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POPULATION DYNAMICS AND ENVIRONMENTAL DEGRADATION IN NIGERIA

BY

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ABSTRACT

This study examined the relationships between population dynamics and environmental degradation in Nigeria. The study specifically: (i) examine the impacts of population growth on the carbon-dioxide (CO_2) emissions from residential buildings and commercial and public services; (ii) identify the effect of population density on the carbon dioxide (CO_2) emissions from residential buildings and commercial and public services; and (iii) investigate the relationship between life expectancy and carbon dioxide (CO_2) emissions from residential buildings and commercial and public services. The specified model was estimated with the autoregressive distributed lag (ARDL) method through multiple regression of Carbon-dioxide emission (CDE) on all explanatory variables namely: Urban Population Growth (UPG), Population Density (PD), Life Expectancy at Birth (LEB), and Renewable Energy Consumption (REC). The results of the study showed that in the short run: there exists a positive and significant relationship between urban population growth and carbon-dioxide emission; there exists a positive and significant relationship in the current year between population density and carbon-dioxide emissions; there exists a negative and significant relationship between population density in one year lag and carbon-dioxide emissions; there exists a negative but insignificant relationship between life expectancy at birth (both current year /one year lag) and carbon emissions; and there exists a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions. While in the long run: there exists a positive and significant relationship between urban population growth and carbon-dioxide emissions; there exists a positive but insignificant relationship between population density and carbon-dioxide emissions; there exists a negative but insignificant relationship between life expectancy at birth and carbon-dioxide emissions; and there exists a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions. The recommendations based on the study are as follows: the Nigerian government should formulate and implement an environmental quality control policy that will focus on reducing carbon-dioxide emissions and other pollutants among the urban population; the Nigerian government to have environmental planning strategies that will focus on the spatial areas of human dwellings for the sustainability of agglomeration; the government put in place policy that will discourage carbon-dioxide emissions for life sustainability and longevity of citizens; and government should regulate the usage of consumption of renewable energy to ameliorate carbon-dioxide emissions and enhance a clean environment.

Keywords: *Carbon dioxide emissions, life expectancy at birth, population density, recycle energy consumption, urban population growth.*

1.0 INTRODUCTION

Population is a multidimensional concept that can relate to the inhabitants of an area's size, distribution, density, or composition. "Environment" is no less complex — including the air, water, and land qualities on which people and all other species depend. The myriad "mediating" influences which ultimately shape this association are further complicating the relationship between population and environment. These include technological factors (e.g. forms of production of energy), political factors (e.g. regulation of the environment) and cultural factors (e.g. attitudes towards wildlife and conservation). Due to individual resource needs as well as individual contributions to pollution, population size is inherently linked to the environment. Due to individual resource needs as well as individual contributions to pollution, population size is inherently linked to the environment. As a result, population growth produces increased demands on air, water, and land environments as they provide the necessary resources and act as sinks for pollutants in the environment. Population policies aimed at reducing future growth are logical responses to the environmental implications of population size, although a reduction in fertility cannot be seen as an adequate response to contemporary human-induced environmental change. A decline in human numbers does not necessarily suggest a downward trend in behaviours of environmental significance. In addition, it is too simplistic to assume that each additional individual has an equal impact on resources.

Global population size is inherently associated with land, air, and water environments as individual use environmental resources and contributes to environmental pollution. While the scale of resource utilization and the level of waste produced vary across individuals and cultures, the fact remains that human survival requires land, water, and air.

As for resource consumption, the implications of population size and growth can be highlighted by two common sense points. First, everyone needs food, which typically requires land for farming or other forms of production of subsistence. Approximately 1.5 billion hectares are grown for agriculture worldwide, representing the most suitable of an estimated 2 to 4 billion hectares characterized as cultivable. Food and Agricultural Organization (FAO) posed in 2011 that 38.4 per cent of the world's land area is covered by agricultural land. Permanent pastures are 68.4% of all agricultural land (26.3% of global land), arable land (row crops) is 28.4% of all agricultural land (10.9% of global land), and permanent crops (e.g. vineyards and orchards) are 3.1% (1.2% of global land). Moreover, Total land used to produce food: 49,116,227 square kilometres or 18,963,881 square miles, including Arable land: 13,963,743 square kilometres or 5,391,431 square kilometres, Permanent pastures: 33,585,676 square kilometres or 12,967,502 square kilometres, and Permanent crops: 1,537,338 square kilometres or 593,570 square kilometres. FAO (2022), affirmed that Nigeria's agricultural sector faces many challenges which impact its productivity. These include; poor land tenure systems, low levels of irrigation farming, climate change and land degradation. Others are low technology, high production cost and poor distribution of inputs, limited financing, high post-harvest losses and poor market access.

An increase in hectares is required to meet the food demands of the projected global population, assuming constant per capita production, to consider future land requirements in the face of the increasing human population. While there has been an excess of potentially cultivable land throughout human history, the human population's exponential growth has accelerated the pace of land-use change.

Nigeria embarked on diversification of the economy in 1960 after its independence with growing industrial, manufacturing, agricultural, financial, and tourist sectors. These sectors require a strong reliance on fossil fuels for their energy needs. The upsurge in the use of fossil fuels for energy generation facilitates CO2 emissions in the country. Besides fossil fuel consumption, human activities such as the destruction of forests (deforestation), bush burning, ranching, and building are believed to be increasing greenhouse gases (GHG) constantly in the atmosphere. Yunfeng and Laike (2010) reported that CO_2 emissions are responsible for 72% of the global warming effects. One of these major effects is that it results in a temperature rise, which in turn causes a rise in sea level from the thermal expansion of the water. Equally, rising temperature means a rising sea level through the addition of meltwater to the sea from melting glaciers, which poses a great threat socially and economically. This rise in sea level causes increasing coastal erosion, flooding, property damage, and potential loss of lives in low-lying coastal countries such as Nigeria.

Economic growth is one of the macroeconomic goals that cannot be compromised in any developing economy like Nigeria. An attempt to achieve economic growth in a country spurs the consumption of energy in the various sectors of the economy. It is instructive to state that between 2000 and 2014, transport alone emitted an average of 47.76% of CO2 emissions in Nigeria (IEA, 2015). Consumption of fossil fuels is a critical source of CO2 emissions orchestrating climate change globally and, Nigeria has been identified as one of the highest producers and consumers of fossil fuel (Alege et al., 2017). It is important to state that the consumption of fossil fuels deteriorates the environmental quality and constitutes serious human health implications in the economy. In the same vein, the degradation of the environment increases budgetary allocation in terms of healthcare financing (Balan, 2016). Consequently, in achieving sustainable economic growth, high use of energy cannot be undermined. This is because, it is necessary to derive various activities ranging from manufacturing, agricultural, service and other sectors of the economy. This unfortunately poses a continuous threat to the ecology and human life in terms of environmental degradation and life expectancy reduction. To guarantee healthy lives and well-being for all in developing economies like Nigeria, the United Nations' sustainable development goal number three (SDG3) emphasizes good health and well-being of citizens in developing economies by 2030. Meanwhile, in the case of Nigeria, the citizens' welfare has been at stake in the last few decades.

This study broadly focused on the impacts of population dynamics on environmental degradation in Nigeria. The study specifically:

i. examine the impacts of population growth on the carbon-dioxide (CO_2) emissions from residential buildings and commercial and public services;
ii. identify the effect of population density on the carbon dioxide (CO_2) emissions from residential buildings and commercial and public services; and
iii. investigate the relationship between life expectancy and carbon dioxide (CO_2) emissions from residential buildings and commercial and public services.

This study is divided into five sections. Following section one, section two examines related literature. Section three discusses the methodology, while section four provides the study's analysis, results and interpretation. Finally, section five summarizes the findings, makes recommendations and concludes the study.

2.0 REVIEW OF RELATED LITERATURE

2.1 Conceptual review:

Population growth

The human population has experienced a period of unprecedented growth, more than tripling in size since 1950. It reached almost 7.8 billion in 2020 and is projected to grow to over 8.5 billion in 2030, the target date for achievement of the Sustainable Development Goals (SDGs).

This growth is the result of two trends: on the one hand, the gradual increase in average human longevity due to widespread improvements in public health, nutrition, personal hygiene and medicine, and on the other hand, the persistence of high levels of fertility in many countries. But is the growth of the human population responsible for the environmental catastrophe our planet is facing? The data tell a different story. For example, although high-income and upper-middle-income countries contain around 50 per cent of the global population, they contribute around 85 per cent of global emissions of carbon dioxide. Such emissions from upper-middle-income countries have more than doubled since 2000, even though the population growth rate was falling throughout this period. Most high-income countries are growing slowly if at all, and for some, the population has been decreasing. Globally, population growth is slowing down and may come to a halt by around 2100, thanks to the smaller family sizes associated with social and economic development. However, given the intrinsic momentum of population growth, the range of plausible trajectories of the global population over the next few decades is quite narrow. For this reason, further actions by Governments to limit the growth of populations would do little to mitigate the forces of climate change between now and 2050 (UNFPA,2020)

Life Expectancy

Life expectancy at birth is the average age at which a person is expected to die. Life expectancy is a common measure of population health in general and is often used as a summary measure when comparing different populations. Life expectancy is also used in public policy planning, especially as an indicator of future population ageing. The level of life expectancy in a country has important implications. It affects fertility behaviour, economic growth, human capital investment, intergenerational transfers and incentives for pension benefit claims.

