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Population Growth, Climate Change and Economic Growth in Nigeria

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Abstract
The study examined impact population growth and climate change on Nigeria's economic growth. Leveraging a comprehensive time-series dataset spanning from 1981 to 2021, the study incorporates crucial variables: Real Gross Domestic Product (GDP), population growth rate, mean annual temperature, carbon dioxide emissions, agricultural value added, and fertility rate. The research employs two distinctive models to unravel the intricate relationships at play: The Autoregressive Distributed Lag Bounds (ARDL) and the quadratic regression model which seeks to determine the optimal levels of population growth and climate change (MTEM) that maximize economic growth. The findings showed cointegration among all the variables used in the study. Population growth was found to have a positive and significant impact on economic growth in Nigeria both in the short-run and long-run. While Climate change found have a negative impact and insignificant on economic growth in Nigeria both in short-run and long-run. The research recommends that the government of Nigeria should also consider alternative old-age security arrangements, such as developing financial markets and robust pension systems, to manage the implications of population growth effectively while avoiding potential diminishing returns.

Keywords: Population Growth, Climate Change, Economic Growth

1. Introduction

1.1 Background of the Study

A substantial population size offers a significant domestic market for the economy, fostering competition that drives technological advancements and innovations. However, while population growth spurs progress, it also brings challenges such as food scarcity and hampers the developmental prospects of nations, contributing to climate change. Among the world's most impoverished nations, rapid population growth is prevalent. For instance, low-income countries like Nigeria are projected to witness nearly a twofold increase in total population from 2020 to 2050. In 2020, Nigeria's annual population growth rate stood at 2.56% (World Bank Development Indicator 2021). Applying the principle of doubling time growth analysis to this high growth rate, Nigeria's population is projected to have expanded by around 3,072,000 individuals in the first year of the estimate, and almost 3,150,643 in the second year. This implies that, given a growth rate of 2.56%, Nigeria is anticipated to double in size within approximately 27 years, as calculated using the doubling time method.

The population of Nigeria is undergoing rapid expansion and is projected to exceed 440 million by 2050 according to the medium variant projection by the United Nations Department of Economic and Social Affairs Population Division (UNDESA, 2015). Within this scenario, the continuous acceleration of population growth further compounds the complexities associated with attaining both social and economic development. Additionally, it amplifies the magnitude of investments and endeavours needed to ensure inclusivity and equity for all segments of the population. The growing population of Nigeria makes it more difficult as a low income country to afford the increasing public expenditure on per capita basis that is needed to eradicate poverty, end hunger and malnutrition, and ensure universal access to health care, education and other essential services.

Climate change pertains to enduring alterations in temperatures and weather trends. While some of these changes may occur naturally, since the 1800s, human activities have predominantly steered climate change, largely as a result of the combustion of fossil fuels (such as coal, oil, and gas), leading to elevated levels of heat-retaining greenhouse gases in the Earth's atmosphere. **(**Joep Meijer, 2021). The environmental and ecological effects of human activity have been studied extensively; there is no scientific consensus about the planet's ultimate carrying capacity for human life (Cohen, 1995; Pengra, 2012; de Sherbinin and *et al*, 2007) [10, 29, 13]. If other factors are kept constant, a growing global population places increasing pressure on the earth's natural resources, in particular common property resources like air and water, whose use is not well regulated by market forces, can cause serious problems to countries.

Nigeria's economic growth, primarily driven by the oil sector, faces challenges of diversification. Efforts to promote sectors like agriculture aim to enhance food security and create jobs. However, corruption, inadequate infrastructure, and inconsistent policies hinder sustained economic growth. The densely-populated areas, fostering economic activities, also contribute to environmental issues such as pollution, traffic congestion, and public health concerns. Importantly, the greater influence on production, consumption, and greenhouse emissions is attributed to the rise in per capita income, reflecting the nuanced dynamics of Nigeria's current status quo.

1.2 Statement of the Problem

The population growth of Nigeria is a problem, because Nigeria has been characterised as the poverty capital of the world, with 93.9 million people currently living below the poverty line, according to an economist, Rewane (2021). Furthermore, an estimated seven million Nigerians reportedly experienced extreme poverty in the single year of 2020. He mentioned that in 2018, Nigeria, with its population exceeding 200 million, was officially designated as the global epicentre of poverty. This report was published by the Brookings Institution, displacing India from its previous position. Over a significant period, the pace of economic expansion within the country has consistently lagged behind the pace of population growth. Consequently, the typical Nigerian has been witnessing a decline in their economic well-being each year. This on-going situation exemplifies a demographic explosion, driven by the imminent challenge of the burgeoning population.

