. According to his prediction, linearly dependent variables will have correlational coefficients greater than 0.70. The presence of multicollinearity among explanatory factors may be indicated by this kind of linear dependence, which is predicted between dependent and independent variables. This only indicates that multicollinearity is prima facie demonstrated when the correlational coefficient between two explanatory variables is more than 0.70.

The result of the estimated correlation matrix indicates that there is a linear relationship (whether positive or negative) between the dependent variable (CO2) and the explanatory variables (GDPPCGR, GDPPCGR2, AGRPOP, FOSC, FD, MVA). There is no multicollinearity among the explanatory variables, though, as there are no correlational coefficients between two of them that are higher than 70%.

Table 2 Results of Estimated Correlation Matrix of the Indicators

	CO_2	GDPPCGR	$GDPPCGR^2$	AGRPOP	FOSC	FD	MVA
CO_2	1.000000						
GDPPCGR	-0.038001	1.000000					
$GDPPCGR^2$	0.054636	0.816169	1.000000				
AGRPOP	-0.449777	0.218933	0.052411	1.000000			
FOSC	0.438386	0.104209	0.077785	-0.126645	1.000000		
FD	-0.651451	0.099163	-0.072739	0.364021	-0.522891	1.000000	
MVA	0.635851	-0.334707	-0.096355	0.511522	0.153485	-0.674855	1.000000

Source: *Researcher's Compilation (2024) using E-Views 9.*

Utilizing the methods of the Philips-Perron (PP) and Augmented Dickey-Fuller (ADF) unit root tests, the stationarity of the variables was examined. The variables were either 1(0) or 1(1), according to the results. The variables (GDPPCGR, $GDPPCGR^2$) were integrated at their levels 1(0), while CO_2, AGRPOP, FOSC, FD and MVA achieved stationarity after differencing the series. That is to say that the series becomes 1(1) after first differencing. The PP unit root test was used to validate the ADF results. The results show that the results of the PP unit root test support those obtained using the ADF.

Table 3 Summarized ADF and PP unit root test results

Variable	**Augmented Dickey-Fuller (ADF)**				**Philip-Perron (PP)**			
	At level	1st Difference	5% Critical Value	Order of Integration	At Level	1st, Difference	5% Critical Value	Order of Integration
CO_2	-2.6929	-9.0637**	-2.9458	1(1)	-2.6929	-19.2443**	-2.9484	1(1)
GDPPCGR	-4.1293**	-	-2.9458	1(0)	-4.0508**	-	-2.9458	1(0)
$GDPPCGR^2$	-5.5092**	-	-2.9458	1(0)	-5.5092**	-	-2.9458	1(0)
AGRPOP	-1.7887	-9.3230**	-2.9511	1(1)	-0.9353	-3.3843**	-2.9484	1(1)
FOSC	-2.7055	-5.8656**	-2.9484	1(1)	-2.8593	-6.8859**	-2.9484	1(1)
FD	-2.3876	-5.5135**	-2.9484	1(1)	-1.4743	-7.0328**	-2.9484	1(1)
MVA	-1.8752	-8.2507**	-2.9484	1(1)	-1.7670	-8.3872**	-2.9484	1(1)

Source: *Researcher's Compilation (2024) using E-Views 9; Note: ** denotes statistical significance at 5% significance level.*

Consequently, the variables' 1(0) and 1(1) unit root test results support using the ARDL technique to estimate the model's parameters. To find out if there is a long-term link between the variables, the study first established the ideal lag duration before doing a cointegration test.

Table 4 Lag Length Selection

Lag Length	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-396.77	**NA**	24.71	23.07	23.38	23.18
1	-283.22	175.18*	0.65	19.38	21.87*	20.24*
2	-225.43	66.05	0.57*	18.88*	23.55	20.49

Source: *Researcher's Compilation (2024) using E-Views 9; Note: * indicates lag selection by the criteria.*

Table 4 revealed that the two different information criteria, namely the Akaike information criterion (AIC) and Final prediction error (FPE) test statistic, suggest 2 as the optimal lag length for the model while Sequential modified (LR), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) chooses 1. However, for consistency's sake, we go with AIC and FPE-selected optimal lag criteria. Having chosen the optimal lag length, the bound test for cointegration is employed to examine the existence of cointegration among the variables and the result is presented in Table 5.

