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Rainfall Variability and Its Effects on the Yield of Rice in Benue South, Nigeria

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Abstract: *Rice is in high demand now as a result of population growth and its importance as sources of energy and other minerals. However, the effect of rainfall variability on yield is a factor to consider by rice farmers in other to have a bumper harvest. The study examined rainfall variability and its effects on the yield of rice in Benue South, Nigeria. Total annual rainfall and yield data for rice in Benue south (1988-2022) was sourced from the office of Nigerian Meteorological station, Lagos and used to characterise the rainfall pattern and to show the relationship between rainfall and rice yield. The Pearson's product moment correlation coefficient (r) was used to show the relationship between rainfall and the yield of rice. The result showed positive and significant relationship between rainfall and years. Rainfall amount is shown to be affected by years with a coefficient of 0.34, showing a moderate positive correlation. Similarly, yield of rice shows a negative significant relationship implying that there is reduction in yield of rice with increase in years (-0.63). Amount of rainfall and rice yield do not show any significant relationship. Based on the findings, the study recommended the adoption of viable adaptation strategies such as irrigation farming, use of improved seed varieties and use of organic and inorganic fertilizer to boost the yield of rice.*

Key words: farmers, rainfall, relationship, rice, yield

INTRODUCTION

Rainfall variability is the fluctuations of rainfall occurrence annually or seasonally above or below a long-term normal value. It is the degree to which rainfall amounts vary across an area or through time. Agriculture which is one of the major areas of socio-economic as well as National Gross Domestic Product (GDP) in most countries in Africa is more vulnerable to rainfall variability. Every year, the rainfall of a location can be different in a specific period, either above or below normal (IPCC, 2014). Rainfall values in last decade reduced drastically and affected crop yields across Nigeria (Iornongo, 2021).

Rice is in high demand now as a result of population growth and its importance as sources of energy and required minerals. However, growth and yield of rice, on the other hand, are all factors to consider by rice farmers in other to have a bumper harvest. Rice yields are insufficient to meet the country's significant population growth, resulting in food shortages (Edu and Oluka, 2022). According to Ogah (2013), decreased rice output is linked to availability of water and pest infestation. Rice productivity is influenced by the environment, biotic and abiotic factors (Edu et al. 2021). No wonder, in the study of Yang et al. (2017), rice yield can be improved through irrigation, fertilization, use of improved varieties, disease and insect controls. Lack of technology and agricultural innovation for rice production is one of the reasons that restrict rice production in some developing nations like Nigeria (Okeke and Oluka 2017).

Rice (Oryza sativa L.) is one of the major cereal crops worldwide and is the staple food for millions of people in Nigeria. It is consumed across all geopolitical zones and socioeconomic classes. Rice is grown under a range of agroclimatic conditions. Rice production has increased significantly in Nigeria in recent years, with the country now one of the largest producers and consumers of rice in Africa (Bin et al. 2023). However, there are still challenges in the production of rice in Nigeria, including climate variability, and environmental stresses (Jonah et al. 2023).

Rice needs a significant amount of water, estimated to be around 500 to 600 mm (Odeniyi et al. 2020). Upland rice grows well where 5 days total rainfall is more than 20 mm from sowing to 15 days before harvesting (about 90 days). Rice needs an optimal temperature for effective growth between 22°C and 31°C and requires 5 to 6 hours of sunshine per day (Odeniyi et al. 2020). Rainfall variability is arguably one of the most important challenges facing African countries, largely due to their geographic exposure, greater reliance on climate-sensitive sectors such as agriculture, and weak capacity to adapt to the changing climate (Bin et al. 2023).

Nigerian agriculture depends profoundly on climate since rainfall is a principal driver of crop yield and growth (Webber, 2017). Rainfall variability and pattern has significantly affected global agriculture in several ways, ranging from direct effects on crop yield. Benue State is proudly referred to as the ‘food basket of the nation’ since the rich nutrients deposits of alluvial soils that support bumper harvest have helped farmers in producing crops on large scale. However, with the climate change and rainfall pattern, rainfall has become a critical issue in recent years. Therefore, rainfall variability and its attendant weather events have become what farmers will have to cope with, since it is fast becoming unpredictable to give accurate account of crop yields on farms (Akinkunmi, 2020).

