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EFFECT OF CLIMATE CHANGE ON THE YIELD OF MAIZE IN SELECTED LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA

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Abstract
This study investigated the impact of climate change on maize yield in selected Local Government Areas (LGAs) of Benue State, Nigeria. Historical rainfall and temperature data were obtained from the archives of the Nigerian Meteorological Station in Abuja, while maize yield records were sourced from the Benue State Agricultural and Rural Development Agency (BNARDA). A total of 43 years (1980–2022) of data were analyzed to assess the relationship between climatic variables and maize yield trends, using trend line equations to illustrate patterns over time. A multistage sampling technique was employed to select six LGAs, and Krejcie and Morgan's formula guided the determination of a sample size of 780 purposively selected farmers. Data collection tools included a self-designed Crop Farmers' Perception Questionnaire (CFPQ) and a Crop Farmers' Perception Interview Guide (CFPIG). The reliability of these instruments was confirmed using the Cronbach Alpha coefficient, yielding values of 0.76 and 0.82, respectively. The results indicated a significant upward trend in rainfall and temperature over the study period, which has positively influenced maize cultivation in the area. The study concluded that climate change, particularly variations in rainfall and temperature, has contributed to improved maize yields in Benue State. It recommends that government bodies and non-governmental organizations support maize production by encouraging farmers to leverage the favorable climatic conditions, while also enhancing access to credit facilities such as loans, grants, and subsidies to facilitate the adoption of climate adaptation strategies and strengthen agricultural resilience.
Key Words: Climate change, Maize yield, Rainfall and temperature, Farmers' perception, Climate resilience

INTRODUCTION

Climate change is one of the most pressing global challenges of our time, posing enormous risks to socioeconomic development and disregarding political boundaries. It threatens food security and sustainable development by impacting agricultural systems, and the Intergovernmental Panel on Climate Change (IPCC, 2022) has found that it has already caused unprecedented challenges worldwide. The IPCC's reports affirm the seriousness of this challenge, emphasizing the need for enhanced mitigation and adaptation actions to address the worsening climate impacts. These impacts will be more damaging in the future, severely compromising agricultural production and food security, and potentially rendering marginal agricultural regions unproductive, affecting ecosystems, economies, and human health worldwide (IPCC, 2021).

Increasing weather and climate extremes have exposed millions to acute food insecurity and reduced water security, with devastating impacts in Africa and worldwide. Climate change will intensify pressure on food production systems, undermining food security (GreenFacts, 2022). Africa, highly vulnerable to climate change and variability, will see agriculture impacted by rising temperatures, altered growing seasons, and extreme weather events, leading to harvest disruptions, drought, flooding, water scarcity, disease spread, and heat stress. While Nigerian agriculture may benefit from increased harvests and new crop cultivation in the short term, the changing climate poses significant long-term risks, emphasizing the need for agriculture to adapt to ensure sustainable food production. Climate change has significantly impacted food supply for the growing population, altering climatic characteristics and leading to a decline in crops cultivated in northern Nigeria (Odjugo, 2010). Consequently, production of major crops like rice, maize, soybeans, and yams has declined over the past few decades, despite increasing population (Adamgbe and Ujoh, 2013). This exacerbates hunger and food

insecurity, relying heavily on food aid nationally and domestically. To address climate change's negative impacts on Nigerian agriculture, particularly crop production in the Guinea savanna region, drastic increases in productivity of staple crops like yam, rice, soybeans, and maize are necessary. These crops are crucial in Benue State and northern Nigeria, constituting the largest annual crop volume (Iornongo, 2021). However, their yields have declined, especially in Benue State, highlighting the need for adaptation strategies to unlock the state's crop production potential (Terseer et al., 2019).

Nigeria's food production, particularly in Benue State, has failed to keep pace with its rapid population growth. To address this disparity, successive governments have implemented policies and programmes aimed at boosting agricultural productivity and efficiency (Boko and Iheanacho, 2021). However, Benue State's crop farmers continue to face challenges such as crop failures, reduced productivity, hunger, and droughts. As the mainstay of the state's economy, employing over 80% of the population, agriculture plays a vital role in sustaining human existence and improving the quality of life (Enokela and Seini, 2013). This underscores the need to investigate the effects of climate change on crop yields in Benue State.