Nigeria, a nation housing a population exceeding 200 million individuals, finds itself in a situation where its resource consumption surpasses its production capacity. Each new person introduced into the population represents an additional consumer, intensifying the demand for the limited resources available. Positioned as the most populous country in Africa and the seventh globally, Nigeria exhibits a total growth rate of 2.6 per cent alongside a total fertility rate of 5.3 per cent (NDHS, 2018). Regrettably, the nation possesses a significant yet predominantly unproductive population that is expanding at a swifter pace than its national output. At present, Nigeria's annual GDP growth rate averages around 1.9 per cent, while its population growth rate reaches 2.4 per cent annually, leading to a negative per capita income outcome. It's evident that Nigeria has not harnessed the potential of the demographic dividend, wherein a sizable working-age population typically fuels accelerated economic growth. Disturbingly, Nigeria holds the top position in terms of out-of-school children, with a staggering count of over 20 million children absent from educational institutions.

However, the continued high population growth, poor school enrollment and high mortality rates questioned the viability of the second National Population Policy (hereafter referred to as NPP). Hence, the need of this study. This on-going research aims to investigate how the interplay of population growth and climate change influences economic advancement specifically in Nigeria.

1.3 Objectives of the Study

The objective of this study is to analyse how population growth and climate change affect economic growth in Nigeria.

1. To ascertain the impact of population growth on Nigeria's economic growth.
2. To determine how climate change impact Nigeria's economic growth.

1.4 Significance of the Study

The study would be beneficial and important to investors, policy maker and students.

The research will aid investors in factoring in the ramifications of climate change while making investment decisions. It will also provide insights into emerging locations attracting population migration, thereby expanding their investment perspectives. Furthermore, individuals engaged in outdoor professions like construction, agriculture, or tourism should explore alternative roles within these sectors or consider transitioning to new industries.

This study's findings could provide policymakers with insights into formulating strategies that balance population growth, climate change mitigation, and economic growth for sustainable development in Nigeria.

2. Literature Review

2.1 Conceptual Review

2.1.1 Population

In statistics, a population refers to the entire set of individuals from which a statistical sample is extracted for research purposes. Therefore, any group of individuals who share a common characteristic can be considered a population. This concept of population encompasses various aspects, including the count of individuals, their demographic attributes such as age, gender, health, education, and family status, as well as demographic processes like birth, death, migration, the formation and dissolution of unions and families. Additionally, it also encompasses the spatial distribution of people across geographic regions and the size of settlements, ranging from rural to urban areas (Cohen 2010).

Population Policies: An integral aspect of a nation lies in its population size. Overpopulation can result in excessive consumption and heightened pressures on resources and essential services, including healthcare and education. Conversely, underpopulation is often unsustainable and can lead to economic setbacks due to a scarcity of working-age adults. Consequently, many governments employ population policies to address both overpopulation and underpopulation. These policies, implemented by governments, consist of a series of measures designed to regulate the country's population size. They may aim to encourage population growth or, conversely, to limit population size. Governments analyze past and current population demographics to predict future trends and changes, helping determine the optimal population size based on available resources. This analysis guides the selection of the most appropriate population policies for the country. Fertility, mortality, and migration are the three primary components considered when formulating population policies, each playing a crucial role in the decision-making process.

2.1.2 Climate change

Climate change refers to significant and long-term alterations in temperature, weather patterns, and environmental conditions on Earth. It is primarily driven by human activities, such as the burning of fossil fuels, deforestation, and industrial processes, which release greenhouse gases like carbon dioxide (CO_2) into the atmosphere, trapping heat and leading to global warming. The consequences of climate change are wide-ranging and impact ecosystems, economies, and societies across the world.

Nigeria, like many other countries, has experienced the impacts of climate change over the past few decades. Nigeria has observed a gradual increase in temperatures over the years. This has resulted in more frequent and intense heat waves, with some regions experiencing temperature extremes that negatively affect agriculture, human health, and energy demands. Changes in rainfall patterns have been a prominent feature of climate change in Nigeria. The country has experienced prolonged dry seasons, leading to droughts and water scarcity, followed by intense rainfall events and floods in some states. These erratic patterns disrupt agricultural cycles and food production. Coastal areas in Nigeria, such as Lagos, Anambra, Delta, Benue, Rivers Kogi etc have witnessed sea-level rise due to global warming. This phenomenon threatens coastal infrastructure, displaces communities, and impacts the livelihoods of those who depend on coastal resource. Northern Nigeria has seen an expansion of desertification and desert encroachment. This has resulted in the displacement of communities, loss of arable land, and increased competition for resources, often leading to conflicts between herders and farmers.

2.2 Theoretical Literature

2.2.1 The Malthusian Theory

This theory was developed by Thomas Malthus in the late 18th century, is a theory of population that suggests that population growth tends to outstrip the growth of resources, leading to a cycle of poverty, famine, and hardship unless checked by various factors. Malthus argued that human population tends to grow at a geometric rate (1, 2, 4, 8, 16, etc.), meaning it doubles at regular intervals. However, he believed that the growth of resources (particularly food production) only increases at an arithmetic rate (1, 2, 3, 4, 5, etc.), which means it grows linearly. This difference in growth rates would eventually result in a population that exceeds the available resources to sustain it.

