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CLIMATE CHANGE AND AGRICULTURAL OUTPUT IN NIGERIA

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ABSTRACT

This study analysed the effect of Climate Change on Agricultural Output in Nigeria. It applied descriptive statistics, Augmented Dickey Fuller (ADF) and OLS on time series data sourced from Central Bank of Nigeria Statistical Bulletin and World Bank Development Indicator for the period of 1990-2025. It revealed that the data were normally distributed based on Jargue Bera statistics and its p-value whereas the unit root test result indicated that the variables are stationary at level which necessitated the choice of OLS. The findings of this study revealed that that climate change variables have positive and insignificant effects on agricultural output, it also submits that government intervention policy has positive and significant effect on agricultural output and on the other hand, insecurity has negative and significant effect on agricultural output in Nigeria within the period of this analysis. Based on this outcome of the study, hence the following policy recommendations would be proffered for the Nigerian economy as: government should build irrigations and dams that will provide alternative sources of water for agricultural production, engage experts and meteorologists to forecast weather that are realistic and up-to-date statistics for farmers, sustain her efforts in subsidy provisions and farm inputs for large scale production of agricultural output and Finally, Federal government and state governments should provide proactive measures to minimize the negative effect of insecurity on agricultural output reduce the issue of food insecurity in Nigeria.

Keywords*: Climate change, agricultural output, agricultural production, economic growth, climate variability, Nigeria*

1. INTRODUCTION

Agriculture remains a cornerstone of the Nigerian economy, contributing approximately 22% to the national GDP and providing livelihoods for nearly 30% of the workforce (Ibrahim, Usman & Bura, 2026). Despite its importance, the sector is dominated by smallholder farmers that lack the technical and financial capacity to mitigate climate shifts or change in the country. This dependence on favorable weather makes the country's food systems exceptionally sensitive to the timing and volume of precipitation (Adeleke, 2023; Ibrahim Usman & Bura, 2026).

Climate change has emerged as one of the most critical global challenges of the 21st century, and its implications are particularly significant for developing countries like Nigeria, where agriculture is a vital sector. Nigerian agricultural sector which employs more than 70% of the population is highly vulnerable to climate change due to its reliance on rain-fed farming systems (Nigerian Meteorological Agency [NIMET], 2020).

It is also a critical sector in Nigeria, accounting for a significant portion of its gross domestic product (GDP) and providing employment to a large percentage of the population. However, the effects of climate change have increasingly threatened this vital sector. Climate change, characterized by rising temperatures, unpredictable rainfall patterns, and extreme weather events, has significant implications for agricultural productivity in Nigeria (Central Bank of Nigeria, 2023).

Nigeria's agriculture is predominantly rain-fed, making it highly vulnerable to climate variability. According to the Intergovernmental Panel on Climate Change (IPCC), climate change leads to reduced crop yields and increased incidence of pests and diseases, which further exacerbate food insecurity (IPCC, 2021). The changing climate affects different agricultural zones in Nigeria differently, with the northern regions experiencing more severe impacts due to increasing desertification and drought (Ozor & Nnaji, 2022). Conversely, the southern regions are more prone to flooding due to rising sea levels and heavy rains, leading to the destruction of farmlands and livestock.

Climate change has also led to shifts in planting seasons, affecting the timeliness of agricultural activities such as planting and harvesting. A study by Adejuwon (2020) showed that unpredictable rainfall patterns have caused farmers to lose a significant portion of their harvests, contributing to low agricultural output. Additionally, high temperatures have been linked to reduce soil moisture content, thus affecting the productivity of crops such as maize, millet, and sorghum (Oladipo et al., 2021).

More to that, the recent data indicate that Nigeria has experienced significant environmental changes since the 1970s, characterized by: Rising Temperatures**:** Average annual temperatures have increased by approximately 1°C over the last century, with projections suggesting a further rise of up to 2.5°C by mid-century (Amuakwa-Mensah & Surry, 2021). Rainfall Instability**:** In the southern rainforest regions, farmers face concentrated high-intensity rainfall that causes erosion and flooding, while the northern savannah regions struggle with desertification and shortened growing seasons (Okon et al., 2021; Ibrahim Usman Bura, 2026). Studies on staple crops such as rice and maize show that protracted droughts and irregular rainfall patterns significantly reduce output per capita (Akanbi, 2022; Okon et al., 2021).

The socio-economic consequences of reduced agricultural output are far-reaching. The decline in food production contributes to higher food prices, lower household incomes, and increased poverty, especially in rural communities that depend heavily on agriculture for their livelihoods (FAO, 2020). Furthermore, climate change-induced food shortages threaten the food security of millions of Nigerians, particularly as the country already faces challenges related to population growth and urbanization.

Moreover, the consequences of declining agricultural output extend beyond the farm. Reduced yields are directly linked toNigeria has shifted from a potential food exporter to a major food importer due to domestic scarcity exacerbated by global warming (Igbokwe-Ibeto, 2019). Prolonged droughts have been found to reduce agricultural jobs, as the lack of productivity undermines the viability of rural livelihoods (Ibrahim Usman &Bura, 2026). Climate-induced land degradation and conflict over arable land have fueled internal migration toward urban centers, further straining food supply chains (Nwankpa, 2022).