Although, there have been several studies on rice in Nigeria (Oyewole et al. 2010; Salleh et al., 2022; Abubakar and Daji, 2022) there is a gap in the knowledge of the relationship between rainfall variability and rice yield in Benue South, Nigeria. This study was conducted to enable farmers identify, appreciate, and understand the effect of rainfall variability on the yield of rice and possibly recommend the resilient measures to the vagaries of rainfall.

This study will address the following research questions:

i. What are the rainfall characteristics of the study area?
ii. What is the effect of rainfall variability on the yield of rice in the area?
iii. What are the adaptation measures to be recommended in rice production in the area?

METHODOLOGY

Study Area

The study was conducted in Benue South region of the state (Fig. 1) which is made up of 9 Local Government Areas of which three Local Governments (Ador, Agatu, Apa, Obi, Oju, Ogbadibo, Ohimini, Okpokwu, and Otukpo) (Agboola et al. 2024). The area has a Tropical Savanna Climate. The rainy season starts in late March and ends in early November. It sees the most precipitation is September, with an average rainfall of 209 mm; and the least precipitation in November, with an average rainfall of 2 mm. The rainy period of the year lasts for 8 months, from March 19 to October, with a sliding 31-day rainfall of at least 0.5 inches. Most of the people are farmers while the inhabitants of the riverine areas engage in fishing as their primary or important secondary occupation.

