



REVIEW ARTICLE

THE EFFECT OF CLIMATE CHANGE ON CROP YIELDS IN NIGERIA (1990 - 2023)

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ABSTRACT

The influence of climate change on Nigeria's agricultural productivity (AGRP) between 1991 and 2023 is examined in this paper, with particular attention paid to important explanatory factors such as GDP, population growth, and CO₂ emissions. The study uses the Autoregressive Distributed Lag (ARDL) model to evaluate the short- and long-term correlations between these variables and agricultural output using time series data from the Food and Agriculture Organization, the World Bank, and the Nigerian Meteorological Agency. The findings highlight the enduring nature of productivity trends by showing that historical agricultural production has a substantial impact on current output. The short-term impact of CO₂ emissions is negligible, despite the fact that they exhibit a slightly significant positive lagged effect on AGRP. The expansion of the labor force and rising food demand, on the other hand, are the main reasons why population growth has a positive and considerable impact on agricultural output. GDP growth has no discernible short-term impact on agricultural output, indicating that without targeted sectoral investments, the agricultural sector does not immediately benefit from broader economic expansion. With implications for policy interventions, the study comes to the conclusion that economic dynamics, demographic pressure, and climate change all influence agricultural output in linked ways. In addition to successful climate adaptation and mitigation measures, the report suggests investing in agriculture-driven economic growth, improving population control techniques, and concentrating on climate-smart practices in order to create a resilient agricultural sector. Nigeria can manage the effects of climate change and maintain long-term food security with the support of this integrated approach.

KEYWORDS

Climate Change, Agricultural Productivity, CO₂ Emissions, Population Growth, Developing Countries.

1. INTRODUCTION

One of the most urgent issues facing the world today is climate change, which has an effect on many industries, especially agriculture. Global food supply is under threat from rising temperatures, changed precipitation patterns, and an increase in extreme weather events like storms, floods, and droughts. Since agriculture frequently depends on steady weather conditions for agricultural production, it is particularly sensitive to these shifts in poorer countries. As the world's population continues to rise, maintaining food security has grown increasingly difficult, necessitating creative methods to sustain agricultural productivity while adjusting to a changing climate.

The impact of climate change on agriculture is becoming more noticeable in sub-Saharan Africa, especially in Nigeria. Due to its heavy reliance on rain-fed systems, Nigeria's agriculture industry is susceptible to changes in the weather. Nigeria's climate has changed significantly over the last few decades, with temperatures rising, rainfall patterns becoming more erratic, and extreme weather events becoming more frequent. Concerns regarding the resilience of Nigerian agriculture have been raised by the direct effects of these climate changes on the yield of staple crops including rice, cassava, and maize. Developing solutions to lessen these consequences and improve the nation's food security requires an understanding of the connection between climate change and agricultural productivity.

1.1 Background to the Study

A major contributor to GDP, employment, and national food security,

agriculture is essential to Nigeria's economy. However, the sector is extremely sensitive to climate fluctuation and long-term climate change due to its heavy reliance on rainfall. Significant climate changes have occurred in Nigeria during the last thirty years, including a rise in the frequency and severity of extreme weather events including droughts and floods, irregular rainfall patterns, and rising temperatures (Ajetomobi et al., 2011). The productivity of important staple crops that are vital for household use and the nation's food supply, such as maize, rice, sorghum, and cassava, is under danger due to these environmental changes.

Unpredictable rainfall disturbs planting and harvesting cycles, and studies reveal that temperature spikes above specific thresholds can significantly lower agricultural yields (Lobell et al., 2011). The effects of climate change on food production and security are substantial because the majority of Nigerian farmers work at the subsistence level and have little access to irrigation, adaptive technologies, and information on climate change. Given this background, it is crucial to conduct an empirical investigation into the ways in which climate-related factors affect Nigeria's agricultural productivity (AGRP) over time. In order to investigate their combined impact on agricultural productivity and to establish a foundation for climate-resilient policy interventions, this study looks at GDP, CO₂ emissions, and population increase as important explanatory factors (Nwafor et al., 2010).