Given the importance of agriculture to Nigeria's economy and the growing threats posed by climate change, it is imperative to investigate the specific effects of climate change on agricultural output in Nigeria. This study will examine how climate-related variables, such as temperature and rainfall variability affecting crop yields and food security in Nigeria. It will also explore adaptation strategies that can help mitigate the adverse effects of climate change on the agricultural Output in the country.

1.1 Objectives of the study

The broad objective of this study is to examine the effect of climate change on agricultural output in Nigeria. Meanwhile, the specific objectives of this study are to:

i. determine the effect of rainfall on agricultural output in Nigeria,
ii. evaluate the effect of variations in Average Annual temperature on agricultural output in Nigeria,
iii. evaluate the effect of government policy intervention on agricultural output in Nigeria and
iv. Assess the effect of insecurity on agricultural output in Nigeria.

1.2 Research questions

This study is guided by the following research questions as:

i. What are the effects of rainfall on agricultural output in Nigeria?
ii. What are the effects of temperature on agricultural output in Nigeria?
iii. In what way has government policy intervention affect agricultural output in Nigeria?
iv. To what extent has insecurity affected agricultural output in Nigeria?

2. LITERATURE REVIEW

2.1 Conceptual review

The conceptual review form the foundation for understanding the interactions between climate change and agricultural output in Nigeria, highlighting the need for research into how climate variability is affecting the country's food production systems and what can be done to enhance resilience.

2.1.1 Climate change

Climate change refers to significant and lasting changes in the statistical distribution of weather patterns over periods ranging from decades to millions of years. It involves global warming due to human activities, such as the emission of greenhouse gases, which leads to changes in temperature, precipitation, and the frequency of extreme weather events. These changes have profound implications for ecosystems, economies, and livelihoods globally, with agriculture being one of the most impacted sectors (IPCC, 2021). In this study, climate change is conceptualized as the driver of environmental shifts that affect Nigeria's agricultural productivity.

Furthermore, some of the factors that influence global climate change include rising temperatures which accounted for increase in average temperatures across the country (Federal Ministry of Environment, 2023). Variability in rainfall that is fluctuations and irregular patterns in the rainy season (Olaniyan & Abiodun, 2022) and extreme weather events that cause more frequent droughts, floods, and storms (Intergovernmental Panel on Climate Change [IPCC], 2023).

2.1.2 Climate Variability

Climate variability refers to the short-term variations in climate patterns, including fluctuations in rainfall, temperature, and the occurrence of extreme weather events such as droughts and floods. While distinct from long-term climate change, climate variability is often exacerbated by global warming, making agricultural planning and productivity more uncertain and challenging (Ozor et al., 2022). This concept is critical to understanding the seasonal and regional impacts of climate change on Nigeria's agriculture.

Vulnerability is the degree to which a system is susceptible to or unable to cope with adverse effects of climate change including climate variability and extremes. Most countries in sub-Saharan Africa (including Nigeria) are likely to suffer the effects of climate change more than other countries in the world. This is due to their geographical location, low income, low institutional capacity as well as their greater reliance on climate sensitive renewable resources. Nigeria like other countries in Sub-Sahara Africa is highly vulnerable to the impacts of climate change. Many towns and villages in Nigeria lie along the coastal, littoral states of the south and Northern front line states. These communities are exposed to climate variability or extremes such as shift in temperature, rainfall, storms and rise in sea levels. These changes in weather patterns impact negatively on agricultural activities and food security. The six geopolitical zones in Nigeria are vulnerable to climate change.

2.1.3 Regional Variability

Northern Nigeria: Higher temperatures and reduced rainfall lead to desertification and decreased arable land (Yusuf & Ayuba, 2023). Southern Nigeria: Flooding due to rising sea levels and increased rainfall disrupts agricultural activities (Eze et al., 2022).

2.1.4 Socio-Economic Implications Food Security: Reduction in food availability and affordability due to lower agricultural outputs (Nwosu, 2023).

2.1.5 Rural Livelihoods: Farmers face financial losses due to reduced yields and increased costs of inputs (Olayinka, 2022).

2.1.6 Migration and Conflict: Climate-induced displacement and competition for resources escalate conflicts, especially in northern regions (Garba & Suleiman, 2023).

2.1.7 Economic Growth

Economic growth is said to be one of the macroeconomic goals of the society. Several authors define the concept of economic growth differently which include: Abass (2005) defined economic growth as the increase in output or national income. A sustained increase in the actual output of goods and services per head is what makes an economy to grow. He further asserted that a percentage increase in the real national output during a given period of time usually a year, over the preceding year's level measures the rate of economic growth .