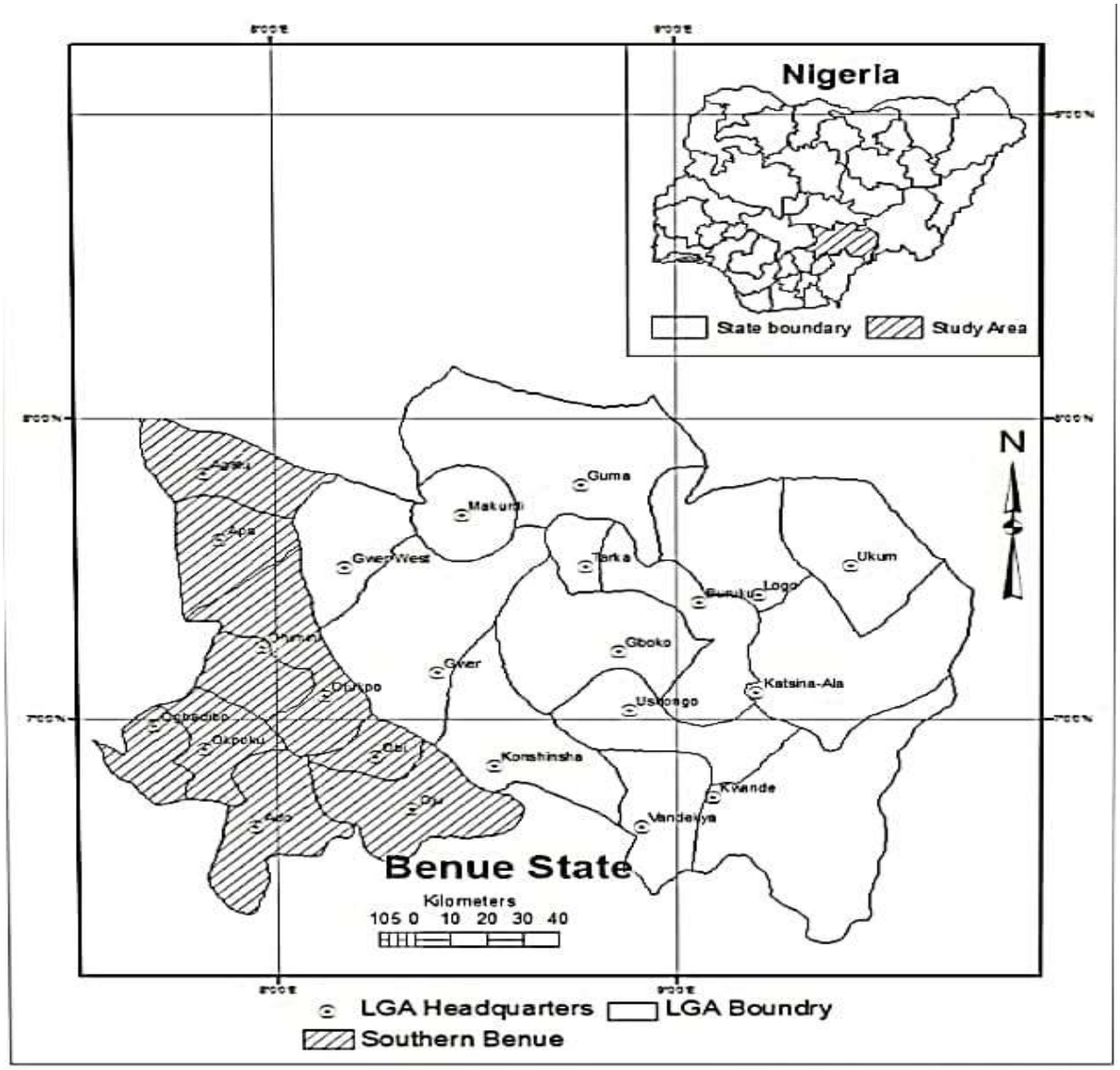

Figure 1: Map of Benue State showing the southern part of the State

Annual Rainfall Trends in the Study Area

The trend in rainfall distribution (1980 – 2022) is presented in Figure 2. The results (y = 7.3207x + 1084.5) suggests that annual rainfall is increasing over time. For every year that passes, rainfall increases by about 7.32 units. The starting point in 1980 is around 1084.5 units. This indicates a steady rise in rainfall over the 42-year period.