Awoji et al. (2023) found that rainfall variability in Benue State is generally trending upward, which presents a valuable opportunity for extensive afforestation and reforestation efforts. This is particularly important in the southern and north-eastern regions of the state, where deforestation poses a significant environmental challenge. To sustain agricultural productivity in the face of these changes, continuous cultivation of root crops, tubers, and cereals—identified as the most suitable for the region—is necessary. Climate change has a profound impact on agriculture, directly influencing crop yields and further complicating the efforts of both national and state governments to boost agricultural production in response to the growing population, all while striving to meet environmental sustainability standards. Moreover, the increasing frequency of extreme weather events is expected to worsen the negative effects on crop yields (CEC, 2009).

In Benue State, changes in climatic conditions have already begun to significantly affect crop production, with maize yields particularly impacted (Iornongo, 2021). Against this backdrop, the present research investigates the impact of climate change on maize yield in Benue State, Nigeria. The study seeks to examine the prevailing climatic characteristics of the region and to explore the relationship between climate change and maize yield, measured in tons per hectare. Through this, the research aims to address existing knowledge gaps and offer practical recommendations to mitigate the adverse effects of climate change on maize production in the state.

MATERIALS AND METHODS

Study Area

Benue State, created on February 3, 1976, is situated in the lower River Benue trough within Nigeria's middle belt region and is renowned as the "Food Basket of Nigeria." The state lies between Latitudes 6°25'59"N and 8°8'06"N and Longitudes 7°30'14"E and 10°00'53"E, covering 34,059 square kilometers kilometres (Terdoo et al., 2016; National Bureau of Statistics, 2018). Benue State shares boundaries with five states and the Republic of Cameroon, with a vegetation characteristic of the southern Guinea Savanna biome (Hula, 2010; Nigerian Investment Promotion Commission [NIPC], 2020).