1.2 Statement of the Problem

Nigeria's economy and food security depend heavily on agriculture, although the sector's productivity levels continue to fluctuate, primarily as a result of climate-related issues. Across the nation, farming operations

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have been disrupted and crop yields have decreased due to rising temperatures, unpredictable rainfall, and an increase in extreme weather events. Population increase is also putting strain on food systems and available agricultural land, and environmental degradation—which is manifested in rising CO₂ emissions—makes it more difficult to maintain sustainable agricultural methods. Nigeria's GDP shows that the country has made significant progress in economic expansion, but these gains have not always been mirrored in increased agricultural resilience.

How these important factors—economic expansion, emissions, and population dynamics—interact with climate change to affect agricultural output across time is still not well understood. Policy solutions might not adequately address the fundamental issues if these links are not empirically understood. By examining the long-term impacts of GDP, CO₂ emissions, and population increase on agricultural productivity in Nigeria between 1990 and 2023, this study aims to close that gap and offer evidence in favor of more focused and flexible agricultural policies.

1.3 Research Questions

This study seeks to answer the following research questions:

- How do GDP, CO₂ emissions, and population growth collectively affect agricultural productivity (AGRP) in Nigeria from 1990 to 2023?
- What is the impact of climate change, as reflected through environmental degradation and demographic pressures, on agricultural output in Nigeria over the same period?

1.4 Research Objectives

The primary objectives of this study are to:

- Analyze the individual and combined effects of GDP, CO₂ emissions, and population growth on agricultural productivity (AGRP) in Nigeria from 1990 to 2023.
- Investigate the influence of climate change, reflected through environmental degradation and demographic pressures, on agricultural output in Nigeria over the same period.

1.5 Scope and Limitations

This study examines how Nigeria's GDP, CO₂ emissions, and population increase affect the country's agricultural productivity (AGRP) between 1990 and 2023. It makes use of time series data from important sources like the Food and Agriculture Organization (FAO), the World Bank, and the Nigerian Meteorological Agency. The study is constrained by the quantity and quality of data available, especially with regard to specific climate variables at the regional level, even if it offers insightful information about the connections between agricultural output and economic, environmental, and demographic issues. Furthermore, not all possible factors that could affect agricultural output are taken into consideration in the study, such as changes in policy or technology improvements, which could also have a big impact on the results.

1.6 Structure of the Paper

The first section of the study provides an overview of climate change, its effects on agricultural productivity, and its global and Nigerian context. After that, it examines the body of research to lay the groundwork for comprehending how population shifts, economic variables, and climate change impact agriculture. A theoretical framework that uses pertinent theories to direct the research comes next. The research strategy, data collection techniques, and econometric models used to examine the connection between Nigerian agricultural productivity and climate change are described in the methodology section.

The findings from the analysis are presented and interpreted, offering insights into the impact of climate change on agricultural output. Based on these results, the paper concludes by providing recommendations for policy interventions aimed at mitigating the adverse effects of climate change on agriculture and enhancing the sector's resilience. The final part of the paper includes a comprehensive list of references, acknowledging all sources consulted throughout the research.

2. LITERATURE REVIEW

Many people agree that one of the main factors affecting agricultural output is climate change, particularly in underdeveloped nations where agriculture is highly dependent on the weather. Rising temperatures, erratic rainfall, and an increase in the frequency of extreme weather events have all been shown to have a negative impact on crop yields in numerous studies. For example, discovered that temperature increases above thresholds unique to a certain crop drastically lower yields, especially for key crops like rice and maize (Lobell et al., 2011). In a similar

vein, research shows that unpredictable rainfall patterns cause scheduling conflicts for planting and harvesting, which lowers agricultural productivity in several Sub-Saharan African countries, including Nigeria (Ajetomobi et al., 2011).

Rain-fed agriculture in Nigeria is known to be vulnerable to climate variability; numerous studies have connected climatic shifts to lower productivity, especially in the northern regions

where farming is largely dependent on seasonal rainfall.

Economic and demographic variables, including GDP, CO₂ emissions, and population expansion, have been recognized as important determinants of agricultural production in addition to climate considerations. Despite being generally beneficial for agriculture, research indicates that GDP development does not necessarily translate into agricultural resilience, particularly when environmental degradation such as rising CO₂ emissions intensifies (Nwafor et al., 2010). Contrarily, population growth raises the demand for agricultural land and food, which frequently results in resource overuse and further strain on food systems (Ajetomobi et al., 2011).