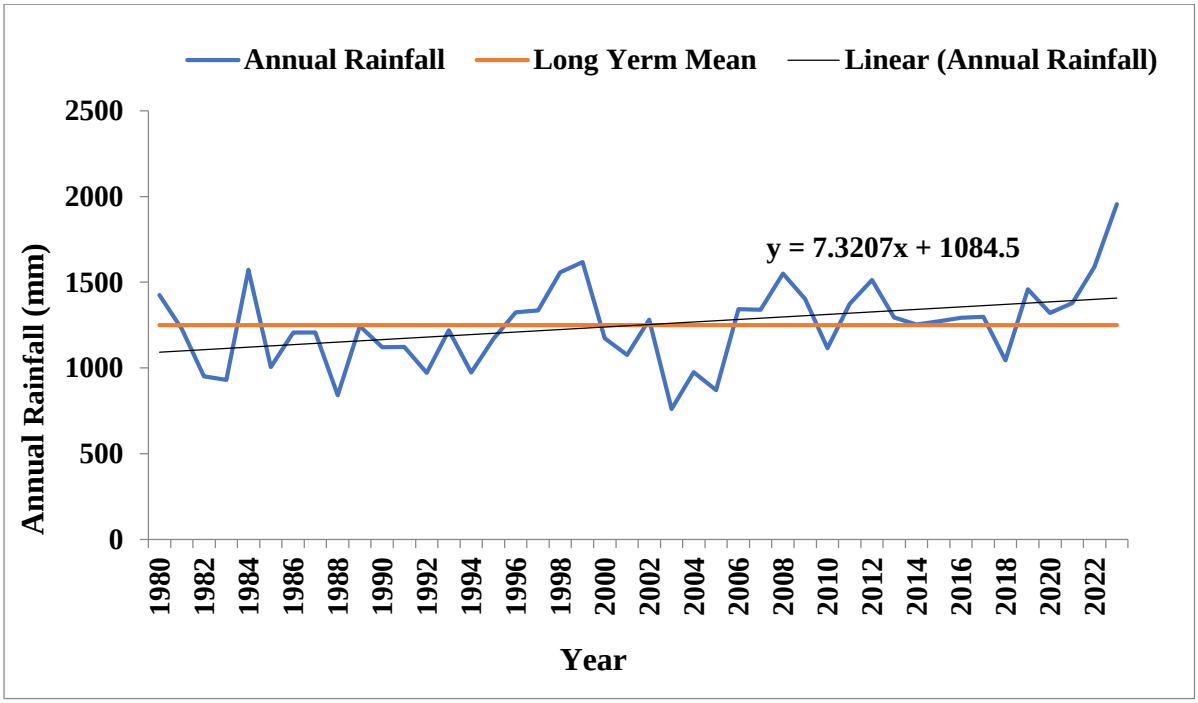

Figure 2: Rainfall data of the Study Area (1980 – 2022)

Analyzing rainfall data in the area between 1980-2022 reveals a complex pattern with fluctuations in annual rainfall totals, number of rainy days, length of growing seasons, onset dates, and cessation dates. Studies indicate a variation and fluctuating tendency in rainfall characteristics over time and space, with anomalies tilted towards a negative pattern.

Key Findings:

i. Rainfall Trend: Research suggests an increasing trend in rainfall amounts in Benue State, aligning with findings from similar regions. A study by Shaibu et al. (2022) showed a variation in rainfall characteristics, while Adamgbe and Ujoh (2013) reported an increase in rainfall amounts in Gboko Local Government Area of Benue State.

ii. Impact on Crop Production: The variability in rainfall characteristics has implications for crop production, including rice. A study by Ikpe and Omede (2025) found that rainfall variability affects maize and rice yields in north-central Nigeria.

iii. Rice Production Trend: Local rice production in Benue State showed an instantaneous growth trend of 0.00122 and a compound growth rate of 3.72% between 1980 and 2016, with a mean quantity of 257,333.06 metric tons per year (Idoma et al., 2017).

Implications for Rice Production:

i. Adaptation Strategies: Farmers may need to adopt viable adaptation strategies like irrigation farming, use of improved seed varieties, and organic/inorganic fertilizers to boost rice yield.
ii. Water Resource Management: Effective water resource management is crucial to mitigate the impacts of rainfall variability on rice production.
iii. Climate Change: Understanding the trends and implications of climate change is essential for developing strategies to improve rice productivity and ensure food security.

The analysis of annual rainfall trends in the study area reveals a complex but overall increasing trend. This has significant implications for water resource management, agricultural planning, and climate change adaptation. Further research could focus on understanding the drivers of these trends and developing strategies to mitigate potential negative impacts and capitalize on opportunities presented by the changing rainfall patterns.

Relationship between Rainfall and Yield Data for Rice in Benue South

The relationship between years, rainfall amount and yield of rice in Benue South is presented in Table 1. The result showed positive and significant relationship between rainfall and year. Rainfall amount is shown to be affected by years with a coefficient of 0.34, showing a moderate positive correlation. Similarly, yield of rice shows a negative significant relationship implying that there is reduction in yield of rice with increase in years (-0.63). Amount of rainfall and rice yield do not show any significant relationship.

Table 1: Rainfall and Yield Data for Rice in Benue South (1988-2022)

Variables	Years	Rainfall (MM)	Rice yield (MT)
Years	1.00		
Rainfall (MM)	0.34*	1.00	
Rice yield (MT)	-0.63**	-0.24^{NS}	1.00

*: Correlation is significant at the 0.05 level (5 %).
**: Correlation is significant at the 0.01 level (1 %).
NS: Not significant correlation at 0.05 level

Correlation Coefficients

Years and Rainfall: The correlation coefficient between Years and Rainfall is 0.34*, indicating a moderate positive relationship between the two variables. This suggests that over the years, there has been a tendency for rainfall to increase. The asterisk (*) typically denotes statistical significance at a certain level (often $p < 0.05$), implying that this relationship is unlikely to be due to chance.