Environmental Implications of population size, distribution, and Composition

Population Size

Population size is inherently linked to the environment as a result of individual resource needs as well as individual contributions to pollution. However, no simple relationship exists between population size and environmental change. Sheer human numbers in some instances have a direct impact on the environment. More often, however, the environmental implications of population size are ultimately determined by complex interactions among many forces, including technology, political and institutional contexts, and cultural factors.

However, as the global population continues to grow, limits on such global resources as land and water have come into sharper focus. For example, only in the latter half of the twentieth century has the unavailability of land become a potentially limiting factor in global food production. Assuming constant rates of production, per capita land requirements for food production now fall within the range of estimated available cultivable land. Likewise, continued population growth occurs in the context of an accelerating human thirst for water: Global water consumption rose sixfold between 1900 and 1995, more than double the rate of population growth. Population size also influences pollution levels in complex ways. Though again this interaction is difficult to gauge, researchers have tried to calculate the relationship between population growth and pollution increases. Studies of air pollution in California, for instance, suggest that a 10 per cent increase in population at the county level produces emissions increase of 7.5 to 8 per cent for pollutants associated with automobile exhaust, largely because local population growth is important as a determinant of the volume of consumption. Greater numbers of people, for instance, typically imply more cars.

Population Distribution

"Population distribution" refers to the dispersal and density of the population. During the past 40 years, two trends have powerfully influenced the distribution of humans around the globe. First, continued high fertility rates in many developing regions, coupled with low fertility in more-developed regions, have resulted in ever-increasing shares of the global population residing in less-developed countries. According to UN estimates, 80 per cent of the world population in 1999 lived in developing nations. Second, the Earth's population is increasingly concentrated in urban areas. As recently as 1960, only one-third of the world's population lived in cities. By 1999, the percentage had increased nearly to half (47 per cent). This trend is expected to continue well into the twenty-first century. The distribution of people around the globe has three main implications for environmental change. First, as less-developed regions cope with an increasing share of the global population, pressures will intensify on already dwindling resources within many of these areas. Second, the redistribution of the population through migration shifts the relative pressures exerted on local environments, perhaps easing the strain in some areas and increasing it in others. Finally, the trend toward urbanization poses particularly complex environmental challenges. The rapid pace of urbanization hinders the development of adequate infrastructure and regulatory mechanisms for coping with pollution and other byproducts of growth, often resulting in high levels of air and water pollution and other environmental ills. Furthermore, urbanization can alter local climate patterns. Concentrations of artificial surfaces, such as brick and concrete, can create "heat islands." In cities with more than 10 million people, the mean annual minimum temperature may be as much as 4 degrees Fahrenheit higher than in nearby rural areas. In addition, poorly planned urban development “sprawl” can result in the loss of agricultural land and natural habitat.

Population Composition

"Population composition" refers to the characteristics of a particular group of people. Age and socioeconomic composition, for instance, have environmental implications. As for age composition, owing to the population boom of recent decades and increased longevity across the globe, today's human population has both the largest cohort of young people (age 24 and under) and the largest proportion of elderly in history. Understanding population characteristics helps illuminate some of the mechanisms through which population dynamics affect environmental conditions. For example, migration propensities vary by age. Young people are more likely than their older counterparts to migrate, primarily as they leave their parental homes in search of new opportunities. Given the relatively large younger generation, we might anticipate increasing levels of migration and urbanization and, therefore, intensified urban environmental concerns. Income is an especially important demographic characteristic relevant to environmental conditions. Across nations, the relationship between economic development and environmental pressure resembles an inverted U-shaped curve; nations with economies in the middle-development range are most likely to exert powerful pressures on the natural environment, mostly in the form of industrial emissions. By contrast, the least-developed nations—because of low levels of industrial activity—are likely to exert relatively lower levels of environmental pressure. In addition, at highly advanced development stages, environmental pressures should subside due to improved efficiencies. Within countries and across households, the relationship between income and environmental pressure is different. Environmental pressures can be greatest at the lowest and highest income levels. Population growth and poverty often interact to produce unsustainable levels of resource use. Furthermore, higher levels of income tend to correlate with increased levels of production and consumption.

Global climate change and land use patterns

Two specific areas of inquiry help to illustrate the challenges of understanding the complex influence of population dynamics on the environment: global climate change and land-use patterns. On the other hand, these examples also demonstrate the growing body of scientific evidence that illuminates the interrelationships between demographics and environmental context.

Global Climate Change

Recent years have been among the warmest on record. Evidence suggests that temperatures have been influenced by growing concentrations of greenhouse gases, such as carbon dioxide, which absorb solar radiation and warm the Earth's atmosphere. To what extent can climate change be attributed directly to demographic factors? A growing body of evidence suggests that many of the changes in atmospheric gas are human-induced. The demographic influence appears primarily in three forms: contributions to CO2 emissions stem from fossil fuel use related to industrial production and energy consumption; land-use changes, such as deforestation, also affect the exchange of carbon dioxide between the Earth and the atmosphere; and other consumption-related processes, such as rice paddy cultivation and livestock production, are responsible for greenhouse gas releases to the atmosphere, particularly methane. Research has shown that population size and growth are important factors in the emission of greenhouse gases. One study concludes that population size and growth will account for 35 per cent of the global increase in CO_2 emissions between 1985 and 2100 and 48 per cent of the increase from developing nations during that period. However, as population growth slows during the next century, its contribution to emissions is expected to decline. This decline will be especially large in the context of developing nations. While population-driven emissions from developed nations are estimated to contribute 42 per cent of CO_2 emissions between 1985 and 2020, they are expected to contribute only 3 per cent between 2025 and 2100.

Land use pattern

Fulfilling the resource requirements of a growing population ultimately requires some form of land-use change, whether to expand food production through forest clearing, intensify production on already cultivated land or develop the infrastructure needed to support the increased population. Indeed, humans can manipulate the landscape that has allowed for the rapid pace of contemporary population growth. Agriculture and deforestation are two prominent forms of human-induced land-use change. During the past three centuries, the amount of Earth's cultivated land has grown by more than 450 per cent, increasing from 2.65 million square kilometres to 15 million square kilometres. At the same time, the world's forests have been shrinking. Deforestation is closely linked to agricultural land-use change because it often represents a consequence of agricultural expansion. A net decline in forest cover of 180 million acres occurred during the 15-year interval 1980–1995, although changes in forest cover vary greatly across regions. Changing land use and deforestation in particular have several ecological impacts. Agriculture can lead to soil erosion, while overuse of chemical inputs can also degrade the soil. Deforestation also increases soil erosion, in addition to reducing rainfall due to localized climate changes, lessening the ability of soils to hold water, and increasing the frequency and severity of floods. Land-use change in general results in habitat loss and fragmentation—the primary cause of contemporary species decline. It has been suggested that if current rates of forest clearing continue, a quarter of all species on Earth could be lost within the next 50 years.