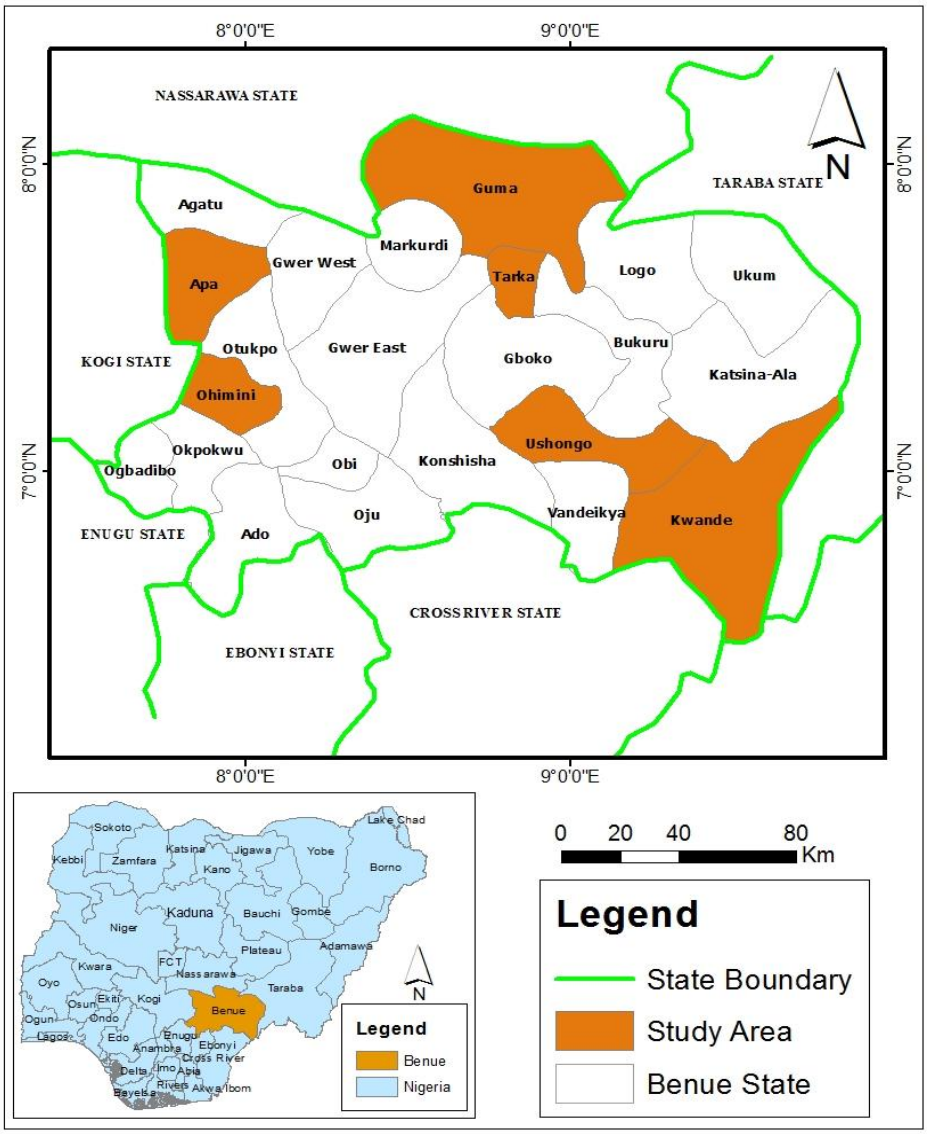

Fig. 1: Benue State (Study Area)
Source; GIS Lab Department of Geography, A.B.U. Zaria.

According to the Köppen climatic classification, Benue State falls within the AW climate, characterized by two distinct seasons: the wet season and the dry season. The state typically experiences 8-10 months of rainfall (Hula, 2010), with the rainy season spanning from April to October and annual rainfall ranging from 1000-2000 mm. The dry season begins in November and ends in March. Temperatures fluctuate between 21°C and 37°C throughout the year. However, the south-eastern part of the state, adjacent to the Obudu-Cameroun Mountain range, has a cooler climate, similar to that of Plateau State (Ologunorisa and Tersoo, 2006). Notably, temperatures within Makurdi, the state headquarters, are consistently high, averaging between 28°C and 32°C, and sometimes reaching up to 37°C (Hula, 2010).

The state's dominant geographical feature is the River Benue, with numerous tributaries, including the Katsina-Ala River. Benue State has a population of approximately 6,096,869 (2006 Population Census) with the Tiv, Idoma, and Igede peoples being the predominant ethnic groups. Agriculture is the backbone of the state's economy, engaging over 70% of the population, with major cash crops including soybeans, rice, and peanuts, and food crops like yam, cassava, and maize (Terdoo et al. 2016).

Methods

This study employed a quantitative research approach, collecting primary data through structured questionnaires administered in the study area. A multistage sampling technique was utilized to select six (6) LGAs (Kwande, Ushongo, Guma, Tarka, Apa and Ohimini). Specifically, the 23 Local Government Areas (LGAs) of the state were alphabetized and systematically sampled, with every second ward selected for inclusion. The sample size was determined using Krejcie and Morgan's (1970) sample size determination formula, which recommends a sample size of 783 for a population ranging from 500,000 to 10,000,000, at a 95% confidence level and a 3.5% margin of error. A 3.5% margin of error was chosen to minimize errors, as smaller sample sizes typically yield larger margins of error.

Primary and secondary data were used, including structured questionnaires, Focus Group Discussion (FGD), rainfall, temperature, and yield data. The instruments used for data collection were the self-structured Crop Farmers' Perception Questionnaire (CFPQ) and the interview guide titled Crop Farmers' Perception Interview Guide (CFPIG). Six multiple FGDs were designed for the six selected LGAs, each comprising eight experienced crop farmers and two extension workers. These participants were selected by the Heads of farmers from each LGA to explore pertinent issues affecting crop production in the area.

The 2006 census figures were projected to 2023 using Newman's (2001) population projection method. The projection of sampled localities' population was based on the Benue State population growth rate of 3%. The formula used was:

$$Pn = Po + ((1+R)/100 \times Po) \times n \quad \text{---------- (1)}$$

Where:

Pn = Population in the recent year;
Po = Population in the base year;
R = annual growth rate;
n = number of intermediary years.