Table 5 Bounds tests for the existence of cointegration.

Test Statistic	Value	Lag	Significance level	Bound critical values	
				Lower Bound	Upper Bound
F-statistic	1.581191	**2**		I(0)	I(1)
			1%	**3.15**	**4.43**
			5%	**2.45**	**3.61**
			10%	**2.12**	**3.23**

Source: *Researcher's Compilation (2024) using E-Views 9. Note: Lower and Upper Bounds critical values for the F-statistic at 5% significance level were taken from Pesaran et al. (2001).*

The bound test result reveals that the computed F-statistic (1.581191) is lesser than the upper (3.61) critical value bound at the 5% significance level; this confirms that a long-run relationship does not exist among the variables employed in the model. Thus, by implication, the study can only estimate the short-run coefficients of the growth equation through the ARDL cointegration method.

Table 6 Estimated Short-Run Relationship Results

Dependent Variable: CO_2				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GDPPCGR)	0.012951	0.007860	1.647655	0.0119**
D($GDPPCGR^2$)	-0.000897	0.000876	-1.023675	0.3158
D(AGRPOP)	0.641861	0.693423	0.925642	0.0635*
D(FOSC)	0.025432	0.013881	1.832184	0.0789*
D(FD)	-0.000449	0.006781	-0.066260	0.9477
D(MVD)	0.007586	0.004861	1.560442	0.0312**
C	1.136035	0.927363	1.225017	0.2320
R-square = 0.707340 **Adjusted R-square = 0.590276** **F-statistic = 6.042343** **Prob (F-statistic) = 0.000126**				

Source: *Summary of result compiled by researchers (2024) using E-Views 9. Note ** and ** * denotes significance at the 5% and 10% levels, respectively.

The ARDL short-run results in Table 6 show that the change in GDP per capita growth rate had a positive and significant effect on CO_2 emission, as expected. This implies that as the GDP per capita growth rate increases, CO_2 emission increases as well in Nigeria. The result suggests that if the GDP per capita growth rate goes up by 1 unit, CO_2 emission will increase by 0.01%. The finding substantiates the results of Sulaiman and Abdul-Rahim (2018), Mesagan and Nwachukwu (2018), Ogundipe *et al.* (2020) for Nigeria, Begun *et al.* (2015) for Malaysia and Adusah-Poku (2016) and Dimnwobi *et al.* (2021) African countries but contradicts the submissions of Aiyetan and Olomota (2017) and Mansoir and Sultan (2018). However, changes in the squared of GDP per capita growth rate and financial development exerted a negative and insignificant effect on CO_2 emission in line with theoretical expectations. The result suggests that the squared GDP per capita growth rate and financial development do not boost CO_2 emissions in Nigeria in the short-run. The results show that a unit increase in the squared of GDP per capita growth rate and financial development would reduce CO_2 emission by 0.0009% and 0.0004, respectively. This result is in harmony with the Environmental Kuznet Curve (EKC) argument of an inverted U-shaped relationship between economic growth and CO_2 emissions. The implication of this result is that as Nigeria's economy grows, her CO_2 emissions level increases as well until some threshold level of economic growth is reached, after which this emission starts to decline.