Conceptual framework

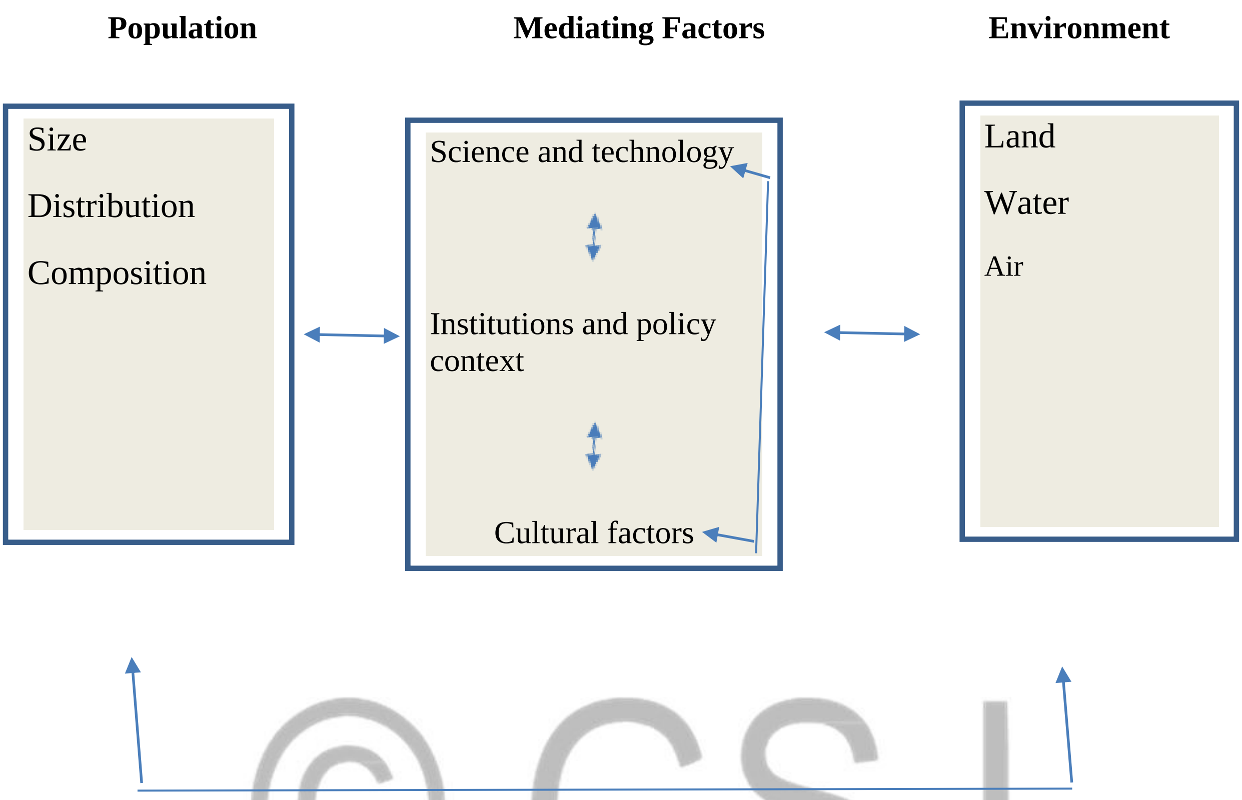


Figure 2.1: Framework for Considering the Relationship Between Population and the Environment

Source: Adapted from MacKellar et al., 1998 in Amare and Belay (2015).

Discussing the relationship between population and the environment is not simple. "Population" is a multidimensional concept that can relate to the size, distribution, density, or composition of an area's inhabitants. "Environment" is no less complex—encompassing qualities of the air, water, and land on which humans and all other species depend. Further complicating the relationship between population and the environment are the myriad "mediating" influences that ultimately shape this association. These include technological factors (e.g., forms of energy production), political factors (e.g., environmental regulation), and cultural factors (e.g., attitudes toward wildlife and conservation). Figure 1.1 presents a conceptual framework describing the relationship between the population and the environment in fairly simple terms.

2.2 Theoretical review

In its simplest form, neo-Malthusianism holds that human populations, because they tended to increase exponentially if fertility is unchecked, will ultimately outstrip Earth's resources, leading to ecological catastrophe. This has been one of the dominant paradigms in the field of population and the environment, but it is one which many social scientists have rejected because of its underlying biological/ecological underpinnings, treating humans in an undifferentiated way from other species that grow beyond the local "carrying capacity." Neo-Malthusianism has been criticized for overlooking cultural adaptation, technological developments, trade, and institutional arrangements that have allowed human populations to grow beyond their local subsistence base.

The controversy over whether rapid population growth in the countries of the South or high consumption in those of the North is to be held responsible for global environmental problems is usually framed in terms of the I= PAT identity first introduced by Ehrlich and Holdren (1974). In a typical formulation, environmental impact (I} is seen as the product of three factors: population (P}; affluence (A}, which is measured by gross national product per person; and technological efficiency (T}, which is expressed as impact per unit of GNP. This identity is useful and suggestive as a first approach because it demonstrates that environmental impact is due, not to one factor alone, but to a combination of factors. However, I = PAT has serious limitations if taken as a basis for more rigorous scientific analysis. The problems with I= PAT can be grouped into two broad categories: (l) the omission of interactions between the variables, and (2) questions related to the choice of variables: (l) I= PAT cannot contribute much to resolving the population versus consumption debate because of differences of opinion concerning the interactions between the factors P, A, and T.

Analysis along I = PAT lines cannot resolve these differences of opinion, because the controversial relationships are not explicit in the equation (Cropper and Griffiths, 1994).

Second, in some decomposition exercises, such as the decomposition of trends in the crude birth rate into age structure and fertility-rate effects, the choice of variables is a straightforward matter of accounting. In the case of I = PAT, the choice is much less self-evident. If the impact to be studied is, say, C02 emissions, why should the emitting unit be taken as the individual rather than, say, the household or the community? In other words, the choice of factors requires substantive justification and should not be taken for granted. The following note concerns itself with the second (and less serious) problem, specifically, with the accounting implications of the fact that I = PAT selects the individual as the demographic unit. We illustrate the consequences of considering households (H) instead of individuals as the consuming unit (i.e., I= HAT instead of I= PAT). The substantive justification for this lies in the fact that for many goods, such as automobile transport and residential energy consumption, there are significant economies of scale: for example, a household of four persons will consume far less than twice as much as a household consisting of two persons (Bumpass, 1990). For goods whose consumption is tied more closely to the earth than to the individual, the size and rate of growth of the population are of less concern than the number and rate of growth of households.

The so-called Boserupian hypothesis, named after agricultural economist Esther Boserup, holds that agricultural production increases with population growth owing to the intensification of production (greater labour and capital inputs). Although often depicted as being in opposition to Malthusianism, Malthus himself acknowledged that agricultural output increases with increasing population density (just not fast enough), and Boserup acknowledged that there are situations under which intensification might not take place.

As Turner and Sharjaat Ali point out, the main difference between the theories of Malthus and Boserup is that Malthus saw technology as being exogenous to the population-resource condition and Boserup sees it as endogenous.

Cornucopian theories espoused by some neoclassical economists stand in sharper contrast to neo-Malthunisianism because they posit that human ingenuity (through the increased supply of more creative people) and market substitution (as certain resources become scarce) will avert future resource crises. In this line of thinking, market failures and inappropriate technologies are more responsible for environmental degradation than population size or growth, and natural resources can be substituted by man-made ones.

2.3 Empirical review

Yi, Wang, Li and Qi (2021) based on the panel data of 108 prefecture-level cities in China from 2003 to 2018, examined the effect of urban density on carbon emissions and established a dynamic panel model. Researchers found that there was a significant negative correlation between urban density and carbon emissions, and the increase in urban density reduced carbon dioxide emissions.

Romanus, Aderemi, Akindele, and Okoh (2020) examined how carbon emissions affect life expectancy in Nigeria using Autoregressive Distributed Lag (ARDL) model. The study focused on how energy consumption impact on life expectancy in Nigeria and found that carbon emissions are significant and negatively affect life expectancy. This finding implied that, on average, carbon emissions are capable of reducing life expectancy by 0.35%. the study concluded by recommending that the Nigerian government should embark on the alternative use of energy that emits lesser carbon. Thus, this will help attain the sustainable development goals of good health and well-being alongside affordable, reliable and sustainable use of energy for all.

Lawal and Abubakar (2019) examined the impact of population growth on carbon dioxide emissions in Nigeria. Time series data from 1975 to 2016 was adopted. Variables such as population, affluence and technology were used as independent variables which were extracted from the IPAT equation. Econometric tools such as Ordinary Least Squares were adopted. The findings show that there is a positive association between CO_2 emission, population and technology whereas affluence has a negative relationship with CO_2. The study concluded that population growth has a marginal impact on the level of CO_2 emission. The paper recommended that there is a need for the government to adopt a climate-friendly technology that will minimize the increasing CO_2 emission, and improve its GDP alongside controlling its population growth.

Weber and Sciubba (2019) investigated the effect of population growth on the environment. The author compiled a dataset of 1062 regions within 22 European countries and analyze the effect of population growth on carbon dioxide (CO2) emissions and urban land use change between 1990 and 2006, using panel regressions, spatial econometric models, and propensity score matching where regions with high population growth are matched to otherwise highly similar regions exhibiting significantly less growth. The authors found a considerable effect from regional population growth on carbon dioxide (CO2) emissions and urban land use increase in Western Europe. By contrast, in the new member states in the East, other factors appear more important.

Lukman, Oluwayemi, Okoro and Onate (2018) investigated the impacts of population total, gross domestic product per capita, urbanization rate and energy use on carbon emissions in Nigeria for a period of 1981-2015 using the autoregressive distributed lag approach to co-integration (ARDL). The empirical results revealed evidence of a long-run relationship among the variables. The generalized ridge regression was used to correct the presence of multicollinearity among the explanatory variables in the long run. Results show that population total, gross domestic product per capita, urbanization rate and energy use have a positive impact on carbon emissions. Energy use and urbanization both contributed significantly to increasing carbon emissions in the long and short run respectively. Because the factors investigated in this study are the increasing trend in this nation there is a need to implement policies to curb the increasing rate of carbon emissions in Nigeria

Sulaiman and Abdul-Rahim (2018) investigated the relationship between population growth and carbon dioxide emission in Nigeria using an autoregressive distributed lag model covering periods from 1971-2000, 1971-2005, and 1971-2010 recursively. The results indicated that population was not a determinant of CO2 emissions in all three periods in the long run. However, economic growth was found to be the only long-run CO2 emissions determining factor within the studied periods. However, in the short run, virtually all the explanatory variables and their lags, that is, population growth, economic growth, and energy consumption, were significant in determining CO2 emissions. The findings suggested that population growth, which is the focal point of the study, could only determine CO2 emissions in the short run. Therefore, population checking measures could be a short-run effective measure to lower the emissions level.