Barro (2000) asserted that for an economic growth to occur, the various systems or institutions such as agriculture, education etc in an economy must witness expansion even though their structure remains the same. Essien (2003), threads the path of Barro to define economic growth to mean an increase in output without a change in technical and institutional arrangement. According to him, expansion of various systems is expected to bring more output without a change in technical and institutional arrangement.

2.1.8 Agricultural Output

Agricultural output is defined as the total volume of agricultural products both crops and livestock produced by farming activities over a certain period. This concept encompasses both the quantity and quality of agricultural produce, influenced by factors such as climatic conditions, soil fertility, and farming techniques (Nwajiuba et al., 2023). In this study, agricultural output will primarily focus on staple crops that are essential to Nigeria's food security and economy, including maize, cassava, rice, and yams.

2.2. Theoretical Framework

The effect of climate change on agricultural output in Nigeria is best explained through a combination of these theoretical lenses. The Ricardian Theory explains the value and spatial distribution of farming, the Cobb-Douglas Production Function quantifies the physical input-output relationships under climate stress, the Theory of Optimal Adaptation accounts for the resilience and behavioral responses of farmers, and the Threshold Effect Theory captures the non-linear and often damaging nature of extreme climate variations. Together, these theories provide a comprehensive understanding of the vulnerabilities and potential mitigation strategies within the Nigerian agricultural sector.

However, in relating very specifically to the current study, it rely on classical theory of agriculture shows how various combinations of inputs can give rise to outputs, which also shows how and to what extent variation in inputs will result to changes in output during a specified period of time. The relationship between the rates of input of productive services and the rate of output of the product is the production function linking output of agriculture with economic growth in Nigeria.

Again, the Solow's neo-classical growth model holds that increase in the quantity of factors of production and the efficiency in their application is important for long-term growth, the theory maintains that foreign capital and improvement in technology are the main sources of sustainable economic growth of less developed countries. It therefore implies that output of agriculture alone may be inadequate in addressing economic growth in a particular country hence the need to capture additional macroeconomic variables such as climate change, cost of capital, the exchange value of money, volume of investment in economic activities amongst other variable. Thus, the classical theory of agriculture and the Solow's neo-classical model are jointly adopted for the study.

2.3 Empirical Review

There are many studies on the effect of climate change and agricultural output in Nigeria. However, this study has reviewed some of these studies which are relevant to the current trend of global climate on agricultural output in Nigeria.

Akinbobola and Afolayan (2021) examined the impact of climate change on the agricultural sector in southwest Nigeria, focusing on specific crops like cocoa and oil palm. They utilized a mixed-method approach, incorporating survey data and climate models. Their results indicated that increasing temperatures were associated with a reduction in cocoa yields by 4% annually, while oil palm production remained relatively stable due to improved farming practices.

Adeagbo and Ojebiyi (2019) examined the long-run relationship between climate change and agricultural output in Nigeria using the Autoregressive Distributed Lag (ARDL) bound test approach on data from 1981 to 2016. Their findings revealed that temperature had a negative and statistically significant impact on agricultural output, while rainfall had a positive effect. The study recommended the adoption of drought-resistant crop varieties to buffer against the adverse effects of rising temperatures.

Alhassan et al. (2020) utilized the Ordinary Least Squares (OLS) technique to assess the impact of climate variability on cereal production in Northern Nigeria. The empirical results indicated that an increase in minimum temperature reduced the yield of maize and sorghum significantly. However, the study found that increased rainfall during the growing season had a positive marginal effect on crop output, underscoring the region's dependence on rain-fed agriculture.

Amadi and Urang (2019) investigated the impact of climate variability on agricultural productivity using an Error Correction Model (ECM). The study analyzed time-series data from 1980 to 2016 and found that while rainfall positively correlates with agricultural output in the long run, rising temperatures exert a heavy negative toll. The authors concluded that heat stress induced by global warming is a major threat to food security and advocated for the expansion of irrigation infrastructure.

Ayanlade, Radeny, and Morton (2018) employed a spatial analysis approach, combining remote sensing data with household surveys to assess the impact of climate change on crop production and food security. Their study established a strong correlation between rising temperatures and declining vegetation health (NDVI), which serves as a proxy for agricultural output. The findings highlighted the spatial disparity in climate vulnerability, noting that the northern Sahelian region faces more severe output reductions compared to the southern part of Nigeria.

Ayinde, Akinnagbe, and Oyewole (2018) applied a Ricardian model to evaluate the economic impact of climate change on agriculture. The study revealed that temperature and rainfall changes significantly affect the net revenue of farmers. The results indicated that a 1% increase in temperature leads to a decrease in crop revenue, particularly for cereals. The authors emphasized that crop diversification is a potent strategy for farmers to adapt to the changing climate.

Bakare (2021) utilized the ARDL bounds testing approach to investigate the effect of climate change on agricultural output in Nigeria from 1980 to 2018. The study found that in the long run, rainfall and carbon dioxide emissions positively relate to agricultural output, likely due to the carbon fertilization effect. However, temperature increases were found to be detrimental to output, confirming the dual-edged nature of climate variables.