Also, the change in the population's annual growth rate exerted a positive and significant effect on CO_2 emission, as expected. This implies that population growth triggers CO_2 emissions in Nigeria in the short-run. The result means that if the growth rate of the population goes up by 1%, CO_2 emissions will increase by 0.64%. This finding concurs with the findings of Begun *et al.* (2015), Adusah-Poku (2016), Maji *et al.* (2017); Aiyetan and Olomota (2017); Dong et al. (2018); Mansoor and Sultan (2018); Sciubba (2018); Abdelfattah *et al.* (2018); Anser (2019); Saidi and Zaidi (2019); Ogundipe *et al.* (2020) and Dimnwobi *et al.* (2021) but contravenes those of Rahman (2017); Sulaiman and Abdul-Rahim (2018) and Edeme and Chibuzo (2018). In addition, changes in fossil fuel consumption had a positive and significant effect on CO_2 emissions. The coefficient of fossil fuel consumption reveals that a unit increase in fossil fuel consumed will result in a 0.03% increase in CO_2 emissions in the short-run. It is an established reality that in order to increase the production of goods and services in Nigeria, both domestic and industrial units have been heavily reliant on burning fossil fuel for energy generation due to her epileptic electricity supply. This finding corroborates with those of Begun *et al* (2015); Adusah-Poku (2016); Aiyetan and Olomota (2017); Mansoor and Sultan (2018); Rahman (2017); Anser (2019);); Ogundipe *et al.* (2020) and Dimnwobi *et al.* (2021).

Finally, change in manufacturing value added was positive and significant in the short-run in line with a priori expectation. A one unit rise in manufacturing value added exacerbates CO_2 emissions by 0.01%. This suggests that the pace of industrialization in order to improve per capita manufacturing value added stimulates CO_2 emissions in Nigeria within the period under study. This finding finds an advocate in Anser (2019) and Sulaiman *et al*. (2022).

The study went ahead to examine the causal relationship between population growth and environmental quality using the Toda and Yamamoto causality test. The TY estimation results depicted in Table 7 showed the existence of a uni-directional relationship between carbon dioxide emission and GDP per capita growth rate (GDPPCGR). Similarly, a uni-directional relationship between GDPPCGR and $GDPPCGR^2$ was found. In addition, the results revealed a bi-directional relationship between GDPPCGR and FD on one hand (meaning that these variables reinforce each other) and a uni-directional relationship between AGRPOP and GDPPCGR, GDP per capita growth rate, FOSC, FD and MVA on the other hand. Furthermore, a one-way causality from AGRPOP, FOSC, FD and MVA to CO_2 was revealed. This affirms the submission of Aiyetan and Olomola (2017).

Table 7 Results of the granger causality test (TY Augmented Lags Methods)

Sources of Causation							
Dependent Variable	**CO_2** X^2	**GDPPCGR** X^2	**$GDPPCGR^2$** X^2	**AGRPOP** X^2	**FOSC** X^2	**FD** X^2	**MVA** X^2
CO_2	-	6.609086 (0.0367)**	1.754837 (0.4159)	0.285858 (0.8668)	1.399070 (0.4968)	1.175537 (0.5556)	0.878830 (0.6444)
GDPPCGR	5.593186 (0.2559)	-	3.826311 (0.0976)*	1.053620 (0.5905)	5.106771 (0.2778)	8.151219 (0.0970)*	4.588407 (0.1008)
$GDPPCGR^2$	3.044515 (0.2182)	3.338318 (0.1884)	-	0.980771 (0.6124)	0.943688 (0.6239)	1.002345 (0.6058)	0.140225 (0.9323)
AGRPOP	8.829717 (0.0003)**	7.885460 (0.0194)**	4.114194 (0.0678)*	-	5.862427 (0.0533)**	8.090737 (0.0075) ***	5.234229 (0.0730)*
FOSC	4.767704 (0.0922)*	42.88884 (0.0000)***	3.185553 (0.2034)	0.926943 (0.6291)	-	5.239361 (0.2841)	3.056578 (0.2169)
FD	0.857047 (0.0780)*	6.521895 (0.0384)**	0.371132 (0.8306)	0.931876 (0.6275)	3.218928 (0.0550)**	-	2.070311 (0.3552)
MVA	1,287348 (0.0999)*	1.665105 (0.43)	8.945158 (0.0114)**	2.337353 (0.3108)	1.091352 (0.5795)	1.292254 (0.5241)	-