Liddle (2013) investigated the impact of population age structure and urbanization on Carbon emissions/energy consumption. This review summarizes the evidence from cross-country, macro-level studies on the way demographic factors and processes—specifically, population, age structure, household size, urbanization, and population density—influence carbon emissions and energy consumption. Analyses employing time-variant data have produced great variance in population elasticity estimations—sometimes significantly greater than one, sometimes significantly less than one; whereas, cross-sectional analyses typically have estimated population elasticities near one. Studies that have considered age structure typically have used standard World Bank definitions, and most have found those variables to be insignificant**.** Average household size has a negative relationship with road energy use and aggregate carbon emissions. Urbanization appears positively associated with energy consumption and carbon emissions. Higher population density is associated with lower levels of energy consumption and emissions.

Zhu and Peng (2012) examined the impacts of population size, population structure, and consumption level on carbon dioxide in China from 1978 to 2008. The authors expanded the stochastic impacts by regression on population, affluence, and technology model and used the ridge regression method, which overcomes the negative influences of multicollinearity among independent variables under acceptable bias. The findings revealed that changes in consumption level and population structure were the major impact factors, not changes in population size. Consumption level and carbon emissions were highly correlated. In terms of population structure, urbanization, population age, and household size had distinct effects on carbon emissions. Urbanization increased carbon emissions, while the effect of age acted primarily through the expansion of the labour force and consequent overall economic growth. Shrinking household size increased residential consumption, resulting in higher carbon emissions. Households, rather than individuals, are a more reasonable explanation for the demographic impact on carbon emissions.

Mariani, Perez-Barahona and Raffin (2009) presented a model in which life expectancy and environmental quality dynamics are jointly determined. They stated that agents may invest in environmental care, depending on how much they expect to live. In turn, environmental conditions affect life expectancy. As a result, this model produces a positive correlation between longevity and environmental quality, both in the long run and along the transition path. Eventually, multiple equilibria may also arise: some countries might be caught in a low-life-expectancy / low-environmental-quality trap. This outcome is consistent with stylized facts relating to life expectancy and environmental performance measures. The authors also discussed the welfare and policy implications of the intergenerational externalities generated by individual choices. Finally, they showed that their results are robust to the introduction of growth dynamics based on physical or human capital accumulation.

3.0 RESEARCH METHODOLOGY

3.1 Research design

The study employed a quantitative research method. The data reflected the impact of independent variables - population dynamics as proxies by population growth, population density, life expectancy at birth, and renewable energy consumption on environmental degradation proxy by carbon-dioxide emissions as the dependent variable.

3.2 Sources of Data

This study used a secondary source of data. The periods of study covered fifty-one (51) years from 1971 to 2021. Time series data were used in this study, and sourced mainly from the World Development Indicators (WDI) of the World Bank publication (2022).

3.3 Model specification

This work is a modification of the work of Lawal and Abubakar (2019) which examined the impact of population growth on carbon dioxide emission. The work is also based on the Neo-Malthusian theory and the I-PAT model of Holder & Ehrlich (1974).

$$CDE = f(UPG, PD, LEB, REC) ---------------------- (1)$$

$$CDE = \propto_0 + \propto_1 UPG + \propto_2 PD + \propto_3 LEB + + \propto_4 REC + \mu \quad ------ \quad -- - (2)$$

Expectation Apriori: $\propto_1 > 0; \propto_2 > 0; \propto_3 > 0; \propto_4 > 0$

Null Hypothesis, H_0: $\propto_1 = \propto_2 = \propto_3 = \propto_4 = 0$

Where:

CDE – measures carbon-dioxide emission as % of total fuel combustion

UPG – Urban Population Growth (the rate of growth of urban population)

PD – Population Density (numbers of people per sq. km of land area)

LEB – Life Expectancy at Birth (average age of living for both males and females)

REC = Renewable Energy Consumption (% of total final energy consumption)

μ = Error term/Stochastic variable

3.4 Method of Estimation

The above-stated model was estimated with the autoregressive distributed lag (ARDL) method through multiple regression of Carbon-dioxide emission (CDE) on all explanatory variables namely: Urban Population Growth (UPG), Population Density (PD), Life Expectancy at Birth (LEB), and Renewable Energy Consumption (REC). E-view 12 software package was used for the analysis and estimation.