The Relative Importance Index Technique (RII) was used to determine the relative importance of various adaptation strategies to climate change in the study area. The RII formula used was:

$$RII = \Sigma W / (A \times N) \quad \text{---------- (2)}$$

Where:

W = Weight given to each factor by the respondents;
A = Highest weight (i.e., 3 in this case);
N = Total number of respondents.

The three-point scale ranged from 1 (Not at all) to 3 (Always). The higher the value of RII, the more important or effective was the adaptation strategy to climate change in the study area.

RESULTS AND DISCUSSION

The socio-demographic characteristics of the farmers in the selected LGAs were identified, analyzed and presented in Table 1. The demographic characteristics of the respondents provide valuable insights into their backgrounds and potential influences on their responses. The majority of respondents are male (586, 75%), while females constitute a smaller proportion (194, 25%). This imbalance may impact the generalizability of the findings, particularly if there are significant gender differences in the variables being studied. The age distribution of respondents is skewed towards the middle-aged group, with 50% (389) falling within the 30-40 years range (Table 1). The 41-50 years age group constitutes 27% (213) of respondents, followed by 15% (114) in the 51-60 years range. The oldest age groups (>61 years) make up a smaller proportion of respondents, with 7% (56) in the 61-70 years range and 1% (8) above 71 years. This age distribution may influence respondents' perspectives, experiences, and attitudes, particularly if age-related factors are relevant to the research topic. Christianity is the dominant religion among respondents, with 93% (724) identifying as Christians (Table 1). Islam and traditional beliefs make up smaller proportions, with 4% (30) and 3% (26) of respondents, respectively. This religious distribution may impact respondents' values, beliefs, and practices, particularly if the research topic is sensitive to religious influences.

Table 1: Socio-demographic Characteristics of the Farmers

Parameters	Options	Respondents(N=780)	Percentages
Sex	Male	586	75
	Female	194	25
Age	30 – 40 years	389	50
	41 – 50 years	213	27
	51 – 60 years	114	15
	61 – 70 years	56	7
	>71	8	1
Religious Belief	Christianity	724	93
	Islam	30	4
	Traditional	26	3
Marital Status	Single	315	40
	Married	401	51
	Widowed	64	8
Level of Education	Primary	289	37
	Secondary	301	39
	Tertiary	180	23
	Others	10	1
Respondents' years of residency in the study area	20 – 30 years	564	72
	31 – 40 years	189	24
	>41 years	27	3

Source: Field Survey, 2024

The majority of respondents are married (401, 51%), followed by singles (315, 40%). Widowed individuals constitute a smaller proportion of respondents (64, 8%) (Table 1). Marital status may influence respondents' experiences, attitudes, and perspectives, particularly if family-related factors are relevant to the research topic. The level of education among respondents is relatively balanced, with 37% (289) having primary education, 39% (301) having secondary education, and 23% (180) having tertiary education (Table 1). A small proportion of respondents (10, 1%) have no formal education. Education level may impact respondents' knowledge, attitudes, and practices, particularly if the research topic requires specific educational background or knowledge. The majority of respondents (72%, 564) have lived in the study area for 20-30 years, indicating a relatively stable and long-term resident population. Smaller proportions of respondents have lived in the area for 31-40 years (24%, 189) or more than 41 years (3%, 27). Length of residency may influence respondents' familiarity with the area, their social networks, and their experiences with local services or issues.

Climatic Characteristics of the Study Area

The temperature and rainfall data of the study area for 43 years (1980-2022) were used to describe climate of the area. The temperature results (Figure 2) show an increase in the maximum temperature of the study area ($y = 0.083x + 32.304$). The slope indicates that for every one-unit increase in the independent variable (x), the dependent variable (y, maximum temperature) increases by 0.083 units. This suggests a positive linear relationship between x and y. The results show a decrease in the minimum temperature of the area ($y=0.0755x+23.5$).