Therefore, it is essential to comprehend how economic performance, environmental stress, and population pressures interact in order to comprehend Nigerian agricultural output. In order to increase resilience against climate change, recent studies have highlighted the necessity of integrated policy approaches that address both the economic and environmental aspects of agricultural development (Deressa and Hassan, 2009; IPCC, 2021).

2.1 Conceptual Clarifications: Climate Change and Crop Yield

The term "climate change" describes long-term changes brought on by both natural and man-made variables in temperature, precipitation patterns, and the frequency of extreme weather events like storms, floods, and droughts. Growing atmospheric quantities of greenhouse gases (GHGs), particularly CO₂, which trap heat and interfere with Earth's climate processes, are the main causes of recent climate change (IPCC, 2021). Through its effects on plant growth conditions, such as temperature, precipitation, and the frequency of extreme weather events, climate change can have an impact on crop output in agriculture. For example, increasing temperatures may surpass some crops' ideal growing thresholds, causing heat stress and decreased photosynthesis, which in turn lowers yields (Lobell et al., 2011).

Similarly, unpredictable rainfall patterns can affect the availability of water for crops, disrupt planting and harvesting seasons, and increase the likelihood of crop failure, particularly for rain-fed agriculture common in Nigeria (Ajetomobi et al., 2011).

The relationship between climate change and crop yield is complex, as it depends on various factors such as the type of crop, the region, and the specific climatic variables involved. While some regions may experience beneficial effects from climate change, such as longer growing seasons or higher carbon dioxide levels that promote photosynthesis, most areas, particularly in Sub-Saharan Africa, are likely to suffer negative impacts. Studies have shown that even moderate increases in temperature and shifts in precipitation patterns can significantly reduce yields for crops like maize, rice, and sorghum, which are critical for food security in Nigeria (Deressa and Hassan, 2009). The vulnerability of Nigerian agriculture to climate change is further compounded by limited access to adaptive technologies, climate information services, and irrigation, which hinder farmers' ability to cope with climate variability. As such, understanding the mechanisms through which climate change influences crop yields is essential for designing effective strategies to mitigate its adverse effects on agricultural productivity and ensure food security.

2.2 Theoretical Literature Review

Many theoretical frameworks, including those centered on environmental economics and agricultural productivity models, have been used to examine the connection between climate change and agricultural productivity. The Ricardian model, which describes how climate factors like temperature and precipitation affect agricultural productivity, is one significant theoretical viewpoint (Mendelsohn et al., 1994). As per this model, the comparative advantage of regions in agricultural production is impacted by climate change. While some regions benefit from warmer temperatures, others—especially those that depend on rain-fed systems—suffer from lower yields as a result of increased heat stress and unpredictable rainfall patterns.

Farmers in more hospitable climes can adapt by switching to alternative crops or changing agricultural practices, according to (Mendelsohn et al., 1994). However, these tactics might not be practical in regions where the

effects of climate change are more pronounced. This model emphasizes how crucial it is to comprehend regional differences in the impacts of climate change in order to forecast the financial ramifications for agricultural output. The idea of environmental degradation and the role of greenhouse gases is another theoretical framework that is used to examine how climate change affects agriculture. This viewpoint holds that human actions like industrialization and deforestation cause CO₂ emissions to rise, which causes global warming and changes the climate in ways that affect agricultural systems.

The hypothesis contends that climate change impacts broader socioeconomic elements including labor availability, market accessibility, and land use in addition to the immediate environmental conditions required for agricultural growth (Schlenker and Roberts, 2009). Because the agricultural sector is extremely vulnerable to changes in climate and lacks the resources to completely adapt to them, this hypothesis is especially pertinent in developing nations like Nigeria. In the face of climate change, maintaining agricultural production and guaranteeing food security becomes a difficult task due to the interplay between economic drivers like GDP and population increase and climate-induced environmental degradation.

2.3 Empirical Literature Review

With special attention to temperature variations, rainfall patterns, and extreme weather events, empirical research has demonstrated a strong correlation between climate change and agricultural output. They discovered that climate change has already had a detrimental impact on agricultural output in Sub-Saharan Africa, especially for rain-fed crops like millet, sorghum, and maize that are highly dependent on rainfall patterns (Deressa et al., 2005). In a similar vein, found that in many developing nations, agricultural yields might drop by 10–20% for every degree Celsius that the temperature rose (Lobell et al., 2011). According to the study, crop productivity has decreased in Nigeria as a result of rising temperatures and erratic rainfall, particularly in the country's northern regions where agriculture is primarily rain-fed (Ajetomobi et al., 2011).