Daramola et al. (2020) examined the relationship between climate change indicators and agricultural productivity using a dynamic panel model. The study covered the period from 1990 to 2018 and found that erratic rainfall patterns and high temperature variability negatively influenced productivity. The empirical evidence suggested that access to credit and extension services moderates the negative impact of climate change on output.

Efiong and Bassey (2020) analyzed the impact of rainfall and temperature on selected food crop yields in Nigeria. Using multiple regression analysis, the study found that temperature variability negatively affects the yield of cassava and yam, while rainfall variability showed a positive but insignificant relationship with cassava yield. The authors concluded that temperature changes are a more potent threat to root crop production than rainfall variability.

Eze and Okoye (2021) employed the Vector Error Correction Model (VECM) to examine the impact of climate variability on the yield of major staple crops (maize, cassava, and rice). The study found evidence of a long-run causal relationship between climate variables and crop yields. Specifically, the results indicated that an increase in average annual temperature negatively affects the yield of all three crops, while rainfall positively impacts cassava and rice but can be detrimental to maize if excessive.

Mshelia, et al. (2021) Mshelia et al. (2021) evaluated the impact of climate change on the output of arable crops in Nigeria. Using a Cobb-Douglas production function, the study incorporated climate variables as inputs. The empirical results showed that climate factors account for a significant proportion of the variation in crop output. The study found that high temperature and low relative humidity negatively influence the output of soybeans and cowpeas.

Nnaji et al. (2019) conducted an empirical analysis of the effect of climate change on agricultural productivity growth in Nigeria. Using the Malmquist Productivity Index, the study found that climate change has slowed the growth rate of agricultural productivity. The

results indicated that technical efficiency is adversely affected by climate variability, particularly in regions with poor soil management practices.

Nwalieji and Uzuegbunam (2018) analyzed the impact of climate change on rice production in Nigeria. Using multiple regression analysis, the study found that rising temperatures and unpredictable rainfall patterns are the major climate factors hindering rice production. The study also highlighted that an increase in the frequency of extreme weather events, such as droughts and floods, has led to a significant decline in rice output in recent years.

Umar et al. (2023) conducted a comprehensive assessment of climate change impacts on agricultural output in Nigeria's central region using remote sensing data and climate modeling. Their study found that climate extremes, particularly droughts and flooding, were becoming more frequent and severely affecting crop productivity. Maize, millet, and sorghum were identified as the most vulnerable crops, with yields declining by 8-12% in extreme weather conditions.

Nwauwa and Okechukwu (2021) explored the effect of climate change indicators on agricultural output in Nigeria, specifically distinguishing between arable and crop production sectors. Using multiple regression analysis, the study found that climatic variables account for a significant portion of the variation in agricultural output. The results indicated that an increase in the rate of rainfall leads to an increase in crop output, but excessive heat associated with rising temperatures negatively correlates with production. The authors advocated for the reforestation of degraded lands to serve as carbon sinks and regulate microclimates in the study area.

Olorunfemi (2020) employed the ARDL econometric technique to examine the dynamic impact of climate change on agricultural output in Nigeria from 1980 to 2018. The study established a long-run relationship between agricultural output, rainfall, temperature, and carbon dioxide emissions. A key finding was that while carbon dioxide (a greenhouse gas) can have a fertilization effect on plants, the accompanying rise in temperature and erratic rainfall patterns in Nigeria ultimately suppresses overall agricultural productivity. The study stressed the need for investment in research and development to create adaptive seed technologies in Nigeria.

Onyeneke, Ozor, and Nnaji (2020) analyzed the cost of climate change to crop production in Nigeria. Using a combination of econometric and descriptive analysis, the study quantified the financial losses associated with climate variability over a decade. The results indicated that climate change has led to a substantial reduction in the yield of staple crops such as cassava, yam, and maize. The study highlighted that farmers who adopted adaptation strategies, such as changing planting dates and using improved varieties, experienced significantly lower yield losses compared to non-adopters in Nigeria.

Ugwuoke and Okeke (2020) conducted a time series analysis to determine the effect of climate change on agricultural output in Nigeria. Their study utilized data from 1980 to 2016 and applied the Ordinary Least Squares (OLS) technique. The findings revealed that rainfall variability and temperature increases are critical determinants of agricultural performance in Nigeria. The regression results showed a negative relationship between temperature and agricultural output, suggesting that heat stress remains a major constraint.

Eze and Okoye (2021) investigated the impact of climate variability on the yield of selected staple crops (maize, cassava, and rice) in Nigeria. By employing the Vector Error Correction

Model (VECM), the study found evidence of both short-run and long-run causality between climate variables and crop yields. Specifically, the study observed that an increase in average annual temperature negatively affects the yield of all three crops, while rainfall positively impacts cassava and rice but can be detrimental to maize if it leads to waterlogging in the study area.