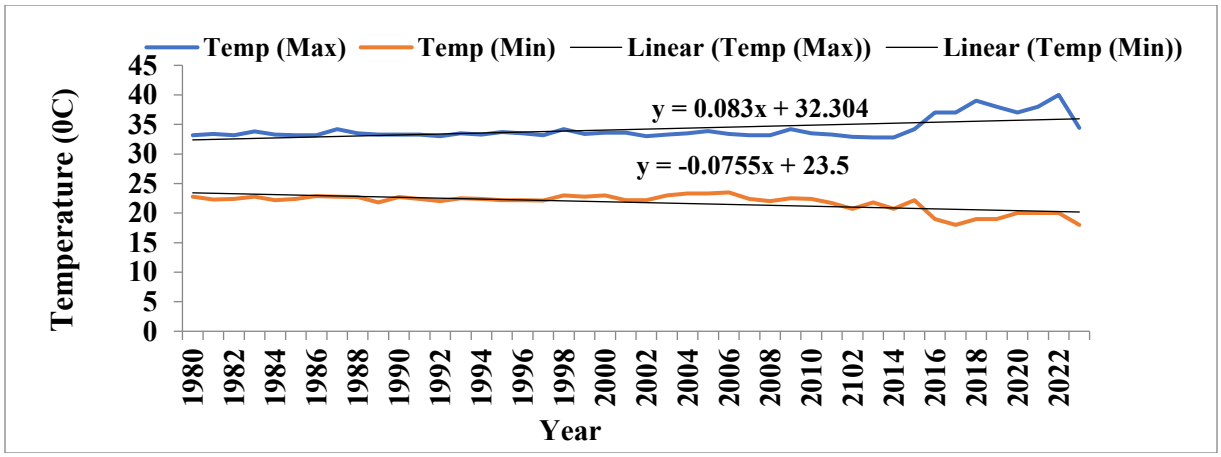

Figure 2: Minimum and Maximum Temperature of the Study Area (1980–2022).
Source: Field Survey, 2024

The rainfall data were analysed to characterize the rainfall pattern of the study area. The results are presented in Figure 3. The linear regression equation (*y=7.3207x + 1084.5*) indicates that for every one-unit increase in x, the rainfall data (y) increases by approximately 7.3207 units. Since the slope is positive, it suggests that the rainfall data is increasing over time or with respect to the independent variable (x). This result aligns with the findings of Adamgbe and Ujoh (2013), who reported an increase in rainfall amounts in Gboko LGA of Benue State. Similarly, Akinola et al. (2019) found that farmers in Benue State perceived an increasing trend in annual rainfall, while observed variability showed an increasing trend in all rainfall variables.

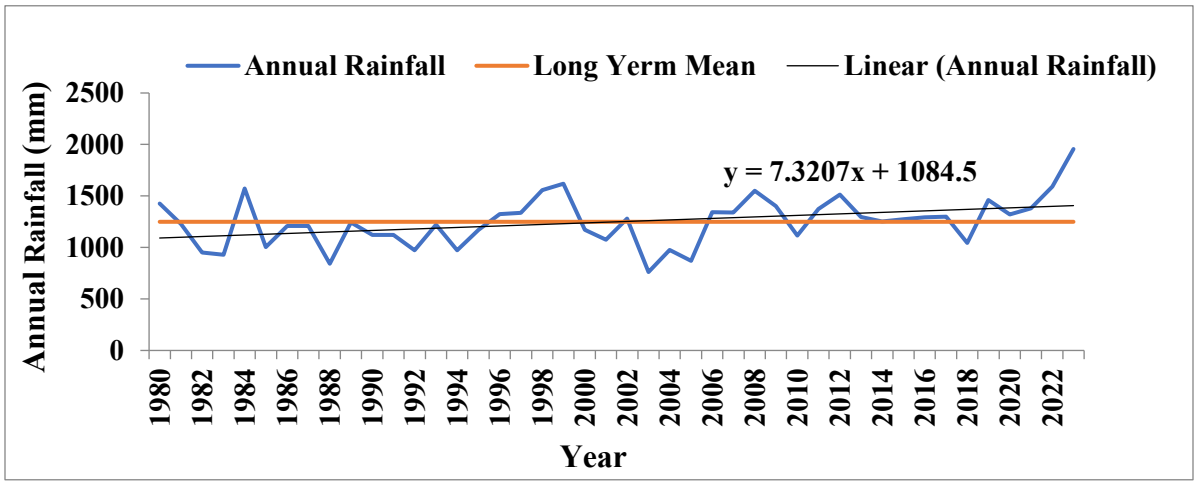

Figure 3: Rainfall data of the Study Area (1980 – 2022)
Source: Field Survey, 2024

The yield data for maize in Benue State is presented in Figure 4. The linear regression equation (y = 0.0538x + 1.6738) describes the relationship between the maize yield data (y) and the year (x). The slope indicates that for every one-year increase, the maize yield (y) increases by approximately 0.0538 units. Since the slope is positive, it suggests that the maize yield has been increasing over time. Based on this equation, it appears that the maize yield has been increasing at a rate of approximately 0.0538 units per year. This implies that the rainfall amount and pattern in the area supports maize yield.