These results emphasize the need for initiatives to lessen the impact of climate change on crop yields and show how vulnerable Nigerian agriculture is to climatic variability. Empirical research has examined how economic and demographic factors, including GDP, population growth, and CO₂ emissions, affect agricultural production in addition to climate variables. According to a study, economic growth has generally improved Nigerian agricultural productivity; however, these gains are frequently outweighed by environmental deterioration, such as rising CO₂ emissions, which lower soil fertility and interfere with irrigation water availability (Nwafor et al., 2010).

Another important element is population expansion, which has been linked to resource depletion and decreased agricultural productivity due to rising demand for food and agricultural land (Ajetomobi et al., 2011). According to a more recent study, which examined the role of CO₂ emissions, increasing emissions have made the effects of climate change on agriculture worse, especially in developing nations with weak adaptation systems (Oladosu et al., 2020). Together, these studies indicate that increasing agricultural resilience in Nigeria and other developing nations requires a multifaceted strategy that takes into account both economic and climate considerations.

2.4. Theoretical Framework

Theoretical frameworks such as Ricardian, Environmental Degradation, and Agricultural Productivity Models provide essential insights into climate-agriculture relationships.

2.5 Ricardian Model

David Ricardo created the Ricardian model of agricultural productivity, which is based on the idea of comparative advantage. This idea holds that a region's climate has a major impact on agricultural output, which in turn dictates the kinds of crops that can be cultivated there. In this sense, climate change modifies the climate, including temperature and precipitation, which impacts crop yields and changes a region's competitive advantage. Using this model to evaluate the effects of climate change on agriculture, discovered that temperature increases above thresholds unique to a certain crop can lower yields, especially in areas where rain-fed agriculture is widely practiced (Mendelsohn et al., 1994).

According to this concept, farmers in climate-friendly areas might switch to more resilient crops or embrace new technology, while farmers in climate-unfriendly areas might see a decline in agricultural output. According to this argument, areas like Nigeria, where a large amount of the agriculture depends on traditional farming practices, are disproportionately impacted by climate change since they have fewer

means to adapt. The Ricardian model aids in the explanation of regional differences in agricultural productivity in Nigeria that result from varying climatic conditions. For instance, because it mostly relies on rain-fed agriculture, northern Nigeria is more susceptible to variations in temperature and precipitation.

Farmers' capacity to adjust is hampered by the region's rising temperatures and changing rainfall patterns, which lowers crop yields and makes them more susceptible to food insecurity. In order to lessen the negative effects of climate change on agricultural productivity, this model highlights the necessity of localized climate adaptation methods, such as the use of irrigation and the creation of crops resistant to drought. Thus, the Ricardian model offers a helpful framework for comprehending how agricultural productivity is affected by climate change, particularly in underdeveloped nations with little ability to adapt.

2.6 Environmental Degradation Theory

The negative impacts of human activity on the environment, especially the release of greenhouse gases (GHGs) like CO₂, and how these alterations impact agricultural output are the main topics of the Environmental Degradation Theory. This theory states that global warming, which modifies Earth's climate systems, is caused by the rising concentration of GHGs in the atmosphere. This has a negative effect on crop yields in agriculture by causing increased temperatures, more extreme weather events, and changed rainfall patterns.

According to the study, the impacts of CO₂ emissions are nonlinear, which means that even slight temperature rises can cause disproportionately huge drops in crop yields (Schlenker and Roberts, 2009). According to this theory, greenhouse gas emissions exacerbate environmental deterioration, which makes it harder for agricultural systems to sustain output levels over time. Given Nigeria's high CO₂ emissions and reliance on agriculture, the Environmental Degradation Theory is especially pertinent to the nation. Deforestation, land degradation, and soil erosion have all been connected to rising CO₂ emissions, which worsen the problems caused by climate change.

Together with rising temperatures, these environmental challenges also make it harder for the agricultural sector to provide the demand for food, particularly in areas where farmers do not have access to climate-resilient farming methods and contemporary agricultural technologies. In order to protect agricultural productivity in Nigeria, this theory emphasizes the necessity of policies that address both climate change and environmental degradation. Examples of such policies include reforestation projects, the promotion of sustainable farming techniques, and the reduction of GHG emissions.