4.0 DATA ANALYSIS, RESULTS AND INTERPRETATION

4.1 Stylized Facts on Population Dynamics and Carbon-dioxide Emissions in Nigeria

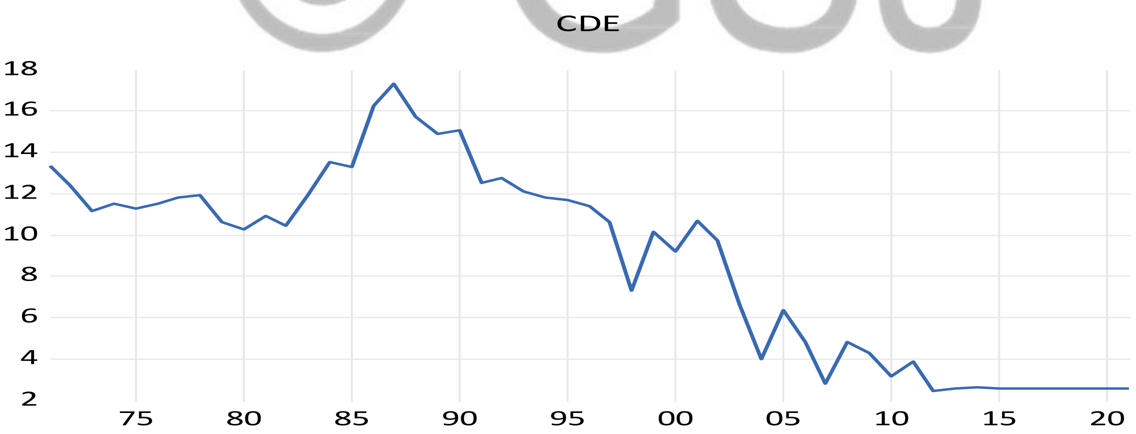


Figure 4.1: Line graph of Carbon-dioxide emission in Nigeria from 1971 to 2021

Source: Author's Computation from E-View 12 Software

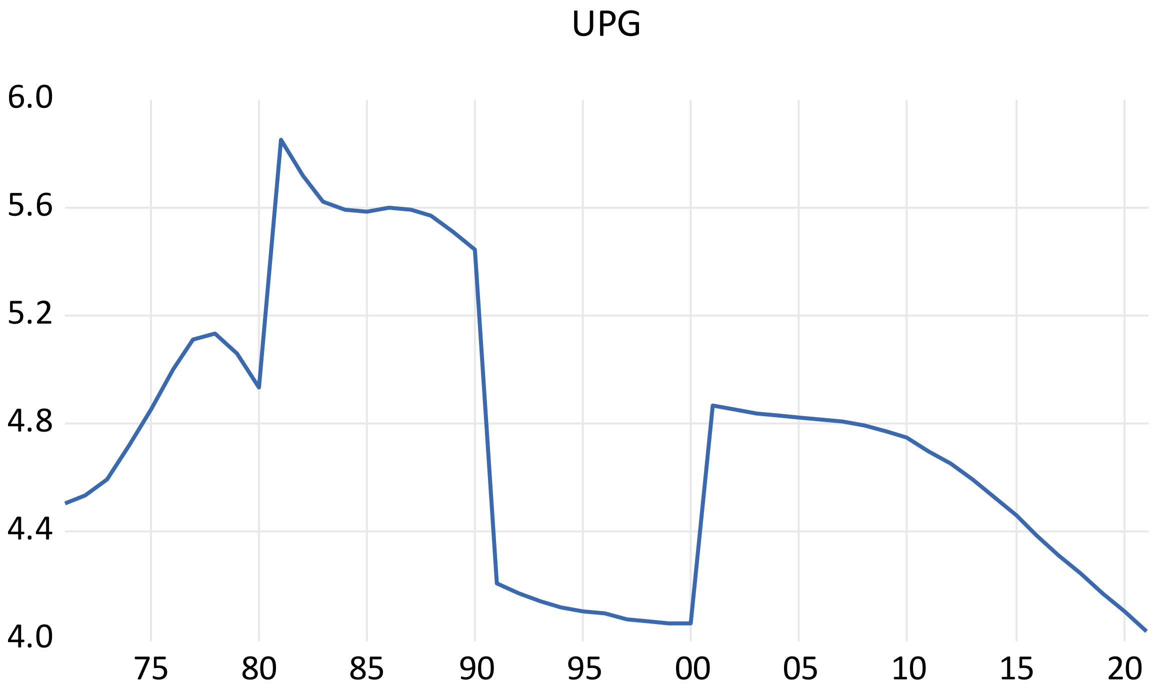


Figure 4.2: Line graph of Urban Population Growth in Nigeria from 1971 to 2021

Source: Author's Computation from E-View 12 Software

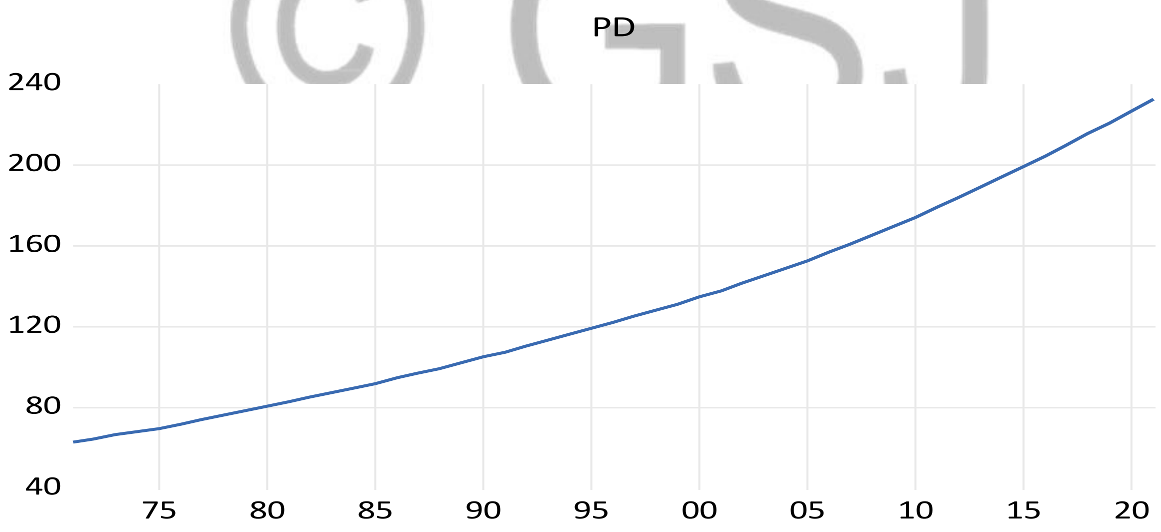


Figure 4.3: Line graph of Population Density in Nigeria from 1971 to 2021

Source: Author's Computation from E-View 12 Software

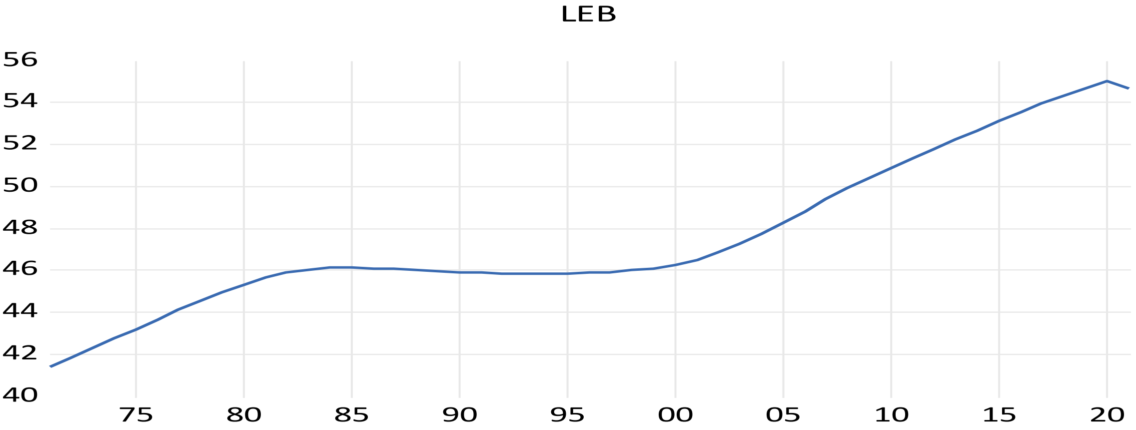


Figure 4.4: Line graph of Life Expectancy at Birth in Nigeria from 1971 to 2021

Source: Author's Computation from E-View 12 Software

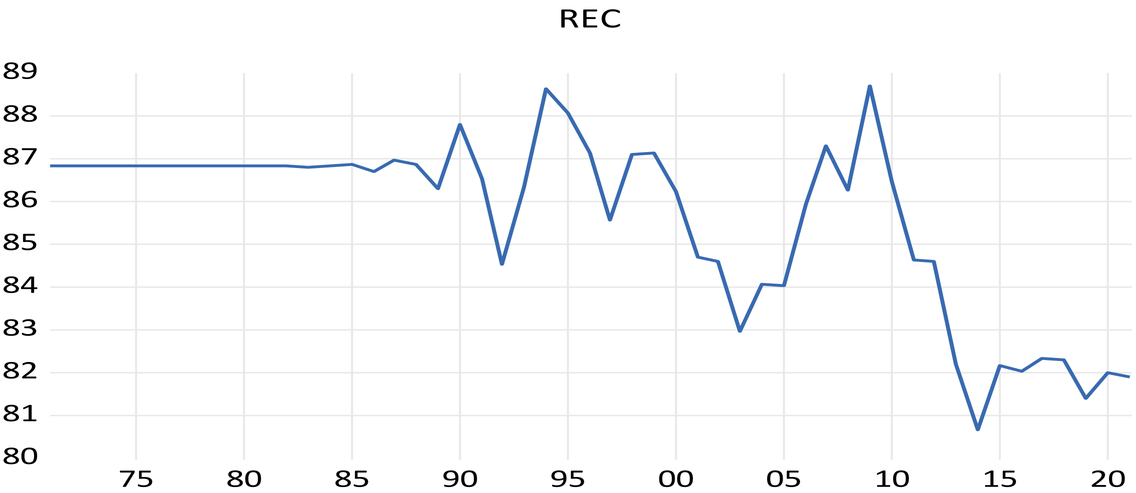


Figure 4.5: Line graph of Recycle Energy Consumption in Nigeria from 1971 to 2021

Source: Author's Computation from E-View 12 Software

4.2 Descriptive Statistics

This examined the statistical values of the dependent and independent variables in this study.

Table 4.1: Descriptive Statistics

	CDE	UPG	PD	LEB	REC
Mean	8.853085	4.739729	130.3677	47.57867	85.58399
Median	10.63123	4.744297	121.5112	46.10100	86.69330
Maximum	17.29227	5.850699	232.1121	55.01800	88.68000
Minimum	2.465234	4.025409	62.91049	41.39200	80.64000
Std. Dev.	4.559766	0.535604	49.54861	3.642477	2.063901
Skewness	-0.191089	0.427752	0.453961	0.624685	-0.877534
Kurtosis	1.699601	2.129533	2.047189	2.425695	2.572893
Jarque-Bera	3.903834	3.165401	3.680863	4.017848	6.933205
Probability	0.142002	0.205420	0.158749	0.134133	0.031223
Sum	451.5073	241.7262	6648.751	2426.512	4364.783
Sum Sq. Dev.	1039.574	14.34357	122753.2	663.3819	212.9843
Observations	51	51	51	51	51

Source: Author's Computation from E-View 12 Software

4.3 Unit Root Test

TABLE 4.2: Augmented Dickey-Fuller Test

Variables	At Level	First Difference	Integration of Order
CDE	-1.972923	-8.008642***	I (1)
	(3.502373)	(-3.504330)	
UPG	-1.681250	-5.440909***	I (1)
	(3.526609)	(-3.526609)	
PD	1.666234	-3.563268**	I (1)
	(-3.523623)	(-3.529758)	
LEB	-5.555738***	-	I (0)
	(-3.523623)		
REC	-2.841531	-7.292140***	I (1)
	(-3502373)	(3.504330)	

Note: The values in parenthesis represent critical t-values at 5% while the values without parenthesis are Dickey-Fuller test-statistic at 1% (***) and 5% (**) probability level.

Source: Author's Computation from E-View 12 Software

Table 4.2 showed the unit root computations for variables involved in the study, where life expectancy at birth stabilized at level; while carbon-dioxide emission, urban population growth, population density, and recycled energy consumption are stabilized at first difference. Thus, the foregoing unit root tests indicate that the estimated model for this study is not spurious.

4.3 ARDL F-Bound Test

Having obtained the results of unit roots for all variables to be stationary at levels and first differences, we conduct a bound co-integration test to know if there is a long-run relation among the variables.

Table 4.3: F-Bound Test

Test Statistic	Value	Signif.	I(0)	I(1)
			Asymptotic: n=1000	
F-statistic	11.00008	10%	3.03	4.06
k	4	5%	3.47	4.57
		2.5%	3.89	5.07
		1%	4.4	5.72
Actual Sample Size	49		Finite Sample: n=50	
		10%	3.24	4.35
		5%	3.834	5.064
		1%	5.184	6.684
			Finite Sample: n=45	
		10%	3.298	4.378
		5%	3.89	5.104
		1%	5.224	6.696

Source: Author's Computation from E-View 12 Software

Table 4.3 showed that F-statistic (11.00008) is greater than lower and upper bound critical values at 1%, 2.5%, 5% and 10% respectively. Thus, the ARDL bounds testing approach for co-integration revealed evidence of a long-run relationship among the variables.