That there is no significant relationship between total rainfall amount and the yield of rice agree with the findings of Tiamiyu et al. (2015) which stated that the effect of rainfall variability on the national rice yield in Nigeria was not statistically significant during the period of study, but had adverse effect

on the yield of rice in the Sudan savanna. The adverse effect, though insignificant during the period of study, is a warning signal to rice stakeholders to take some precautionary measure against unfavourable effects of rain variability on rice yield. The result further agrees with the findings of Agidi (2017) in Nasarawa State where the trend analysis showed a decreasing trend on rice yield in relation to annual rainfall amount.

Years and Rice Yield: The correlation coefficient between years and rice yield is -0.63*, indicating a strong negative relationship. This suggests that over the years, rice yield has been decreasing significantly. The double asterisk (*) often denotes a higher level of statistical significance (often $p < 0.01$), underscoring the robustness of this finding.

Rainfall and Rice Yield: The correlation coefficient between rainfall and rice yield is -0.24NS, indicating a weak negative relationship that is not statistically significant (denoted by NS). This suggests that the direct impact of rainfall on rice yield is not strong or consistent enough to be statistically significant in this analysis.

Interpretations

1. Impact of Time on Rainfall and Rice Yield:
   The positive correlation between years and rainfall suggests a trend of increasing rainfall over time. However, the moderate nature of this correlation indicates that while there is a tendency towards more rainfall, the relationship is not overwhelmingly strong. The strong negative correlation between years and rice yield is concerning, as it indicates a significant decline in rice yield over the years. This trend could be influenced by various factors, including changes in climate, soil degradation, pest and disease pressures, or other agricultural challenges.

2. Impact of Rainfall on Rice Yield:
   The weak and non-significant correlation between rainfall and rice yield suggests that rainfall alone may not be a dominant factor in determining rice yield in this context. This could imply that other factors, such as soil quality, irrigation practices, crop management, or pest and disease management, play more critical roles in influencing rice yield.

Implications

Agricultural Practices: The decline in rice yield over the years, despite a potential increase in rainfall, suggests that other environmental or management factors are adversely affecting rice production. This might necessitate a review of current agricultural practices, such as the use of fertilizers, pest control measures, or irrigation management. The trends observed could be indicative of broader climate change impacts. Increasing rainfall might be beneficial in some contexts but could also lead to issues like waterlogging or increased pest and disease pressure, which might explain the decline in rice yield.

The results highlight a concerning trend of declining rice yield over the years, which is not strongly linked to rainfall patterns. Understanding the underlying causes of this decline is crucial for developing strategies to improve rice productivity and ensure food security. Given the complexity of factors influencing agricultural productivity, a multidisciplinary approach to research and intervention is likely to be most effective.

CONCLUSION

The study assessed rainfall variability and its effects on rice yield in Benue South, Nigeria, from 1988 to 2021. Key findings include: rainfall showed an increasing trend over the years with fluctuations (0.34); rice yield significantly declined over the years and no significant relationship was found between rainfall amount and rice yield (-0.63). The study suggests that the decline in rice yield might be influenced by factors beyond rainfall, such as soil degradation, pest and disease pressures, or inadequate agricultural practices.

Recommendation

The study suggests that the decline in rice yield might be influenced by factors beyond rainfall, such as soil degradation, pest and disease pressures, or inadequate agricultural practices. To improve rice productivity and ensure food security, the study recommends:

i. Early-Maturing Crop Varieties: Planting early-maturing rice varieties can help farmers adapt to variability in rainfall characteristics, especially the length of growing seasons.
ii. Soil and Water Management: Training on soil and water management in rice production is essential for averting the adverse effects of rainfall variability on rice yield.
iii. Policy Interventions: Policies focusing on increasing the growth rate of local rice production in Benue State should be intensified, and breeders should develop rice varieties with desirable traits like aroma

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