Ayanlade, Radeny, and Morton (2018) using a spatial approach by combining remote sensing data with household survey data to assess the impact of climate change on crop production and food security in Nigeria. The study utilized spatial analysis to correlate rainfall and temperature trends with vegetation health (NDVI). The empirical results indicated a strong correlation between increasing temperatures and declining vegetation health, which translates to lower crop yields. The study further noted that the impact is more severe in the northern Sahelian region of Nigeria compared to the southern region, emphasizing the geographical disparity in climate vulnerability.

Adeosun et al. (2021) examined the vulnerability of agricultural output growth in Nigeria to climate change using data covering 1986–2015. The study focused on the effects of average annual rainfall, temperature, drought, floods, forest area and agricultural nitrous oxide emissions on agricultural output. The researchers employed descriptive statistics, unit-root testing and ordinary least squares estimation to examine the relationship between climatic and environmental factors and agricultural output. The findings indicated that average annual rainfall, temperature and forest area positively influenced agricultural output within the estimated model. In contrast, drought, floods and agricultural nitrous oxide emissions had negative effects on agricultural output. These results indicate that the relationship between climate change and agricultural production is not necessarily uniform across climatic indicators. In particular, favourable rainfall and temperature conditions may support agricultural activities, whereas extreme weather events can undermine production.

Amankwah (2023) investigated the relationship between long-term climate variability, the adoption of agricultural technologies and crop productivity in rural Nigeria. Unlike studies based exclusively on national time-series data, the research used nationally representative, geographically referenced household-survey and plot-level data. It examined the adoption of sustainable agricultural practices, including improved seeds, organic and inorganic fertilizers, and legume intercropping, as potential means of improving agricultural productivity under changing climatic conditions. The study employed multivariate and ordered probit models to examine the adoption and intensity of adoption of sustainable practices, while an instrumental-variables approach was used to investigate their effects on productivity. The study's central contribution was to examine climate variability alongside farmers' technology-adoption decisions and the productivity implications of those decisions at the plot level. Its findings and analysis underscore the importance of agricultural technologies and sustainable farming practices in helping rural farmers respond to climate-related production risks. The study is particularly relevant because it moves beyond the direct relationship between climatic variables and output to consider how farmers' production decisions can influence productivity outcomes. It also provides a basis for examining whether improved seeds, appropriate fertilizer use and intercropping can strengthen farmers' resilience to changing climatic conditions.

Oghenekevwe and Adesoye (2024) investigated the effects of climate change on agricultural productivity in Nigeria over the period 1991–2022. The study employed annual data obtained from the Central Bank of Nigeria Statistical Bulletin and the World Bank database.

Agricultural GDP was used as an indicator of agricultural productivity, while rainfall, temperature and carbon dioxide emissions represented the principal climatic and environmental variables. The researchers adopted the autoregressive distributed lag (ARDL) framework and conducted unit-root and bounds tests to examine the time-series properties of the variables and the existence of a long-run relationship. The results indicated that rainfall, temperature and carbon dioxide emissions exerted negative effects on agricultural productivity in both the short run and the long run. The error-correction mechanism suggested that approximately 8% of the preceding period's disequilibrium was corrected annually.

Dwamena et al. (2022) investigated the effects of rainfall, minimum and maximum temperatures, and relative humidity on the yields of cassava, yam and maize in Ghana's Ashanti Region. The study sought to establish how variations in climatic conditions influenced the productivity of these major food crops. The researchers employed correlation analysis and separate multiple linear regression models to examine the relationships between the climatic variables and crop yields per hectare. The findings revealed that increases in maximum temperature reduced the yields of all three crops, while increases in minimum temperature reduced maize yield. Higher relative humidity negatively affected maize yield, whereas increased rainfall reduced cassava yield within the estimated model. The regression models explained approximately 63.8% of the variation in maize yield, 74.3% in cassava yield and 64.2% in yam yield.

Atiah et al. (2022) examined the vulnerability of maize production to climate variability in Ghana, focusing on rainfall, soil moisture, and minimum and maximum temperatures. The study was motivated by the importance of rain-fed agriculture to livelihoods and food security, as well as the need to understand how changing weather conditions affect maize productivity. The researchers analysed climatic and maize-yield data to investigate trends and relationships between weather conditions and crop production. The findings indicated decreasing trends in rainfall and soil moisture alongside increasing trends in maize yields and minimum and maximum temperatures over the period examined. These trends suggest that the relationship between temperature and crop production cannot be interpreted independently of other factors, such as improved agricultural practices, crop varieties and production inputs. The study also investigated the effects of below-normal and above-normal rainfall conditions on maize yields, highlighting the importance of rainfall distribution rather than annual totals alone. Its findings are relevant to the present research because maize is an important staple crop in Ghana and is particularly vulnerable to heat stress and irregular rainfall. The study supports the need for climate-informed planting decisions, improved soil-moisture management and agricultural practices that strengthen resilience to changing climatic conditions.