4.4 Optimal Lag Length

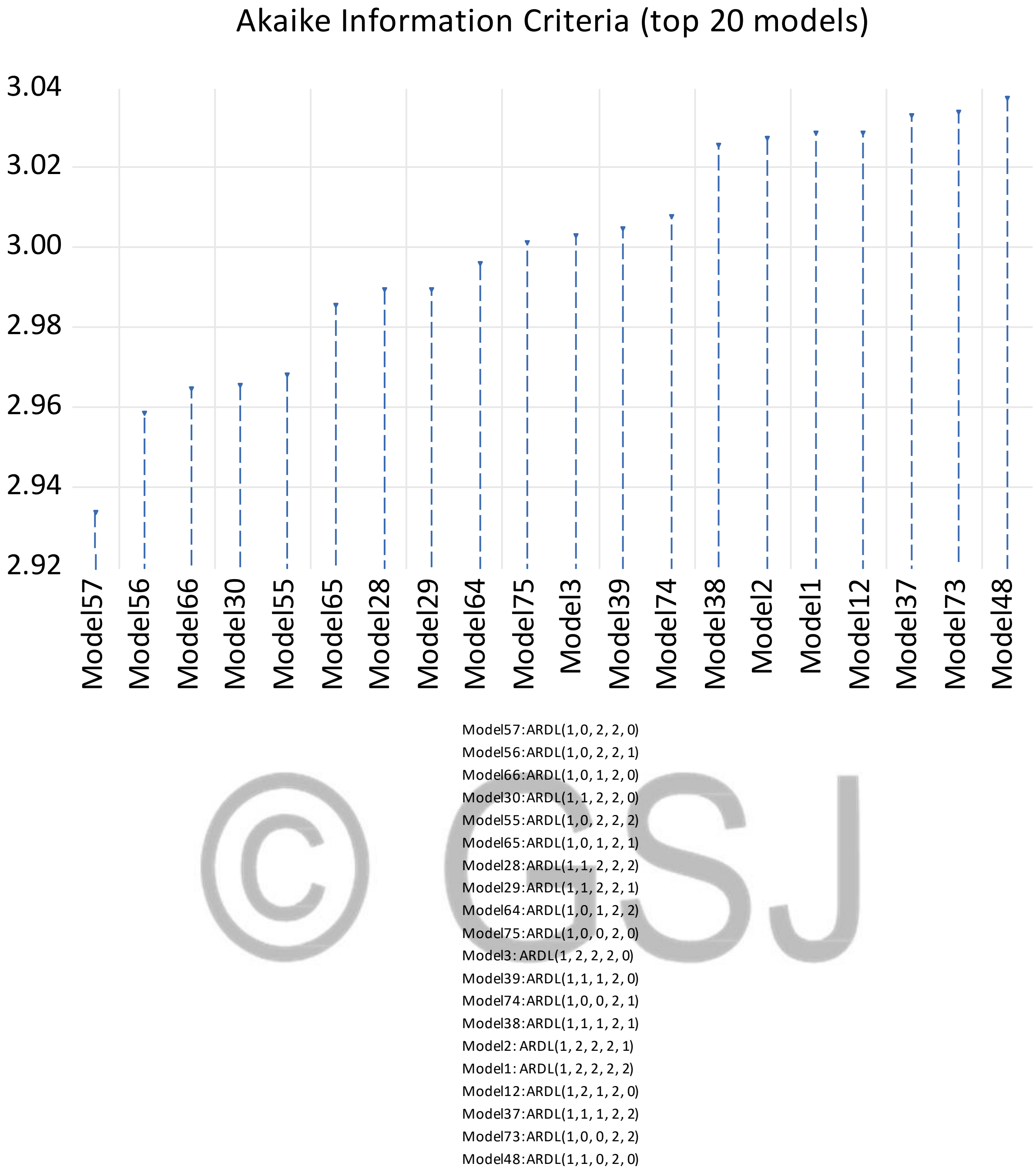
Table 4.4: Lag Length

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-512.6720	NA	2538.285	22.02860	22.22542	22.10266
1	-41.43662	822.1554	1.45e-05	3.039856	4.220801	3.484254
2	25.35036	102.3120	2.54e-06	1.261687	3.426753	2.076416
3	133.4665	142.6213	8.15e-08	-2.275171	0.874017*	-1.090110
4	178.4896	49.81278*	4.23e-08*	-3.127217*	1.006091	-1.571825*

* 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
HQ: Hannan-Quinn information criterion

Source: Author’s Computation from E-View 12 Software

Table 4.4 shows that the maximum lag for the model is 4 because high numbers of lag selection criteria supported lag 4,



which is indicated by (*).

Figure 4.6 Criteria Graph

Source: Author's Computation from E-View 12 Software

Figure 4.6 indicates the top twenty selected models based on Akaike information criteria. Thus, the best model among the selected ones is a model with a small Lag length – model (1,0,2,2,0).

4.5 ARDL Short Run Result and Interpretation

Table 4.5: ARDL Result – dependent variable – Carbon-dioxide Emission (CDE)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
CDE(-1)	0.054160	0.138879	0.389983	0.6987
UPG	1.729948	0.544153	3.179155	0.0029
PD	9.666282	4.029948	2.398612	0.0215
PD(-1)	-16.92833	8.063245	-2.099444	0.0425
PD(-2)	7.273041	4.327537	1.680642	0.1010
LEB	-0.285957	1.773426	-0.161245	0.8728
LEB(-1)	-13.25500	4.558994	-2.907440	0.0061
LEB(-2)	13.16999	3.135692	4.200028	0.0002
REC	0.067097	0.125335	0.535340	0.5955
C	13.78354	15.95612	0.863841	0.3931
@TREND	-0.323093	0.142685	-2.264372	0.0293

R-squared	0.965764	Mean dependent var	8.688716
Adjusted R-squared	0.956754	S.D. dependent var	4.576673
S.E. of regression	0.951747	Akaike info criterion	2.933710
Sum squared resid	34.42122	Schwarz criterion	3.358404
Log likelihood	-60.87588	Hannan-Quinn criter.	3.094838
F-statistic	107.1937	Durbin-Watson stat	2.035228
Prob(F-statistic)	0.000000		

*Note: p-values and any subsequent tests do not account for model selection.

Source: Author's Computation from E-View 12 Software

Table 4.5 shows the short-run model, where the coefficient determination (R-squared) is 0.965764 and the adjusted R-squared is 0.956754. Thus, 95% of the explanatory variables explained the dependent variables – carbon-dioxide emissions in Nigeria. The value of the F-statistic is 107.1937 and is significant at 1% probability. The value of Durbin-Watson is 2.035228, which made the model not spurious but stable.

Short-run Variables Analysis

Table 4.5 indicates that the coefficient of urban population growth is 1.729948 and is significant at a 1% level of probability. Thus, the foregoing result indicates that a 1% increase in urban population growth lead on average to a 1.72% increase in carbon-dioxide emissions. This result implies that there exists a positive relationship between urban population growth and carbon-dioxide emission. This result signified that the increase in urban population contributed to an increase in carbon-dioxide emissions within the period of study.

The coefficient of population density is 9.666282 in the current year and is significant at a 5% level of probability. Thus, the foregoing result implies that a 1% increase in population density in the current year leads on average to a 9.67% increase in carbon-dioxide emissions. There exists a positive relationship in the current year between population density and carbon dioxide emissions. This result depicted that an increase in population density caused an increase in carbon emissions within the period of study. While the population density in one year lag is (-16.929833) and is significant at a 5% level of probability. Thus, the foregoing result implies that a 1% increase in population density in one year lag leads on average to a 16.9 decrease in carbon-dioxide emissions. There exists a negative relationship between population density in one year lag and carbon dioxide emissions. The result signified that population density in one year lag caused a decrease in carbon-dioxide emissions.

The coefficient of life expectancy at birth in the current year is (-0.285957) but not significant, while in coefficient of life expectancy in one year lag is (-13.25500) and is significant at a 1% level of probability. Thus, a 1% increase in life expectancy at birth in the current year and a one-year lag lead on average to 0.29% and % 13.3% respectively decreases in carbon-dioxide emissions. There exists a negative relationship between life expectancy at birth and carbon emissions.

The coefficient of renewable energy consumption is 0.067097 but not significant. Thus 1% increase in renewable energy consumption leads on average to a 0.07% increase in carbon-dioxide emissions. There exists a positive relationship between renewable energy consumption and carbon-dioxide emissions.