The Malthusian Trap: Malthus argued that when population growth outpaces resource growth, a society would inevitably reach a point where living conditions deteriorate due to resource scarcity and increased competition. This situation is often referred to as the "Malthusian trap" or "Malthusian catastrophe." He proposed two types of checks that could limit population growth: Positive Checks- These are factors that increase the death rate, such as famine, disease, war, and other forms of misery and suffering. Preventive Checks- These are factors that reduce the birth rate, such as delayed marriage, abstinence, and contraception. Malthus believed that individuals and societies should practice moral restraint and limit their family size voluntarily to avoid overpopulation.

Malthus' predictions did not fully materialize as he described. Technological advancements in agriculture and other sectors have allowed for increased food production and resource utilization. Additionally, changes in societal norms and family planning have influenced birth rates. As a result, many critics argue that Malthus underestimated human adaptability and technological progress. While Malthus' ideas have been criticized and modified over time, his theory continues to be influential in discussions about population growth and resource sustainability. It has also sparked debates about the potential challenges associated with rapid population growth and resource constraints, especially in the context of global issues like food security and environmental sustainability.

2.2.2 The Theory of Demographic Transition

The theory of demographic transition is a model that describes the population changes that occur as society's progress through various stages of development. It was first proposed by demographer Warren Thompson in 1929 and has since become a widely accepted framework for understanding how population dynamics shift over time. The theory identifies four main stages of demographic transition: The first stage High birth rates and high death rates. In this initial stage, both birth rates and death rates are high, resulting in a relatively stable population size. High birth rates are often associated with the lack of family planning, limited access to healthcare, and high child mortality. High death rates can be attributed to factors like disease, poor sanitation, and inadequate medical care. The second stage, High birth rates and declining death rates; In this stage, death rates begin to decline significantly due to improvements in healthcare, sanitation, and living conditions. Birth rates remain high or even increase, leading to rapid population growth. This stage is often referred to as the "population explosion" phase. Third stage, declining birth rates and low death rates; as societies continue to develop, birth rates eventually start to decline. This decline in birth rates can be attributed to factors such as increased access to education, economic opportunities for women, and the availability of contraception. Meanwhile, death rates remain low. Population growth continues, but at a slower pace than in Stage 2. The fourth stage low birth rates and low death rates. In the final stage of demographic transition, both birth rates and death rates are low, resulting in a stable or slowly growing population. Societies at this stage often have well-established healthcare systems, higher living standards, and a greater emphasis on family planning.

Not all countries progress through these stages at the same rate or in the same way. Additionally, some regions or countries may experience a "Stage 5" where birth rates fall below replacement level, leading to population decline and potential demographic challenges, such as an aging population. The theory of demographic transition is a valuable tool for policymakers and demographers because it helps in understanding how changes in birth and death rates are linked to economic and social development. It also highlights the importance of family planning, healthcare, and education in influencing population growth and structure. As societies progress through these stages, they often experience significant shifts in their social and economic landscapes, which can have far-reaching implications for the future.

2.3 Empirical Literature

Okoh and Ochei (2017) conducted an empirical analysis of the impact of a growing population on agricultural output in Nigeria, with a particular focus on examining the Malthusian hypothesis. They utilized time series data from Nigeria spanning the years 1986 to 2016. To investigate the relationship between agricultural production and population growth in the Nigerian economy, the researchers employed the Johansen co-integration test. The findings of their study indicated that indeed, there is a long-run relationship between agricultural production and the population growth in the Nigerian economy. Specifically, the long-run model revealed the presence of an inverse relationship between agricultural output and the growth of the Nigerian population. This outcome affirmed the validity of the Malthusian effect in Nigeria, suggesting that as the population grows, agricultural output tends to decrease relative to the population's needs.

Ogbuabor and Egwuchukwu (2017) [20] investigated the impact of climate change on economic growth in Nigeria. To achieve this objective, they employed the ordinary least squares (OLS) estimation technique and utilized data spanning the period from 1981 to 2014. The study focused on several variables to capture the effects of climate change. These included changes in annual rainfall, carbon emissions, and forest depletion. Additionally, the research incorporated control variables such as changes in government expenditure, domestic private investment, and exchange rates to ensure the robustness of their estimations. The findings of the study revealed significant insights into the relationship between climate change and economic growth in Nigeria. Both in the long-run and short-run, the results indicated that carbon emissions had an negative impact on output growth in Nigeria. Furthermore, forest depletion was found to have a negative effect on national output growth in the short-run. Specifically, the study suggests the need for the Nigerian government to formulate and implement policies aimed at curbing carbon emissions and mitigating forest depletion.