Gyamerah et al. (2024) examined the marginal effects of climate variability on maize yields in four locations in the Upper East Region of Ghana. The study sought to identify which climatic variables were most important in explaining maize-yield variation and to determine the temperature conditions associated with higher or lower yields. The researchers used climate and agricultural data from the study locations and applied a random forest machine-learning approach, the Mann–Kendall trend test and Sen's slope estimator. The findings indicated that maximum and minimum temperatures were among the most important climatic indicators affecting maize yields. The analysis showed that maize yields tended to decline when temperatures exceeded approximately 32°C, while yields tended to be higher around 24°C in the locations studied. These results suggest that excessive heat can impose

substantial constraints on maize production in northern Ghana. The study is particularly relevant because its machine-learning approach can identify nonlinear relationships that conventional linear regression may not adequately capture. It also provides evidence for developing temperature-sensitive agricultural advice and improving farmers' access to heat-tolerant maize varieties. However, the estimated temperature thresholds should be interpreted within the context of the four study locations rather than assumed to apply uniformly throughout Ghana.

Kwakye et al. (2025) investigated the effects of climate variability and cultivated land area on cassava, yam and maize yields in Wenchi Municipality, Ghana. The study used time-series data covering 2000–2021 on rainfall, minimum temperature, maximum temperature, cultivated area and crop yields. The researchers employed a quantitative approach and estimated multiple linear regression models with logarithmic transformations to determine the effects of climatic conditions and cultivated land area on the yields of the selected crops. Diagnostic tests were conducted to assess whether the regression assumptions were satisfied. The study provides recent, location-specific evidence on the relationships between climatic variables and the productivity of three important food crops. Its focus on cultivated land area is useful because crop output may change not only because of climatic conditions but also because of changes in the amount of land under cultivation. The study is relevant to the present research because it uses a relatively recent observation period and examines crops with different climatic requirements. It also demonstrates the importance of including non-climatic production factors when estimating the effect of climate change on agricultural output. For a complete empirical interpretation, the individual regression coefficients and significance levels should be reported directly from the original article rather than inferred from the study's objectives or methodology.

Danso (2025) examined the effects of climate change on food production in Ghana, with emphasis on the country's dependence on rain-fed agriculture and the adaptation and mitigation strategies that may reduce climate-related production risks. The study focused on changes in temperature and rainfall and their implications for major food crops, including maize, cassava, yam and millet, over the period 2010–2022. The research addressed the need to understand how recent climatic fluctuations influence food production and how adaptation strategies can support agricultural resilience. Its analysis considered differences in crop vulnerability and the importance of developing responses that are appropriate to the requirements of individual crops and farming environments. The study highlighted the need for effective adaptation and mitigation measures to address the risks that climate variability poses to food production. Its policy implications include strengthening agricultural extension services, improving access to climate information and encouraging farming practices that reduce vulnerability to irregular rainfall and excessive temperatures. The study is relevant because it focuses on a relatively recent period and connects climate-related production challenges with practical adaptation strategies. Nevertheless, the precise econometric techniques and individual effect estimates should be confirmed from the full article before making quantitative claims about the magnitude of the impact of climate change on Ghana's agricultural output.

Amare and Balana (2023) investigated how climate change influences agricultural productivity, household income sources, crop choices and input-use decisions in Nigeria. The researchers combined panel data from nationally representative household surveys with long-term satellite-based temperature and precipitation data linked to households through geographical information. Their approach distinguished between harmful degree days,

growing degree days and changes in precipitation during crop-growing periods. This enabled the study to investigate how exposure to different temperature conditions affects agricultural production rather than relying solely on average annual temperature. The findings indicated that a 15% increase in changes in harmful degree days, equivalent to one standard deviation in the study's measure, was associated with an average 5.22% reduction in agricultural productivity, after controlling for other factors. This result suggests that increased exposure to damaging heat can substantially reduce agricultural productivity in Nigeria. The study is particularly important because it captures differences in temperature exposure during crop-growing periods and relates these differences to household-level agricultural outcomes.

Akukwe et al. (2024) examined the perceived effects of climate change on agricultural productivity in Igbo-Etiti Local Government Area of Enugu State, Nigeria. The study focused on an agrarian community and used complementary data-collection methods, including questionnaires, direct observation and key-informant interviews, to investigate how climatic changes affected agricultural activities. Rather than relying exclusively on national agricultural-output statistics, the researchers examined farmers' experiences and perceptions of climate-related changes in their production environment. The study addressed the implications of climate change for agricultural productivity in a location where rural livelihoods depend substantially on farming. Its approach is valuable because farmers' experiences can reveal local production problems, including changes in rainfall patterns and other environmental conditions that may not be adequately captured by aggregate national statistics. The findings provide context-specific evidence for understanding the vulnerability of agricultural communities to climatic changes and the importance of adaptation at the local level. The study is relevant to the present research because it demonstrates the value of combining quantitative agricultural data with local evidence when investigating climate change and agricultural productivity. However, since the study was location-specific and included farmers' perceptions, its findings should not be interpreted as a direct national-level estimate of the causal effect of climate change on agricultural output.