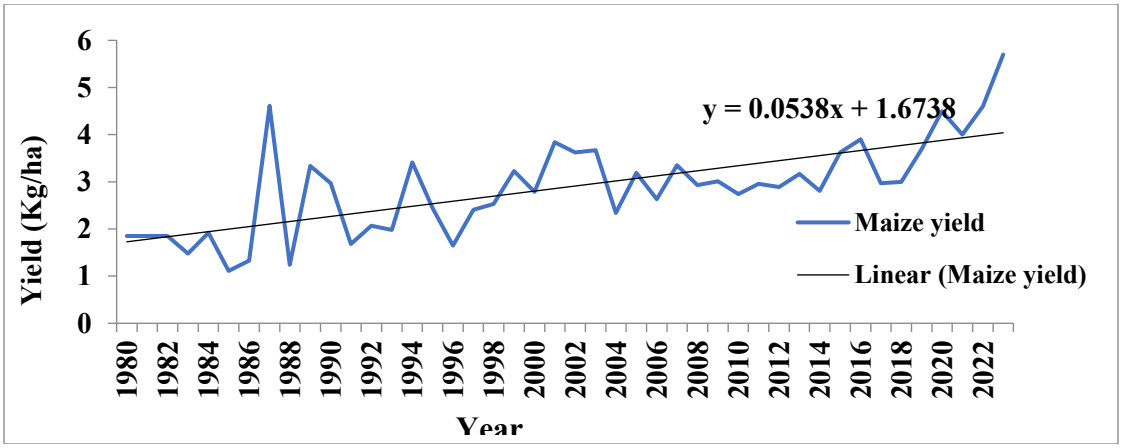

Figure 4: Maize Yield in the Study Area (1980–2022)
Source: Field Survey, 2024

Over the 43-year period (1980-2022), the maize yield increased by approximately 2.26 units (42 years *0.0538 units/year). This suggests that maize yields have been improving over time, possibly due to factors such as: advances in agricultural technology and practices; improved crop varieties and hybrids; increased use of fertilizers and pesticides; better irrigation and water management practices. This result agrees with the findings of Isaac and Ikpe (2024) which reported that maize yield is increasing in Kaduna State as a result of increase in rainfall and the adoption of viable adaptation strategies.

The farmers' perception of the relationship between rainfall and the maize yield in the area

Summary of the findings from the FGDs conducted on the farmers revealed that the maize farmers perceived increase in rainfall over the years which has positively affected the yield of maize. Beside the favourable rainfall and temperature pattern, the farmers stated that, farmers in the area adopts viable adaptation strategies such as the use of organic and inorganic manure, improved seed varieties, and mixed cropping

CONCLUSION

This study investigated the effect of climate change on maize yield in selected LGA of Benue State, Nigeria. The findings reveal a significant increase in rainfall and temperature in the study area over the past four decades (1980-2022). The rainfall and temperature trends support maize cultivation, as evidenced by the increasing yield in the study area. The farmers' perceptions on the positive impact of rainfall and temperature on the yield of maize aligns with the analyzed weather data. The study therefore concluded that climate change positively supports maize yield in the study area.

Recommendations:

Based on the findings of the study, the following recommendations are made:

1. Since the climate of the area supports the yield of maize, the farmers should be encouraged by the government at all levels and Non-governmental Organizations to cultivate more maize taking advantage of the favourable climate.
2. Improve access to credit: Enhance access to loans, grants, and subsidies to help farmers adopt more adaptation strategies and improve their resilience.

By adopting these recommendations, farmers in the study area can improve on their productivity, enhance maize yields, and contribute to food security in Benue State, Nigeria.

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