Source: *Summary of result compiled by researcher's (2024) using E-Views 9.* **Note** ****, ** and * indicate significance at the 1%, 5% and 10% levels, respectively. The figures outside bracket and those in bracket are the* X^2*-statistic with their respective p-values.*

The study conducted diagnostic tests to certify whether the parameter estimates were consistent and capable of being utilized in making economic deductions. The diagnostic tests results in Table 9 show that the model passed most of the tests conducted. This is because their probability values were greater than the chosen 0.05% level of significance. Based on the findings, there were no problems of heteroskedasticity, serial correlation and misspecification in our model. Nevertheless, normal distribution of the errors was not sustained.

Table 9 Diagnostic Results for ARDL Model

Test	Test Statistic	P-value	Null hypothesis	Decision
Jarque-Bera normality test	31.22088	0.0000	H_o: The error terms are normally distributed.	Cannot reject H_o
Heteroskedasticity Test: ARCH	0.065760	0.7992	H_o: No heteroskedasticity	Cannot reject H_o
Ramsey RESET test	2.102229	0.1600	H_o: Correctly specified	Cannot reject H_o
Breusch-Godfrey LM test	2.667721	0.0908	H_o: No serial correlation	Cannot reject H_o

Source: *Summary of result compiled by researcher's (2024) using E-Views 9.*

V. CONCLUSION AND RECOMMENDATION

Examining the relationship between population growth and CO_2 emissions is crucial and requires urgent attention. Rapid population growth could stir greater energy consumption and industrial activities which exacerbates CO_2 emissions and related hazards such as extreme weather events. This study used annual time series data sourced from World Bank, World Development Indicator (WB, WDI) for the period of 1986 to 2022 to examine the relationship among annual growth rate of the population, GDP per capita growth rate, fossil energy consumption, financial development, manufacturing value added and CO_2 emissions in Nigeria. Under the framework of the ARDL Bounds testing approach to cointegration, the result clearly showed that there exists no long-run relationship among the variables employed in the model. The short-run results revealed positive and significant effect of GDP per capita growth rate, annual growth rate of the population, fossil energy consumption and manufacturing value added on CO_2 emissions, while a negative and insignificant effect of financial development CO_2 emissions was shown.

Also, the results of the causality test revealed a unidirectional causality running from annual growth rate of the population, fossil energy consumption, manufacturing value added to CO_2 emission in Nigeria. A key revelation from this study is that population growth is the major driver in CO_2 emission in Nigeria over the past two decades. Based on these findings, the study therefore recommends that policy makers in Nigeria during policies design towards promotion of environmental quality in the nation to incorporate population regulation measures such as intensifying awareness campaign on family planning, assigning a particular number of children to a couple and improving financial status of women which would invariably, lead to improved financial standing which could allow them have fewer children. In addition, government should diversify into other sources of energy like solar and wind energies which do not harm the environment. Also, Pollution abatement equipment should be embraced just as laws on gas flaring should be effective to discourage the multinational oil companies to desist from gas flaring. Finally, it is imperative to promote cooperation among various stakeholders to increase the environmental consciousness of citizens' involved in manufacturing production chain in order to amplify the sustainability of the environment.

A) Suggestions for Further Studies

1. An assessment of the role of governance on environmental quality so far can be carried out as well. This is to identify if the institutional qualities of governance such as political stability, rule of law, government effectiveness, regulatory quality and control of corruption have been effective in improving/exacerbating environmental deterioration.
2. Given that the financial development variable is negatively related with CO_2 emission, future research should focus on finance-environmental nexus in other developing nations and find out if financial growth improves environmental quality by reducing carbon dioxide emissions.
3. In addition to the above, sectoral disaggregated energy consumption should be explored with emphasis on the contribution of these energy components to carbon dioxide emissions. The knowledge of this will inform suitable policies that will improve the energy sector and other sectors of the economy.

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