Table 4.6: Error Correction Model

ECM Regression
Case 5: Unrestricted Constant and Unrestricted Trend

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.78354	2.093254	6.584742	0.0000
@TREND	-0.323093	0.070005	-4.615308	0.0000
D(PD)	9.666282	3.547442	2.724860	0.0097
D(PD(-1))	-7.273041	3.364923	-2.161429	0.0370
D(LEB)	-0.285957	1.475847	-0.193758	0.8474
D(LEB(-1))	-13.16999	2.616653	-5.033145	0.0000
CointEq(-1)*	-0.945840	0.121311	-7.796788	0.0000

R-squared	0.607517	Mean dependent var	-0.201227
Adjusted R-squared	0.551448	S.D. dependent var	1.351705
S.E. of regression	0.905292	Akaike info criterion	2.770444
Sum squared resid	34.42122	Schwarz criterion	3.040704
Log likelihood	-60.87588	Hannan-Quinn criter.	2.872981
F-statistic	10.83517	Durbin-Watson stat	2.035228
Prob(F-statistic)	0.000000		

Source: Author’s Computation from E-View 12 Software

The ECM is statistically significant at a 1% level of probability. An adjustment parameter of (-0.945840) implies that 95% of any deviation from disequilibrium in the previous period (year) will be corrected for in the current period (year). The foregoing result was supported by Narayan and Smyth (2006) who stated that an error correction term lies between -1 and -2 means that the equilibrium is achieved in a decreasingly fluctuating form or changing frequently but decreasingly.

Table 4.7: ARDL Long Run Result – dependent variable – Carbon-dioxide Emission

Variable	Coefficient	Std. Error	t-Statistic	Prob.
UPG	1.829007	0.515127	3.550593	0.0010
PD	0.011619	0.062246	0.186663	0.8529
LEB	-0.392205	0.426484	-0.919624	0.3636
REC	0.070939	0.131584	0.539115	0.5930

EC = CDE - (1.8290*UPG + 0.0116*PD -0.3922*LEB + 0.0709*REC)

Source: Author’s Computation from E-View 12 Software

Urban population growth

In the long run, the coefficient of urban population growth is 1.829007 and significant at a 1% probability level. Thus 1% increase in urban population growth leads on average to a 1.8% increase in carbon-dioxide emissions within the period of study. There exists a positive relationship between urban population growth and carbon-dioxide emissions.

Population density

In the long run, the coefficient of population density is 0.011619 and not significant. Thus, a 1% increase in population density leads on average to a 1.2% increase in carbon-dioxide emissions. There exists a positive relationship between population density and carbon-dioxide emissions within the period of study.

Life expectancy at birth

In the long run, the coefficient of life expectancy at birth is (-0.392205) and not significant. Thus, a 1% increase in life expectancy at birth leads on average to a 39% decrease in carbon-dioxide emissions. Thus, there exists a negative relationship between life expectancy at birth and carbon dioxide emissions.

Renewable energy consumption

In the long run, the coefficient of renewable energy consumption is 0.070939 and not significant. Thus 1% increase in renewable energy consumption leads on average to a 7% increase in carbon-dioxide emissions. This implies that there exists a positive relationship between renewable energy consumption and carbon-dioxide emissions.

Residual diagnostics:

Table 4.7: Correlogram of Residuals

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.018	-0.018	0.0168	0.897
		2	-0.251	-0.252	3.3700	0.185
		3	0.028	0.019	3.4124	0.332
		4	-0.235	-0.317	6.4733	0.166
		5	-0.172	-0.199	8.1477	0.148
		6	0.206	0.042	10.621	0.101
		7	-0.129	-0.273	11.603	0.114
		8	-0.003	-0.031	11.604	0.170
		9	0.278	0.089	16.428	0.058
		10	-0.109	-0.114	17.183	0.070
		11	-0.321	-0.345	23.945	0.013
		12	-0.088	-0.378	24.468	0.018
		13	0.105	-0.044	25.230	0.022
		14	0.141	-0.069	26.641	0.021
		15	0.216	-0.056	30.066	0.012
		16	0.114	0.063	31.043	0.013
		17	-0.128	-0.075	32.328	0.014
		18	-0.039	-0.040	32.448	0.019
		19	0.026	0.033	32.502	0.027
		20	-0.281	-0.164	39.327	0.006

*Probabilities may not be valid for this equation specification.

Source: Author's Computation from E-View 12 Software

Table 4.7 shows the correlograms of Q statistic which can be used to check autoregressive conditional heteroskedasticity (ARCH) in the residuals. We confirmed that in the estimated equation/model there is ARCH in the residuals, the autocorrelations and partial autocorrelations are not zero at all lags and the Q-statistics are significant

Table 4.8: Correlogram of Residuals Square

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.001	-0.001	2.E-05	0.996
		2	-0.062	-0.062	0.2020	0.904
		3	0.067	0.067	0.4464	0.931
		4	0.089	0.085	0.8838	0.927
		5	-0.089	-0.082	1.3322	0.932
		6	0.239	0.251	4.6525	0.589
		7	0.094	0.072	5.1821	0.638
		8	-0.099	-0.075	5.7775	0.672
		9	-0.063	-0.068	6.0229	0.738
		10	0.040	-0.032	6.1255	0.805
		11	0.013	0.043	6.1361	0.864
		12	-0.079	-0.112	6.5563	0.885
		13	-0.073	-0.124	6.9217	0.906
		14	0.014	0.032	6.9349	0.937
		15	-0.056	-0.016	7.1642	0.953
		16	-0.041	-0.010	7.2929	0.967
		17	-0.080	-0.122	7.7922	0.971
		18	-0.035	-0.014	7.8893	0.980
		19	-0.060	0.019	8.1933	0.985
		20	-0.034	-0.042	8.2958	0.990

*Probabilities may not be valid for this equation specification.

Source: Author's Computation from E-View 12 Software

Table 4.8 shows the correlogram of the residual squared and we confirmed that in the estimated equation/model there is ARCH in the residuals, the autocorrelations and partial autocorrelations are not zero at all lags and the Q-statistics are significant.

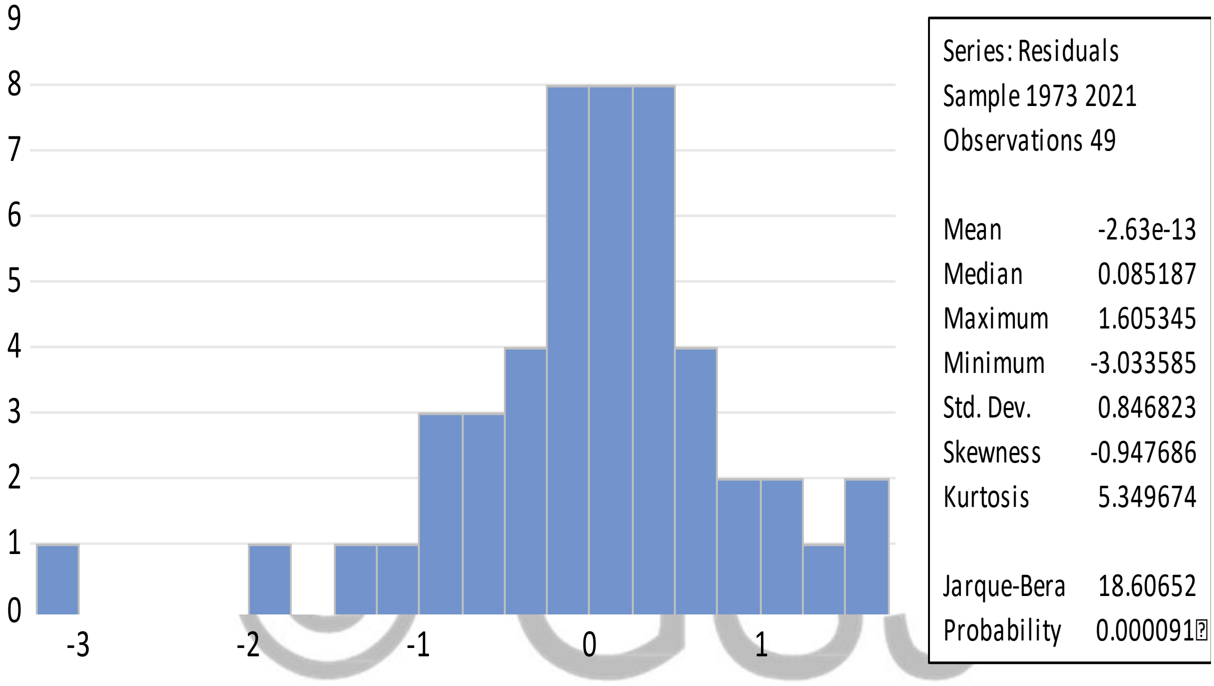


Figure 4.7: Histogram Normality Test

Source: Author's Computation from E-View 12 Software

Figure 4.7 displays a histogram and descriptive statistics of the residuals, including the Jarque-Bera statistic for testing normality. If the residuals are normally distributed, the histogram should be bell-shaped and the Jarque-Bera statistic should not be significant. Thus, the residuals of this model are not bell-shaped and not normally distributed since the probability of the Jarque-Bera statistic is significant at a 1% level of probability.

Table 4.9: Serial correlation LM Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	1.384783	Prob. F(2,36)	0.2634
Obs*R-squared	3.500392	Prob. Chi-Square(2)	0.1737

Source: Author's Computation from E-View 12 Software

Table 4.9 indicates that the serial correlation LM test has no evidence of the presence of serial correlation since the p-value of the F-statistic is considerably more than 0.05 (i.e. 5%).

