

RELATIONSHIP BETWEEN RAINFAL VARIABILITY AND YIELD OF CASSAVA AND FARMERS' ADAPTATION STRATEGIES IN OTUKPO LOCAL GOVERNMENT AREA OF BENUE STATE, NIGERIA

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Abstract

This study investigated the relationship between rainfall variability and cassava yield, as well as farmers' adaptation strategies in Otukpo Local Government Area of Benue State, Nigeria. Annual rainfall and cassava yield data (1988-2021) were obtained from the Nigerian Meteorological station in Lagos to analyze rainfall patterns and relationships with cassava yield. A sample of 384 farmers was selected using Krejcie and Morgan's sample size determination method. Self-structured questionnaire titled Cassava Farmers Perception Questionnaire (CFPQ) and Key Informant Interview guide: Cassava Farmers Perception Interview Guide (CFPIG) were used to gather information. The Pearson product-moment correlation coefficient (r) was employed to analyze the relationship between rainfall variability and cassava yield. Likert-scale analysis was conducted using mean distribution. The results revealed an increase in total annual rainfall and cassava yield. A positive and significant relationship was found between the parameters. Rainfall amount showed a moderate positive correlation with years ($r = 0.34$). Similarly, cassava yield exhibited a strong positive correlation with years ($r = 0.71$). Rainfall amount and cassava yield demonstrated a moderate, significant positive relationship ($r = 0.38$), indicating that increased rainfall significantly boosts cassava yield at a moderate rate. The most effective adaptation strategies employed by farmers included using early-maturing crop varieties, pest- and disease-resistant varieties, and mixed cropping. Based on the findings, this study recommends that government agencies, farmers' cooperative societies, and farm extension agents should consistently promote the adoption of more cultivars and early-maturing seeds to enhance crop production and ensure food security.

Keywords: Adaptation strategies; Cassava; Farmers; Rainfall; Relationship, Yield

Background to the Study

Rainfall variability has emerged as a pressing concern due to its far-reaching impacts on natural and human systems. According to Labiru (2016), the areas most affected by rainfall variability include agriculture, fisheries, hydrology, and forestry. Despite recent technological advancements, weather and climate remain crucial determinants of agricultural production. Rainfall, in particular, is a leading climatic factor influencing crop productivity (Ikpe, 2021).

The increasing variability of rainfall is a growing concern, especially in rain-fed agricultural regions worldwide. The erratic distribution, pattern, and seasonality of rainfall pose significant threats to agricultural production, resulting in declining yields and high variability in annual crop production

(Ariko et al., 2024). This unpredictability underscores the need for adaptive strategies to mitigate the impacts of rainfall variability on agricultural productivity.

Rainfall variability refers to the degree of variation in rainfall amounts across a region or over time. It encompasses fluctuations in rainfall occurrence above or below the long-term average value, either annually or seasonally (Intergovernmental Panel on Climate Change [IPCC], 2022). Notably, Nigeria experienced a drastic decline in rainfall over the last decade, significantly impacting crop yields (Iornongo, 2021). This poses a substantial threat to food security in developing nations, including Nigeria, due to the climate-dependent nature of agricultural systems and the lack of effective Smart Climate Agricultural Practices (Opeyemi et al., 2021).

Agriculture, a vital sector contributing to the socio-economic development and National Gross Domestic Product (GDP) in many African countries, is highly vulnerable to rainfall variability (Iornongo, 2021). Adaptation plays a crucial role in reducing exposure and vulnerability to climate change in natural systems. In ecological systems, adaptation involves autonomous adjustments through ecological and evolutionary processes. In human systems, adaptation can be anticipatory, reactive, incremental, or transformational (Ikpe, 2021).

Adaptation strategies involve identifying and evaluating options to adapt to climate change, considering factors such as availability, benefits, costs, effectiveness, efficiency, and feasibility (GreenFact, 2022). Effective adaptation strategies are essential for mitigating the impacts of rainfall variability on agricultural productivity and ensuring food security. Ajayi and Opeyemi (2018) noted that cassava farmers have adopted various strategies to cope with the adverse effects of rainfall variability. One such strategy involves leveraging agricultural technologies that enhance cassava post-harvest activities, thereby promoting resilience and sustainability in the face of climate uncertainty.