Sulaiman and Abdul-Rahim (2017) explored the intricate three-way relationship between CO2 emissions, energy consumption, and economic growth in Malaysia, focusing on data spanning from 1975 to 2015. The research findings indicated that economic growth in Malaysia was not significantly influenced by either energy consumption or CO2 emissions. This implies that economic expansion in Malaysia during the specified period was relatively independent of these factors. The study also revealed that CO2 emissions tended to increase with rises in both energy consumption and economic growth. This indicates a positive correlation between CO2 emissions and the other two variables. The researchers employed the simple Ordinary Least Squares (OLS) method, a commonly used statistical technique for regression analysis, to derive these findings.

In their research, Ogunleye and Owolabi (2018) conducted an investigation into the impact of population growth on the economic growth of Nigeria. The study utilized data spanning from 1981 to 2015 and employed the ordinary least squares (OLS) method for their analysis. The study considered several independent variables, including fertility rate, population growth, and exchange rate. The results of the findings indicated a positive relationship between population growth and economic growth in Nigeria. In contrast, the study found that the remaining independent variables, specifically fertility rate and exchange rate, were statistically insignificant in their influence on economic growth during the same period.

Qing Feng, Amy, and Li (2018) employed the cohort component qualitative method to project and assess the consequences of fertility decline on demographic dividends, specifically focusing on the period from 1960 to 2015 across 201 countries. Their findings revealed that without the observed fertility decline, the Gross Domestic Product (GDP) of Sub-Saharan Africa would have been $321 billion less than its current value, and the child dependency ratio would have been higher by 16. According to Qing Feng, their study underscores a critical imperative to reduce fertility rates as a strategic measure for maximizing the utilization of demographic dividends.

Berlemann and Wenzel (2018) [5] conducted an extensive exploration of the short- and long-term growth impacts of rainfall patterns using a comprehensive panel dataset encompassing over 150 countries, spanning the years 1951 to 2013. The findings discovered compelling empirical evidence indicating that long-term negative growth consequences are associated with rainfall deficits. It was also found that the negative growth impacts of rainfall deficits were particularly pronounced in poor and emerging economies, excluding the Sub-Saharan African subsample.

The study of Dong, Hochman, and Zhang, (2018) [15] delved into the complex interplay among carbon dioxide (CO2) emissions, economic growth, population growth, and the use of renewable energy sources across different regions. They used an unbalanced panel dataset consisting of data from 128 countries over the period spanning from 1990 to 2014. To account for the observed cross-sectional dependence and slope heterogeneity in the panel data, the researchers applied a range of econometric techniques. The findings from their study tests confirmed the presence of significant cross-sectional dependence and heterogeneity among the countries included in the panel dataset. This indicates that these variables exhibit varying relationships across different regions. The empirical results, based on the common correlated effects mean group (CCEMG) estimator, revealed that both population size and economic growth had a positive and statistically significant impact on CO2 emissions levels, both at the global level and within different regions. The study found that an increase in renewable energy intensity led to a reduction in CO2 emissions across all six regions studied. Notably, the coefficient representing this relationship was notably higher in South and Central America and Europe & Eurasia compared to other regions. This difference could be attributed to the varying proportions of renewable energy sources in the primary energy mix in these regions. The panel causality tests conducted, revealing diverse causal relationships among the variables across different regions. These findings highlight the complex and region-specific nature of the interactions between CO2 emissions, economic growth, population size, and renewable energy use.

In Stock's (2020) research on climate change, climate policy, and economic growth, the study focused on the interconnected factors of temperature, carbon dioxide (CO2) emissions, and Gross Domestic Product (GDP). The study recognized rising temperatures as a central indicator of climate change. As global temperatures increase, it leads to a variety of climatic changes, including more frequent droughts, hotter days, and more intense rainfall and storms.

The primary driver of the observed global warming and associated climate changes is attributed to anthropogenic carbon dioxide (CO2) emissions. These emissions result from the combustion of fossil fuels, such as coal, oil, and natural gas. The study's findings have significant implications for climate policy. To address the challenges posed by climate change, it is crucial to reduce anthropogenic CO2 emissions.

In the study of Nathaniel and Khan (2020) [26] delved into an examination of the impacts of renewable and non-renewable energy consumption on environmental degradation within a panel of ASEAN countries. To ensure comprehensive analysis, they incorporated economic growth, urbanization, and trade as controlled variables. As a measure of environmental degradation, the researchers utilized the ecological footprint. The noteworthy findings emerging from their research spotlighted economic growth and non-renewable energy consumption as the principal culprits behind long-term environmental degradation. In essence, these two factors were identified as the primary contributors to the deterioration of the environment in the ASEAN countries studied. Their investigation revealed a distinctive outcome regarding renewable energy consumption. Surprisingly, it was determined that renewable energy consumption did not have a significant impact on environmental degradation in the long run. This observation held true not only for the aggregate group of ASEAN countries under scrutiny but also for each individual nation within the sample. This unique insight into the ineffectiveness of renewable energy consumption in curbing environmental degradation challenges conventional expectations and bears implications for environmental policy and energy sustainability. Furthermore, the study reinforced the well-established notion, widely supported by empirical evidence in the energy literature, that there exists a causal relationship between CO2 emissions and energy consumption. This finding underscores the need for strategic approaches to energy consumption and emissions reduction to address environmental concerns effectively.