2.7 Agricultural Productivity Models

The elements that affect agricultural output, such as labor, capital, technical advancements, and climatic circumstances, are the subject of agricultural productivity models. In order to lessen the negative effects of climate change on crop yields, these models highlight the importance of technological developments. For example, even in the face of adverse weather circumstances, productivity can be increased by implementing climate-smart agriculture practices, such as the use of crop types resistant to drought, effective irrigation systems, and soil management strategies. Utilizing contemporary farming methods and technologies can mitigate some of the worst effects of climate change, enabling farmers to boost their output and adjust to shifting circumstances (Deressa et al., 2005). According to this hypothesis, if the right technology are used, agricultural systems can withstand climate change.

The Agricultural Productivity Model emphasizes the value of funding agricultural research, infrastructure, and technology in Nigeria in order to increase resistance to climate change. Nigeria has the potential to increase agricultural productivity through the broad use of technologies that improve crop resilience to climate stress, notwithstanding the major obstacles provided by climate variability. The creation of rice and maize cultivars that are resistant to drought, for instance, can lessen the adverse effects of increased temperatures and less rainfall. However, farmers' access to information, financial resources, and government backing are necessary for these technologies to be effective.

Therefore, the Agricultural Productivity Model highlights the critical role of policy interventions in promoting sustainable agricultural practices and technological innovations that can bolster productivity in a changing climate.

3. METHODOLOGY

This study's quantitative technique uses time series data from 1990 to 2023 to evaluate how climate change is affecting Nigeria's agricultural

productivity. GDP, CO₂ emissions, population growth, and agricultural productivity (AGRP) are important factors. Both short-term and long-term dynamics are captured by the study using the Autoregressive Distributed Lag (ARDL) model.

3.1 Research design

This study uses a descriptive and analytical research design, concentrating on the analysis of time series data from 1990 to 2023. The study intends to examine the connections among population increase, economic indicators (GDP), climate-related factors (such temperature and CO₂ emissions), and agricultural productivity (AGRP). In order to capture the long-term impacts of climate change on agricultural outputs, the design incorporates both cross-sectional and time-series data. The study aims to investigate the immediate and long-term effects of these variables on AGRP in Nigeria using econometric models ARDL. This method enables a thorough comprehension of the dynamics at work as well as the discovery of trends and patterns that guide policy suggestions for improving agricultural resilience.

3.2 Source of Data

This study looks at how climate change affects Nigeria's agricultural productivity using time series data from a number of reliable sources. The Nigerian Meteorological Agency (NIMET), which offers data on important climate variables like temperature and precipitation from 1990 to 2023, is one of the main data sources. For evaluating the economic and environmental aspects affecting agricultural output, the Food and Agriculture Organization (FAO) and the World Bank also provide data on GDP, population growth, and CO₂ emissions. Utilizing these several data sources guarantees thorough coverage of the variables being studied, enabling a solid examination of the connection between crop yields and climate change.

3.3 Model Specification

Dependent Variable: AGRP				
Method: ARDL				
Date: 04/11/25 Time: 21:02				
Sample (adjusted): 1991 2023				
luded observations: 33 after adjustments				
Maximum dependent lags: 1 (Automatic selection)				
Model selection method: Akaike info criterion (AIC)				
Dynamic regressors (1 lag, automatic): CO2 GDP POP				
Fixed regressors: C				
Number of models evalulated: 8				
Selected Model: ARDL(1, 1, 0, 0)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.*
AGRP(-1)	0.421934	0.155356	2.715918	0.0114
CO2	-0.100007	0.110960	-0.901283	0.3754
CO2(-1)	0.203876	0.106879	1.907546	0.0671
GDP	-2.20E-06	3.96E-06	-0.554710	0.5837
POP	3.07E-07	1.01E-07	3.048685	0.0051
C	-11.73346	6.016501	-1.950214	0.0616
R-squared	0.972797	Mean dependent var		78.51061
Adjusted R-squared	0.967760	S.D. dependent var		23.11857
S.E. of regression	4.151080	Akaike info criterion		5.847580
Sum squared resid	465.2495	Schwarz criterion		6.119672
Log likelihood	-90.48507	Hannan-Quinn criter.		5.939130
F-statistic	193.1088	Durbin-Watson stat		2.620338
Prob(F-statistic)	0.000000			
Source: Authors' computation, (Eviews 10).				