3. RESEARCH METHODOLOGY

3.1 Research Design

This study combines both descriptive and quantitative methods. The descriptive research will be used to examine descriptive statistical relationship while the ex-post facto research design will be used to analyze the effect of climate change on agricultural output in Nigeria. There is usually a serious limitation relating to the conduct of experiments in economics as the subject matter of economics mostly deals with human behaviour. Ex-post facto research design enables the researcher to deal with human behaviour and economic indices summarized in the form secondary data.

3.2 Nature and Sources of Data

The nature of data to be used in this study is basically secondary data which will be obtained from the Central Bank of Nigeria (CBN) publications, National Bureau of Statistics (NBS) publications, and World Bank database, 2026.

3.3 Data Required

Time series data will be required in this study on effect of climate change on agricultural output in Nigeria. The variables include Agricultural output (AGO), Average Annual Rainfall

(AAR), Insecurity (ISC), Average Annual Temperature (TEM), Government policy intervention (GPI) for the period 1990-2025.

3.4 Method of Data Analysis

To achieve the research objectives for the study, an econometric analysis (ordinary Least Squares) will be done for the period of 1990 and 2025.

The Augmented Dickey Fuller (ADF) unit root test is conducted first to determine the stationarity of the variables over a long period of time.

To examine the causal links between agricultural output and climate change in Nigeria, the Pairwise Granger Causality tests will be applied. This is to enable the researcher distinguishes clearly bi-directional causation, uni-directional causation and zero causation between the dependent and independent variables and amongst the explanatory variables.

3.5 Specification of the Model

The primary model showing the technical relationship between agricultural output and Climate change following the works of Kamil, Sevin and Festus (2017) and Apeh, Idoko and Adeshina (2012) is specified thus:

AGO = F (CLM) ---------- (3.1)

Where:

AGO = Agricultural Output

CLM = Climate Change

Equation (3.1) can be expanded to cover other variables affecting agricultural output in Nigeria following from the empirical works of Sulaiman (2014) as follows:

AGO = F (AAR + ATE + ISC + GPI+ μ), ---------- (3.2)

Equation (3.2) was explicitly specified to cover the stochastic element as follows;

$AGO = b_0 + b_1AAR + b_2ATE + b_3ISC + b_4GPI + U$ ---------- (3.3)

Where b_o= Intercept;

b_1-b_4 = regression coefficients to be estimated;

AGO = agriculture Output

AAR = Average Annual Rainfall

ATE = Average Annual Temperature

ISC = Insecurity

GPI= Government Policy Intervention on agriculture

GFCF = Gross Fixed Capital Formation

U = Stochastic error term

4. DATA PRESENTATION AND ANALYSIS

4.1 Data presentation

This section started with data presentation, summary of descriptive statistics, unit root test and model estimation in order to examine the impact of oil revenue on economic growth in Nigeria. Similarly, the study conduct diagnostic tests such as normality test, autocorrelation, heteroscedasticity, Ramsey RESET test and stability to ensure the estimated model made all the criteria of the analysis for policy recommendations. In addition, the data presentation has Agricultural output (AGO), Average annual Rainfall (ARF), Average Annual Temperature (ATE), Insecurity (ISC), Government Intervention on Agriculture (GIV) for the research work.

More to that, the data for this study would be presented in the various figures to reveal the trend pattern of the time series. This trend analysis has provided the movement of the data over the period of the study. Agricultural output (AGO), Average annual Rainfall (ARF), Average Annual Temperature (ATA), Insecurity (ISC), Government Intervention on Agriculture (GIV).

Table 4.1: **Summary of Descriptive Statistics**
Sample: 1990 2023

	AGO	ARF	ATE	ISC	GIV
Mean	13230.17	320.0324	33.26471	235.1188	887.5629
Median	8032.640	291.8000	35.00000	149.6426	603.0045
Maximum	53273.14	868.4000	40.00000	825.0163	4486.206
Minimum	106.6267	25.00000	25.00000	0.000000	24.04860
Std. Dev.	14728.50	218.4979	4.322659	255.8171	977.0161
Skewness	1.229772	0.710122	-0.733946	0.974594	2.001693
Kurtosis	3.614468	2.836266	2.136507	2.750479	7.156437
Jarque-Bera	9.104815	2.895525	4.108799	5.470587	47.17936
Probability	0.010542	0.235096	0.128170	0.064875	0.000000
Sum	449825.9	10881.10	1131.000	7994.039	30177.14
Sum Sq. Dev.	7.16E+09	1575464.	616.6176	2159600.	31500492
Observations	34	34	34	34	34

Source: Extracted from Researcher's computation, 2026.

Furthermore, the maximum values for each of the variables were ₦ 53273.14bn, 868.4000mm, 40.00000^{o}c, ₦ 825.0163and ₦ 4486.206 for Agricultural output (AGO), Average annual Rainfall (ARF), Average Annual Temperature (ATE), Insecurity (ISC), Government Intervention on Agriculture (GIV) respectively.