Nabila Khurshid, Asma Fiaz, Jamila Khurshid, and Kashif Ali (2021) investigated the impact of climate change on economic growth in Pakistan. Their study utilized the non-linear autoregressive distributional lag (NARDL) technique, enabling the estimation of asymmetric effects of climate change on Pakistan's economic growth. Empirical analysis was conducted using annual data spanning the years 1980 to 2021. The research findings revealed that both CO2 emissions and mean temperature had asymmetric effects on economic growth, both in the long-run and short-run. The impact of CO2 emissions on economic growth showed asymmetry. CO2 emissions categorized as CO2_POS had a negative influence on economic growth, whereas CO2 emissions categorized as CO2_NEG also had a negative impact. Similarly, mean temperature exhibited an asymmetric effect on economic growth. MEANT_POS (positive deviations from mean temperature) had a positive impact on economic growth, while MEANT_NEG (negative deviations) had a negative influence. Precipitation, in contrast, had a consistently positive and significant long-term impact on economic growth. The research findings emphasized the necessity for comprehensive mitigation policies at both the national and global levels to address human-induced climate change in Pakistan.

2.4 Gap in Literature

It is important to acknowledge that based on an extensive review of previous research work no prior studies have specifically explored the combined impact of optimal population growth and optimal climate change temperature on economic growth in Nigeria. Indeed, identifying the peak scenarios of population growth and climate change is crucial for policymakers and the government to proactively prepare for potential adverse situations. Particularly, Nigeria, with its low per capita income and strong reliance on its environment for sustenance, needs to be well-equipped to address the impacts of population dynamics and climate change.

To contribute to this understanding, the researcher aims to bridge this knowledge gap by employing a quadratic non-linear equation to construct a model. This model is designed to scrutinize both the impact and the nature of the relationship—whether it is monotonic or parabolic—between these critical factors.

3. Methodology

The research design for the study was Ex-post facto. This type of design seeks to establish cause-effect relationships. These variables consist of Real gross Domestic Product (RGDP), Population growth rate (POPgr), Mean Annual Temperature (MTEM) Carbon dioxide (CO2), Agricultural Value added (AGVA), and fertility rate (FLR) from 1981 to 2021 (40 years). Data for the variables were obtained from World Bank Development indicators. The data collected was subjected to descriptive statistic, correlation matrix, Augmented Dickey-Fuller Unit Root test statistic, ARDL Bounds tests for cointegration test, Heteroscedasticity White Test, Normality test, Ramsey Reset, Jarque Bera, Breuch-Godfrey Serial Correlation LM Test. The method of data analysis was Granger causality technique and autoregressive distributive lag model.

4. Results

4.1 Data Presentation and Analysis of Results

4.1.1 Descriptive Statistics

Table 1 below presents the descriptive statistics for both the dependent variable and independent variables used in the estimated model.

Table 1: Summary Variable Descriptive Statistics

	RGDP	POPGR	(POPGR)^2	MTEM	(MTEM)^2	CO2	AGVA	FLR
Mean	265.6273	2.578049	6.651951	27.21683	740.8502	76559.15	8.462927	6.124390
Median	189.9100	2.600000	6.760000	27.23000	741.4729	73505.00	5.120000	6.100000
Maximum	511.7700	2.700000	7.290000	27.86000	776.1796	133465.0	18.74000	6.800000
Minimum	113.0900	2.500000	6.250000	26.39000	696.4321	35200.00	2.300000	5.200000
Std. Dev.	142.9111	0.075869	0.393391	0.311026	16.90675	27964.67	5.689823	0.438623
Skewness	0.578023	0.382292	0.413342	-0.252198	-0.216964	0.072466	0.499182	-0.176868
Kurtosis	1.715269	1.859254	1.895779	3.145965	3.112712	1.895984	1.697864	2.197688
Jarque-Bera	5.102755	3.221730	3.250464	0.471022	0.343370	2.118089	4.599328	1.313425
Probability	0.077974	0.199715	0.196866	0.790167	0.842244	0.346787	0.100293	0.518553
Sum	10890.72	105.7000	272.7300	1115.890	30374.86	3138925.	346.9800	251.1000
Sum Sq. Dev.	816943.8	0.230244	6.190244	3.869488	11433.53	3.13E+10	1294.963	7.695610
Observations	41	41	41	41	41	41	41	41

E-view computation by the author

Prior to drawing any inferences from a dataset, it is crucial to conduct a thorough examination of all variables. This preliminary step allows for a comprehensive overview of the data, enabling the identification of any potential violations of statistical assumptions.