3.5 Interpretation of Results

The ARDL (1,1,0,0) model's empirical findings provide crucial new information about how Nigeria's agricultural productivity (AGRP) and climate change relate to one another between 1991 and 2023. A high level of persistence in agricultural performance is shown by the positive and statistically significant lagged value of agricultural productivity (AGRP(-1)). This implies that prior productivity levels have a substantial impact

The purpose of this study's model specification is to evaluate how Nigeria's agricultural productivity (AGRP) is affected by economic and demographic factors such as GDP, CO₂ emissions, and population growth between 1990 and 2023. AGRP, the dependent variable, serves as a stand-in for actual agricultural output. Population growth (as an annual percentage change), CO₂ emissions (in metric tons), and GDP (measured in constant prices) are the main explanatory factors.

The model's general form can be described as follows:

$$AGRP_t = \alpha + \beta_1 GDP_t + \beta_2 CO_2 + \beta_3 POPULATION_t + \varepsilon_t$$

Where:

AGRP_t = represents Agriculture productivity at time (t)

GDP_t, CO_{2t}, and POPULATION_t are the explanatory variables at time (t).

α = constant term

ε_t = error term

This model is estimated using multiple regression analysis to establish the relationship between AGRP and the explanatory variables. Additionally, the ARDL model will be employed to capture both short-term and long-term effects of these variables on agricultural output.

3.4 Empirical Analysis

The impact of GDP, CO₂ emissions, and population increase on agricultural productivity (AGRP) in Nigeria between 1990 and 2023 is evaluated empirically using multiple regression and ARDL models. After that, both short-term and long-term dynamics are investigated using the ARDL model, with robustness checks and diagnostic tests guaranteeing reliable results.

on current outputs, indicating the sector's structural stability. The current period's CO₂ emissions have a negative but statistically negligible effect on agricultural production, suggesting that while rising emissions may be dangerous for the environment, they may not instantly have a discernible effect on crop yields. Nonetheless, there is a positive and marginally significant effect of the lagged CO₂ emissions (CO₂(-1)), which may indicate a delayed fertilization effect.

or adaptation responses that improve productivity over time.

GDP, used as a proxy for economic growth, shows a negative and statistically insignificant relationship with agricultural productivity. This implies that increases in GDP do not necessarily translate into improvements in the agricultural sector, possibly due to limited reinvestment in agriculture or sectoral imbalances. In contrast, population growth (POP) has a positive and highly significant effect on agricultural productivity, indicating that demographic expansion may contribute positively to agricultural output, possibly through increased labor force participation or market-driven production incentives.

With an R-squared value of 0.9728, the model demonstrates good explanatory power, meaning that the variables included account for more than 97% of the variation in agricultural productivity. The trustworthiness of the model estimates is increased by the Durbin-Watson statistic of 2.62, which indicates the lack of autocorrelation. All things considered, the results highlight how dynamic and complex the relationship between climate change and agriculture is, and how important it is for policy responses to take into account both environmental and demographic factors in order to improve agricultural resilience.

4. SUMMARY OF KEY FINDINGS

With an emphasis on the roles of CO₂ emissions, GDP, and population growth as explanatory factors, this study examines the effects of climate change on agricultural productivity (AGRP) in Nigeria between 1991 and 2023. The goal is to comprehend how these variables affect agricultural output variations, especially when considering climate variability. The Autoregressive Distributed Lag (ARDL) model is used in the empirical study to look at the correlations between these variables over the short and long terms. The significant positive coefficient for AGRP(-1) indicates a strong persistence in agricultural productivity. This implies that current levels of productivity are significantly influenced by agricultural output from the preceding year.

To put it another way, past performance has a significant impact on current production, which is consistent with the hypothesis that agricultural systems are impacted by historical trends and often exhibit inertia. The model suggests that CO₂ emissions do not have a major direct impact on agricultural output in the short term, as it shows a negative but negligible short-term effect of present CO₂ levels on AGRP. The impact of CO₂ emissions on productivity, however, may be delayed, as evidenced by the positive and marginally significant relationship between AGRP and the lagged value of CO₂ emissions (CO₂(-1)).