While, the minimum values of₦ 106.6267bn, 25.00000mm, 25.00000^{o}c , ₦ 0.000000bn, and ₦ 24.04860 and 5.4% for the Agricultural output (AGO), Average annual Rainfall (ARF), Average Annual Temperature (ATE), Insecurity (ISC), Government Intervention on Agriculture (GIV) respectively for the Nigerian economy which shows that lowest values of both independent and dependent variables.

However, one of the vital tools used for research is Jarque-Bera statistics and its p-values as: 9.104815 (0.010542), 2.895525(0.235096), 4.108799 (0.128170), 5.470587 (0.064875), and

47.17936 (000000) which showed that the data were normally distributed variables except Agriculture output(AGO) and Government Intervention (GIV). This indicated that the *p-values* were statistically insignificant at 5% level. It means that the study strongly rejects the null hypothesis and concluded that the time series data involved are normally distributed.

4.2 Unit Root Test

The study adopted Augmented Dickey Fuller (ADF) to estimates the level of stationarity of the time series data. The outcomes of the stationarity test are presented in Table 4.2.

Table 4.2: Unit root Test Using Augmented Dickey Fuller

Variables	ADF Test Statistic Value	Mackinnon Critical Value (5% Level)	Prob.*	Order of Integration	Remark
Log (AGO)	-3.606474	-2.954021	0.0110*	I(0)	Stationary
Log (ARF)	-3.300507	-2.954021	0.0230*	I(0)	Stationary
Log (ATE)	-3.959865	-2.954021	0.0045*	I(0)	Stationary
Log(ISC)	2.625252	-2.976263	0.0000*	I(0)	Stationary
Log(GIV)	-1.576259	-2.954021		I(0)	Stationary
			0.04832*		

Note: * represented the variable is significant @ 5% first differencing respectively.
Source: Researcher's Computation, 2026.

From Table 4.2, it shows that the ADF result indicated that economic growth i.e Agriculture output(AGO) was not stationary at level but it becomes stationary after first difference. Its value of -3.606474 and p-value of 0.0110 prove that Agriculture output(AGO) was stationary at first difference meaning that the null hypothesis was strongly rejected.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This study analyzed the effect of climate change on agricultural output in Nigeria. It uses time series data obtained from the Central Bank of Nigeria statistical Bulletins, (CBN, 2025) and World Bank Development Indicators (2025) for the periods 1990-2025.

Furthermore, this study underpinned its analysis on Structural Transformation Model and Malthusian Theory of population respectively. It applied descriptive statistics which revealed that the data are normally distributed based on Jarque Berra Statistics and its probability values. Moreover, the findings from Unit root test using Augmented Dickey Fuller indicated that all variables are stationary at level. That is, they integrated of order zero (I0) which necessitated the choice of Ordinary Least Squares (OLS) as method of data analysis.

More to that, the OLS result showed that the coefficient of Average annual Rainfall (ARF) of 0.104451; this agreed with the apriori expectation that there is positive impact between Average annual Rainfall (ARF) and Agricultural output (AGO) in a given economy. That is, by the coefficient of Average annual Rainfall (ARF) of 0.104451, it means 1 unit or 1% increase in Average annual Rainfall (ARF) would result 0.104451 units or 10.44% increase in Agricultural output (AGO) in Nigerian economy within the study periods of 1986 to 2023. This variable has significant value of *T-value* of 0.630439 and *P-value* of 0.5333. This result revealed that Average annual Rainfall (ARF) was statistically insignificant in the model at 5% level of significance.

More to that, the result also indicated that the co-efficient of Average Annual Temperature (ATE) 0.054137 aligns with apriori expectation that is a positive relationship exists between Average Annual Temperature (ATE) and Agricultural output (AGO) in Nigerian economy. From section four, the coefficient Average Annual Temperature (ATF) of 0.054137, it means if 1% or 1 unit increase in Average Annual Temperature (ATF) would lead to 0.054137 units or 5.4% increase in Agricultural output (AGO). In addition, it was statistically significant by its *t-value* of 0.075802 and *p-value* of 0.0301 respectively in the long-run.

5.2 Conclusion

This study concluded that climate change variables have positive and insignificant effects on agricultural output in Nigeria. It also submits that government intervention policy has positive and significant effect on agricultural output in Nigeria. However, insecurity has negative and significant effect on agricultural output in the study area within the period of this analysis. Based on this outcome of the study, hence the following policy recommendations would be proffered for the Nigerian economy.

5.3 Recommendations

This study on effect of global climate change on agricultural output in Nigeria has recommended the following policy options for the country based on the objectives of the study as:

i. Government should build irrigations and dams that will provide alternative sources of water for agricultural production in Nigeria to improve agricultural output in the country.
ii. Federal government and private sector should engage experts and meteorologists to forecast weather that are realistic and upto-date statistics for farmers in Nigeria to improve temperature in the farming season.
iii. Federal Government should sustain her efforts in subsidy provisions and farm inputs for to enhance large scale production of agricultural output in Nigeria.
iv. Finally, Federal government and state governments should provide proactive measures to minimize the negative effect of insecurity on agricultural output in Nigeria.

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