4.1.2 Unit Root Test

In this study, we employed Augmented Dickey Fuller (ADF) tests to examine the propensity of a unit root test across a series of data. Table 2 shows the results of unit root testing.

Table 2: Unit Root Result

Variables	ADF Statistics	5% Critical Value	Order of Integration
RGDP	-2.93	-3.25	I(1)
POPgr	-2.93	-5.74	I(1)
C02	-2.93	-7.54	I(1)
AGVA	-2.94	-5.10	I(1)
MTEM	-2.94	-3.27	I(0)
FLR	-2.94	-8.58	I(1)
(POPgr)^2	-2.94	-5.76	I(1)
(MTEM)^2	-2.94	-3.26	I(0)

E-view computation by the author

The result from Table 2 shown that the variable of mean annual temperature (MTEM) was stable at level indicating that they do not require differencing due to zero-order integration I(0). However, after initial differencing, the other variables, which included real gross domestic product (RGDP), population growth rate (POPgr), climate change (CO2), Agricultural value added (AGVA), Fertility rate (FLR) are stable at first difference I(1). This implies that the variables used in the study were integrated at order I(0) and I(1).

4.1.3 Lag Length Criteria

Table 3 Model 1

Obtaining an optimal lag for ARDL analysis is very essential. Too many lag in a model can lead to loss of degree of freedom, cause multicollinerity, triggers serial correlation in the error terms, and misspecification of errors.

Table 3: Lag Length Result

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-595.6476	NA	2277241.	31.66566	31.92423	31.75766
1	-382.8673	347.1679*	212.6613*	22.36144	24.17140*	23.00541*
2	-344.8183	50.06453	221.1335	22.25359	25.61495	23.44954
3	-304.8879	39.93042	273.4559	22.04673*	26.95949	23.79465

E-view computation by the author

From the result of Lag length criteria such as LR, FPE, SC and AIC supported lag one (1) as the optimal lag to be used.

4.1.4 ARDL Bound Test Result for cointegration

Table 4: Bounds Test Result

Test Statistic	Value	K
F-statistic	4.569789	5
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

E-view computation by the author

From the above Table 4 F- Statistics F_k4.57 is greater than upper bounds value I(1) critical value (i.e, 3.79) at a 5% significant level, then we reject H_0, the outcomes of these statistics in agreement shows the presence of cointegration among the variables meaning a long-run relationship in the variables. The null hypothesis rejected and the alternative hypothesis accepted. Hence, long-run and short-run are both estimated. The error correction model (ECM) was also estimated.

4.1.5 Short-run Results

The Presence of Cointegrating Vectors between Variables Indicates a Long-Run Relationship among the Variables;
Therefore, The Vec Model Can be Applied. Structural Short and Long-Run Relationships are Indicated in Vecm Estimation (Bulent, 2013).
The presence of cointegrating between variables indicates a long-run relationship among the variables; therefore,

Table 5: Short-run Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(POPGR)	100.896481	21.061106	4.790655	0.0000
D(MTEM)	-1.667382	4.714490	-0.353672	0.7259
D(CO2)	-0.000120	0.000088	-1.369893	0.1803
D(AGVA)	9.331327	2.927605	3.187359	0.0032
D(FLR)	-22.113919	11.943448	-1.851552	0.0733
CointEq(-1)	-0.254890	0.078890	-3.230962	0.0029
Cointeq = RGDP - (395.8439*POPGR -6.5416*MTEM - 0.0005*CO2 +				
20.5656*AGVA -86.7588*FLR -162.7261)				
E-view computation by the author				

The short-run result above POPgr (100.897), the positive coefficient indicates that a one-unit increase in population growth is associated with an increase of approximately 100.90 units in Real GDP. The high t-statistic value (4.790655) and the very low p-value (0.0000) suggest strong statistical significance. This implies that population growth has a significant positive impact on Real GDP in the short run.

The negative coefficient of MTEM suggests that a one-unit increase in mean annual temperature (MTEM) is associated with a decrease of approximately 1.67 units in Real GDP. However, the t-statistic (approximately -0.353672) is relatively small, and the associated p-value (0.7259) indicates that this coefficient is not statistically significant. This suggests that the relationship between mean annual temperature and Real GDP is not significant in the short run.

CO2 showed a negative coefficient meaning that a one-unit increase in CO2 is associated with a decrease of approximately 0.00012 units in Real GDP. The t-statistic (-1.369893) and the p-value (0.1803) indicate that this coefficient is not statistically significant. This implies that the relationship between CO2 and Real GDP is not statistically significant in the short run.