Table 4.10: Heteroskedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.672127	Prob. F(10,38)	0.7427
Obs*R-squared	7.364330	Prob. Chi-Square(10)	0.6907
Scaled explained SS	9.632410	Prob. Chi-Square(10)	0.4733

Source: Author's Computation from E-View 12 Software

Table 4.10 indicates that Heteroskedasticity – Breuch-Godfery test has no evidence of the presence of serial correlation since the p-value of F-statistic is considerably more than 0.05.

Stability Test:

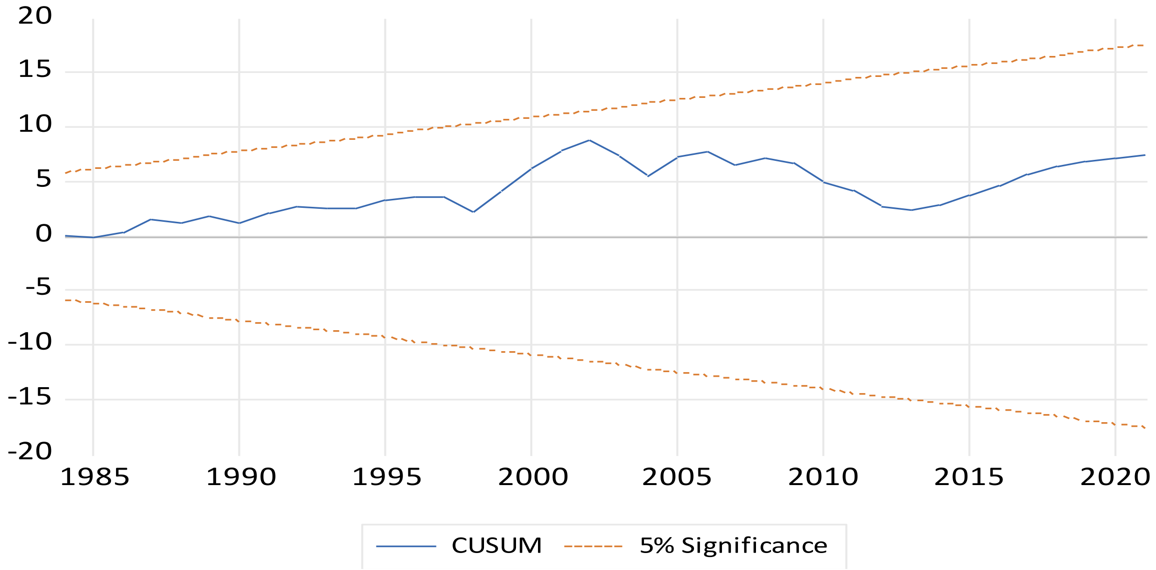


Figure 4.8: Cusum Test at 5% significant

Source: Author's Computation from E-View 12 Software

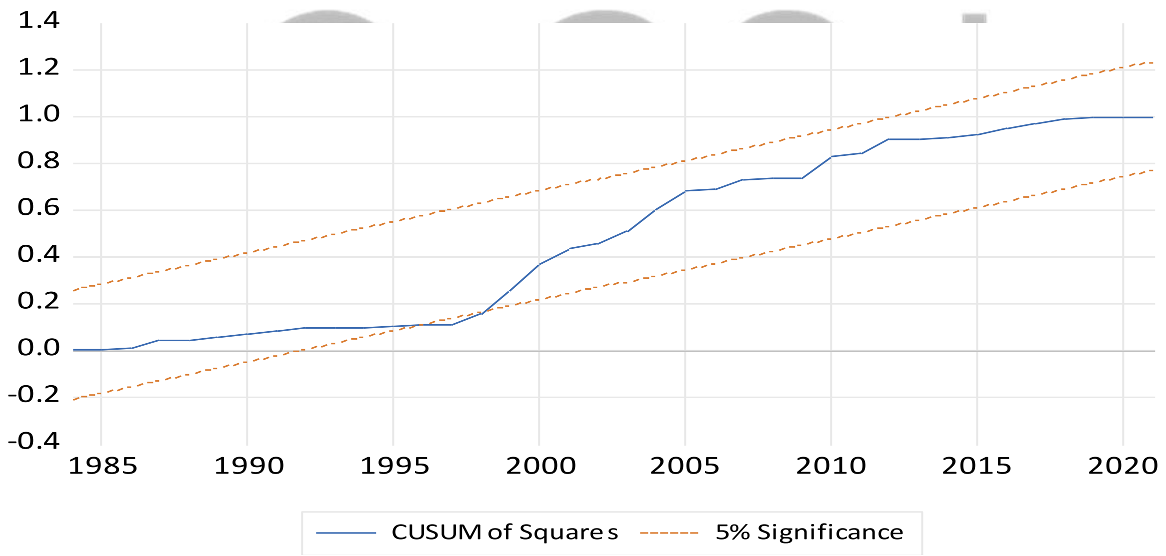


Figure 4.8: Cusum of Square Test at 5% significant

Source: Author's Computation from E-View 12 Software

Figures 4.8 and 4.9 show the plots of the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMSQ) tests. The plots show that the error correction model is stable during the periods of study as they are within the critical bounds of 5%.

5.0 SUMMARY OF FINDINGS, DISCUSSION, CONCLUSION AND POLICY RECOMMENDATIONS

5.1 Summary of Findings

In the course of this study, the following were found.

In the short run:

- there exists a positive and significant relationship between urban population growth and carbon-dioxide emission;
- there exists a positive and significant relationship in the current year between population density and carbon-dioxide emissions;
- that there exists a negative and significant relationship between population density in one year lag and carbon-dioxide emissions;
- there exists a negative but insignificant relationship between life expectancy at birth (both current year /one year lag) and carbon emissions; and
- there exists a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions.

In the long run:

- there exists a positive and significant relationship between urban population growth and carbon-dioxide emissions;
- there exists a positive but insignificant relationship between population density and carbon-dioxide emissions;
- there exists a negative but insignificant relationship between life expectancy at birth and carbon-dioxide emissions; and
- there exists a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions.

5.2 Discussion

In both short and long runs, there exists a positive and significant relationship between urban population growth and carbon-dioxide emission. The foregoing findings agreed with the works of Lawal and Abubakar (2019); Lukman, Oluwayemi, Okoro and Onate (2018); and finally, Sulaiman and Abdul-Rahim (2018).

In the short run, there exists at the current year a positive and significant relationship between population density and carbon-dioxide emission, at one year lag, there exists a negative and significant relationship between population density and carbo-dioxide emission. In the long run, there exists a positive but insignificant relationship between population density and carbon dioxide emissions. The foregoing results agreed with the works of Yi, Wang, Li and Qi (2021), which found that there was a significant negative correlation between urban density and carbon emissions, and the increase in urban population density reduced carbon dioxide emissions. Also, the foregoing result agreed with the work of Liddle (2013), which stated that higher population density is associated with lower levels of energy consumption and emissions.

In both short and long runs there exists a negative but insignificant relationship between life expectancy at birth and carbon-dioxide emissions. This foregoing result agreed with the works of Romanus, Aderemi, Akindele, and Okoh (2020) which found that carbon emissions are significant and negatively affect life expectancy. In line with the finding, Mariani, Perez-Barahona and Raffin (2009) found a positive correlation between longevity and environmental quality, both in the long run and along the transition path.

In both short and long runs, there exists a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions. The foregoing result conformed with the work of Zhu and Peng (2012), which found that consumption level and carbon emissions were highly correlated.

5.3 Conclusion

In an attempt to find the relationship between carbon-dioxide emissions and population dynamics proxies by urban population growth, population density, life expectancy at birth and renewable energy consumption, we concluded that in the long run, there is a positive and significant relationship between urban population and carbon-dioxide emissions; there exists a positive but insignificant relationship between population density and carbon-dioxide emissions; there exists a negative but insignificant relationship between life expectancy at birth and carbon-dioxide emissions; and finally, there exists a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions.

5.4 Policy recommendations

The following recommendations are based on the findings of this study.

- Having established a positive and significant relationship between urban population growth and carbon-dioxide emissions, the Nigerian government should formulate and implement an environmental quality control policy that will focus on reducing carbon-dioxide emissions and other pollutants among the urban population.
- Existence of a positive but insignificant relationship between population density and carbon-dioxide emissions called for the Nigerian government to have environmental planning strategies that will focus on the spatial areas of human dwellings for the sustainability of agglomeration.
- An existence of a negative but insignificant relationship between life expectancy at birth and carbon dioxide emissions signified that government should admit that life expectancy at birth is reducing with increasing in carbon-dioxide emissions and it is therefore necessary that the government put in place policy that will discourage carbon-dioxide emissions for life sustainability and longevity of citizens.

- The existence of a positive but insignificant relationship between renewable energy consumption and carbon-dioxide emissions indicated that government should regulate the usage of consumption of renewable energy to ameliorate carbon-dioxide emissions and enhance a clean environment.

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