This raises the prospect of a delayed benefit, maybe as a result of fertilization effects brought on by CO₂, whereby higher CO₂ levels may eventually increase crop yields, even though this relationship is not immediately evident.

Given that GDP's coefficient is negative and not statistically significant, its influence on agricultural output seems to be negligible. This implies that short-term increases in agricultural production are not always a direct result of economic expansion as indicated by GDP. This result might be a reflection of the gap between overall economic expansion and the particular difficulties that the agriculture industry faces, like poor infrastructure, a lack of technical innovation, and a lack of funding for agricultural R&D.

AGRP, however, is positively and statistically significantly impacted by population expansion (POP). According to the coefficient, a growing population raises agricultural productivity, most likely as a result of an expanding labor force and rising food demand. Because of this positive association, it is possible that the expanding population will boost agricultural productivity by increasing market demand or by giving farmers additional labor.

The constant term in the model is negative and marginally significant, suggesting that, even after accounting for the other variables, there are underlying challenges that negatively impact agricultural productivity. These challenges could include environmental degradation, poor soil quality, inadequate infrastructure, and climate-related stresses that persist over time and undermine agricultural output.

The model's fit is very strong, with an R-squared value of 0.9728, meaning that the model explains approximately 97.28% of the variation in agricultural productivity. This indicates that the combination of the variables included in the model provides a robust explanation for the fluctuations in AGRP. The F-statistic further confirms the statistical significance of the model, and the Durbin-Watson statistic of 2.62 indicates that there is no significant autocorrelation in the residuals, supporting the validity of the regression results.

The F-statistic further confirms the statistical significance of the model, and the Durbin-Watson statistic of 2.62 indicates that there is no significant autocorrelation in the residuals, supporting the validity of the regression results.

Overall, the findings suggest that agricultural productivity in Nigeria is influenced by a combination of factors, including the persistence of past productivity levels, demographic changes, and environmental factors. While economic growth, as measured by GDP, does not significantly affect AGRP in the short term, population growth emerges as a key driver of agricultural output. The study also underscores the importance of addressing environmental issues, such as CO₂ emissions, and the need for integrated policy interventions to enhance the resilience of the agricultural sector. In light of these findings, policies that focus on sustainable agricultural practices, climate adaptation strategies, and population management could be crucial in ensuring long-term agricultural productivity and food security in Nigeria, especially in the face of climate change.

5. CONCLUSION AND RECOMMENDATION

Taking into account the contributions of CO₂ emissions, GDP, and population growth, this study examines the relationship between climate change and agricultural productivity (AGRP) in Nigeria between 1991 and 2023. The empirical results demonstrate how agricultural production is very persistent, with previous outputs influencing present levels. Although CO₂ emissions had no effect on AGRP in the short term, their delayed effects suggest a possible long-term advantage, maybe due to CO₂-induced fertilization effects. Contrarily, population growth is essential for increasing agricultural output, most likely as a result of growing work force size and increased food demand.

Nonetheless, the short-term effect of GDP on AGRP is minimal, indicating the necessity of more targeted investments in the agriculture industry. The study comes to the conclusion that a complex interaction of demographic, economic, and environmental factors affects agricultural output in Nigeria. Population pressure makes matters worse by raising the need for food and land use, while climate change, as manifested in environmental degradation and CO₂ emissions, has led to variations in agricultural productivity. The results emphasize the necessity of integrated policy initiatives that take a comprehensive approach to addressing these variables. To improve the resilience of agriculture,

The adoption of drought-resistant crops and effective water management strategies are examples of climate-smart agriculture practices that must be prioritized. Furthermore, because population increase has a beneficial impact on agricultural output, policy should focus on giving workers the skills and knowledge they need to satisfy the growing demands of agriculture. Furthermore, it is crucial to focus economic growth on investments in infrastructure, technology, and agriculture, even though GDP growth by itself does not immediately increase agricultural productivity. Policies for climate adaptation and mitigation, including studies on the long-term effects of CO₂ emissions and climate change, should also be given top priority.

By adopting these strategies, Nigeria can ensure a resilient and sustainable agricultural sector that supports food security and economic stability in the face of climate challenges.

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