AGVA had a positive coefficient which indicates that a one-unit increase in Gross Value Added in agriculture (AGVA) is associated with an increase of approximately 9.33 units in Real GDP. The large t-statistic (3.187359) and the low p-value (0.0032) suggest strong statistical significance. This implies that AGVA has a significant positive impact on Real GDP in the short run.

FLR (-22.11319)revealed a negative coefficient meaning that a one-percent increase in fertility rate (FLR) is associated with a decrease of approximately 22.11 units in Real GDP. The t-statistic (-1.851552) is moderate, and the associated p-value (0.0733) is slightly above the common significance level of 0.05. This suggests that the relationship between fertility rate and Real GDP might be marginally significant in the short run.

The R-squared value, which assesses the model's fitness, indicates a well-fitted model. Approximately 99.8% of the variance in the dependent variable can be elucidated by the independent variables. Moreover, the probability value of the F-statistic (0.000) underscores the joint statistical significance of the variables (refer to the appendix for details).

The results of the ECM model show that the value of the ECM coefficient is negative and significant (−0.2549). In practical terms, a negative and statistically significant ECM value in the long-run relationship, as observed above, underscores the presence of cointegration among the variables. This ECM value denotes that approximately 25.49% of deviations are rectified annually, showcasing both stability and a swift speed of adjustment. Put differently, the ECM coefficient's small magnitude suggests that the process of realigning short-term deviations with the long-run equilibrium trajectory occurs at a gradual pace. Nevertheless, the ECM model indicates stability. The ECM value of -0.2549 implies that the previous year's shocks' disequilibrium relative to the long-run equilibrium persists into the present year.

2 movement in the dependent variable with the - adjusted of 60.04%. The fitness of the model is explained by the F-statistic which is 8.64.

Table 6: ARDL long-run result

ARDL Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
POPGR	395.843891	167.719917	2.360148	0.0245
MTEM	-6.541587	18.222839	-0.358977	0.7220
CO2	-0.000472	0.000296	-1.593683	0.1208
AGVA	20.565567	5.710678	3.601248	0.0011
FLR	-86.758821	64.853673	-1.337763	0.1904
C	-162.726129	499.105034	-0.326036	0.7465

Structural short and long-run relationships are indicated in VECM
E-view computation by the author

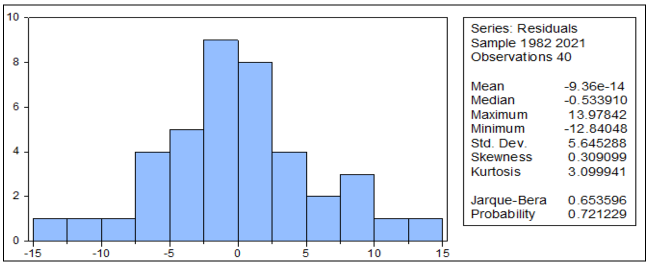
In the long run, a one-unit increase in population growth is associated with an increase of approximately 395.84 units in Real GDP. The positive coefficient is supported by a t-statistic value of 2.360148, and the associated p-value (0.0245) indicates that this coefficient is statistically significant. This suggests that population growth has a significant positive impact on Real GDP in the long run.

MTEM (-6.54) with negative coefficient indicates that a percentage increase in mean annual temperature (MTEM) is associated with a decrease of approximately 6.54 units in Real GDP. However, the t-statistic (-0.358977) is relatively small, and the associated p-value (0.7220) suggests that this coefficient is not statistically significant. This implies that the relationship between mean annual temperature and Real GDP is not significant in the long run. CO2 Coefficient -0.00047) The negative coefficient suggests that a one- per cent increase in CO2 is associated with a decrease of approximately 0.00047 units in Real GDP. The t-statistic (-1.593683) and the p-value (0.1208) indicate that this coefficient is not statistically significant. This implies that the relationship between CO2 and Real GDP is not statistically significant in the long run. Also In the long run, a one-unit increase in Agricultural Value Added (AGVA) is associated with an increase of approximately 20.57 units in Real GDP. The t-statistic (3.601248) is relatively large, and the associated p-value (0.0011) indicates strong statistical significance. This implies that AGVA has a significant positive impact on Real GDP in the long run.

FLR a negative coefficient implies that a one-unit increase in fertility rate (FLR) is associated with a decrease of approximately 86.76 units in Real GDP. The t-statistic (-1.337763) is moderate, and the associated p-value (0.1904) is above the common significance level of 0.05. This suggests that the relationship between fertility rate and Real GDP might not be statistically significant in the long run.

Diagnostic Test of the Model to Check Reliability of the Estimate

Normality Test



E-view computation by the author

The result shown the residuals are normally distributed. From the prob. Value of jarque bera 0.721 greater than the 5% critical value, the null hypothesis is rejected while the alternative accepted.

Table 7: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.042366	Prob. F(1,31)	0.3521
Obs*R-squared	1.301235	Prob. Chi-Square(1)	0.2901

E-view computation by the author

The diagnostic results of the LM test indicate the absence of serial correlation within the model. The probability (prob.) value further supports this observation 0.2901 greater than 0.05.

Table 8: Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	3.714779	Prob. F(7,32)	0.0047
Obs*R-squared	17.93235	Prob. Chi-Square(7)	0.0123
Scaled explained SS	12.05020	Prob. Chi-Square(7)	0.0989

E-view computation by the author

The results of heterskedasicity test prove that the model was free from heterskedastical, which is the model is homoskedastical.

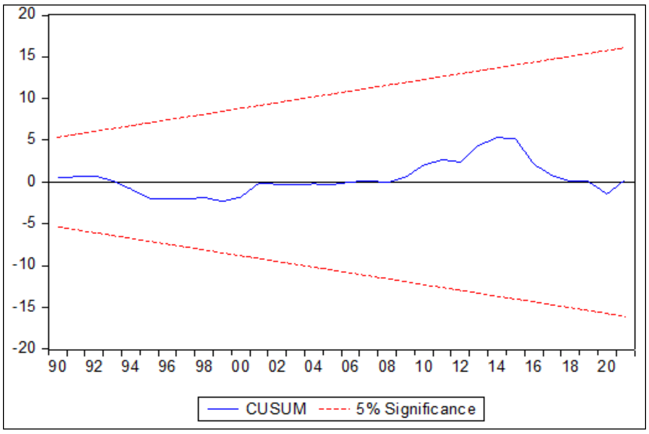
Table 9: Ramsey Reset Test

	Value	Df	Probability
t-statistic	0.266434	31	0.7917
F-statistic	0.070987	(1, 31)	0.7917

E-view computation by the author

The Ramsey Reset Test was employed to assess the suitability of the model's functional form. The probability value of the F-statistic, which is 0.79, indicates that the model is appropriately specified.

Cusum Test for Stability



E-view computation by the author

The plot cusum remained between 5% critical bound which prove the stability of the parameters.

5. Findings, Conclusion and Recommendations

5.1 Summary of Findings

The findings of the study can be summarized as follows:

First, in the short run, a one-unit increase in population growth was associated with an approximately 100.90-unit increase in the Real GDP. The t-statistic (4.790655) was highly significant with a p-value of 0.0000, suggesting a significant positive impact of population growth on the dependent variable in the short run. While In the long run, a one-unit increase in population growth was associated with an approximately 395.84-unit increase in Real GDP. The positive coefficient was supported by a t-statistic of 2.360148, and the associated p-value (0.0245) indicated statistical significance. This implies that population growth has a significant positive impact on Real GDP in the long run.

Second, in the short run, a one-unit increase in mean annual temperature (MTEM) was associated with a decrease of approximately 1.67 units in the dependent variable. However, the t-statistic (-0.353672) was relatively small, and the p-value (0.7259) indicated that this coefficient was not statistically significant, suggesting no significant relationship between mean annual temperature and the dependent variable in the short run. In the long run, a one-unit increase in mean annual temperature (MTEM) was associated with a decrease of approximately 1.67 units in Real GDP. Similarly, the t-statistic (-0.353672) was relatively small, and the p-value (0.7259) suggested that this coefficient was not statistically significant, indicating no significant relationship between mean annual temperature and Real GDP in the long run.

5.2 Conclusion

This study examined the relationships between population growth, climate change, and economic growth in Nigeria using data from 1981 to 2021. In both the short and long run, population growth had a significant positive impact on Real GDP, with strong statistical evidence. This implies that population growth contributes significantly to economic expansion in Nigeria. The study found no statistically significant impact of climate change on economic growth in Nigeria, neither in the short nor long term. This implies that the variables analyzed do not exert a substantial influence on the country's economic growth within the study's scope. Optimal population growth analysis revealed a U-shaped relationship, highlighting that there is an optimal level of population growth for maximizing Real GDP.

5.3 Recommendations

Based on the findings and conclusions of the study, the following recommendations are proposed for government, policymakers, and researchers:

1. Government of Nigeria should also consider alternative old-age security arrangements, such as developing financial markets and robust pension systems, to manage the implications of population growth effectively while avoiding potential diminishing returns. Implementing policies that promote family planning, education, and healthcare can help control population growth within an optimal range.
2. Government of Nigeria should prioritize climate change mitigation and adaptation measures to safeguard economic stability. Investments in renewable energy sources, environmental conservation, and climate resilience strategies are essential for mitigating the potential negative effects of climate change on economic growth. Additionally, making clean energy sources such as cooking gas readily available and affordable can help discourage the use of firewood for cooking and reduce deforestation.

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