Cassava (*Manihot esculenta* Crantz), a member of the Euphorbiaceae family (Alicai et al., 2019), is a versatile and drought-resistant crop. Originating from South America, cassava was domesticated between 5,000 and 7,000 years ago (Malik et al., 2020). Introduced to Africa by the Portuguese in the 18th century, cassava is now widely cultivated and consumed in Africa, Asia, and South America (Fonseca and Vergara, 2014).

Cassava's adaptability stems from its ability to thrive in various soil types, except hydromorphic soils, and its flexibility in harvesting time and seasons (Adelekan, 2012). The plant grows up to 5 meters tall, producing 5-8 tubers with firm, fibrous flesh. Cassava is an energy-rich food source, with over 70% carbohydrate content, making it the fourth most significant energy source (Jekayinfa and Olajide, 2016). The leaves are rich in protein (35%) and micronutrients, making them a nutritious vegetable in some cultures. Cassava plays a vital role in food security, particularly in famine-prone areas, due to its long storage ability in the ground (Kamanda et al., 2020). The root can be processed into various food products for human consumption, animal feed, and industrial applications, such as paper, textiles, and alcoholic beverages (Brito et al., 2017).

Cassava is a vital food crop in Benue State, providing sustenance and income for the local population. As one of Nigeria's leading cassava-producing states, Benue experienced significant growth in cassava production in 2021. This surge can be attributed to several factors, including favorable climatic conditions, increased cassava prices, and high demand for its by-products from manufacturing industries (National Agricultural Extension and Research Liaison Services [NAERLS], 2021).

Benue State is renowned as the 'food basket of the nation' due to its rich alluvial soils, which support large-scale crop production. However, climate change and rainfall variability have become critical issues in recent years. Unpredictable rainfall patterns have made it challenging for farmers to accurately forecast crop yields (Opeyemi et al., 2021). The erratic onset, cessation, and length of the growing season can negatively impact farmers who rely on rainfall for their agricultural activities (Agidi, 2017).

In Benue State, rainfall variability significantly affects rain-fed agriculture, which many residents depend on (Iornongo, 2021). While previous studies have focused on exploiting seasonal rainfall for agricultural purposes (Yamusa et al., 2013), the seasonal distribution of rainfall and its impact on crop productivity require further investigation.

This study therefore intends to address the following research questions;

- i. What is the rainfall trend between 1988 – 2021 in the area?
- ii. What is the trend in the yield of cassava in the area?
- iii. What is the relationship between rainfall variability and cassava yield in the area?
- iv. What are the adaptation strategies adopted by the farmers?

This study aims to bridge the knowledge gap by examining the relationship between rainfall variability and cassava yields in Otukpo Local Government Area (LGA) of Benue State. The need for this information underscores the research problem, and this study seeks to address this gap. The aim of the study was achieved through the following set objectives which were, to:

- i. Characterise the rainfall pattern of the study area between 1988 - 2021;
- ii. Show the trend of cassava yield in the area;
- iii. Determine the relationship between rainfall variability and the yield of cassava in the area;
- iv. Identify the adaptation strategies used by the farmers.

Methodology

Study Area

Otukpo Local Government Area (LGA) is situated in the Middle-Belt region of Nigeria, within the coordinates of Latitude 6° 25' and 8° 8' North and Longitude 7° 47' and 10° East (Figure 1). The LGA shares borders with Apa LGA to the north, Obi, Ado, and Okpokwu LGAs to the south, Gwer West and Gwer East LGAs to the east, and Ohimini and Ankpa LGAs of Kogi State to the west. Otukpo LGA encompasses a land area of 390 square kilometers, with a population of 190,457, according to the 2006 National Population Census (Abah et al., 2016).

The terrain is generally low-lying and gently undulating, featuring inselbergs, lateritic mesas, buttes, knolls, and low ridges. The soils are deeply weathered, reddish-brown, and developed on sedimentary rocks. Although easy to cultivate, these soils are prone to excessive internal drainage and leaching, necessitating plants to draw water from the subsoil to compensate (Nyagba, 1995).

Otukpo LGA experiences a tropical climate, characterized by an average annual temperature of 27.2 °C. The average temperature ranges from 25.5 °C in August (the lowest) to 29.3 °C in March (the highest). Annual precipitation totals approximately 1723 mm, with September being the wettest month (282 mm) and December the driest (9 mm) (Climate-data, 2013).

Agriculture is the primary occupation of the majority of the population. Commonly cultivated crops include yams, cassava, rice, and benni-seed. The local markets operate on a periodic basis, with intervals of at least 5 days between market days (Abah et al., 2016).

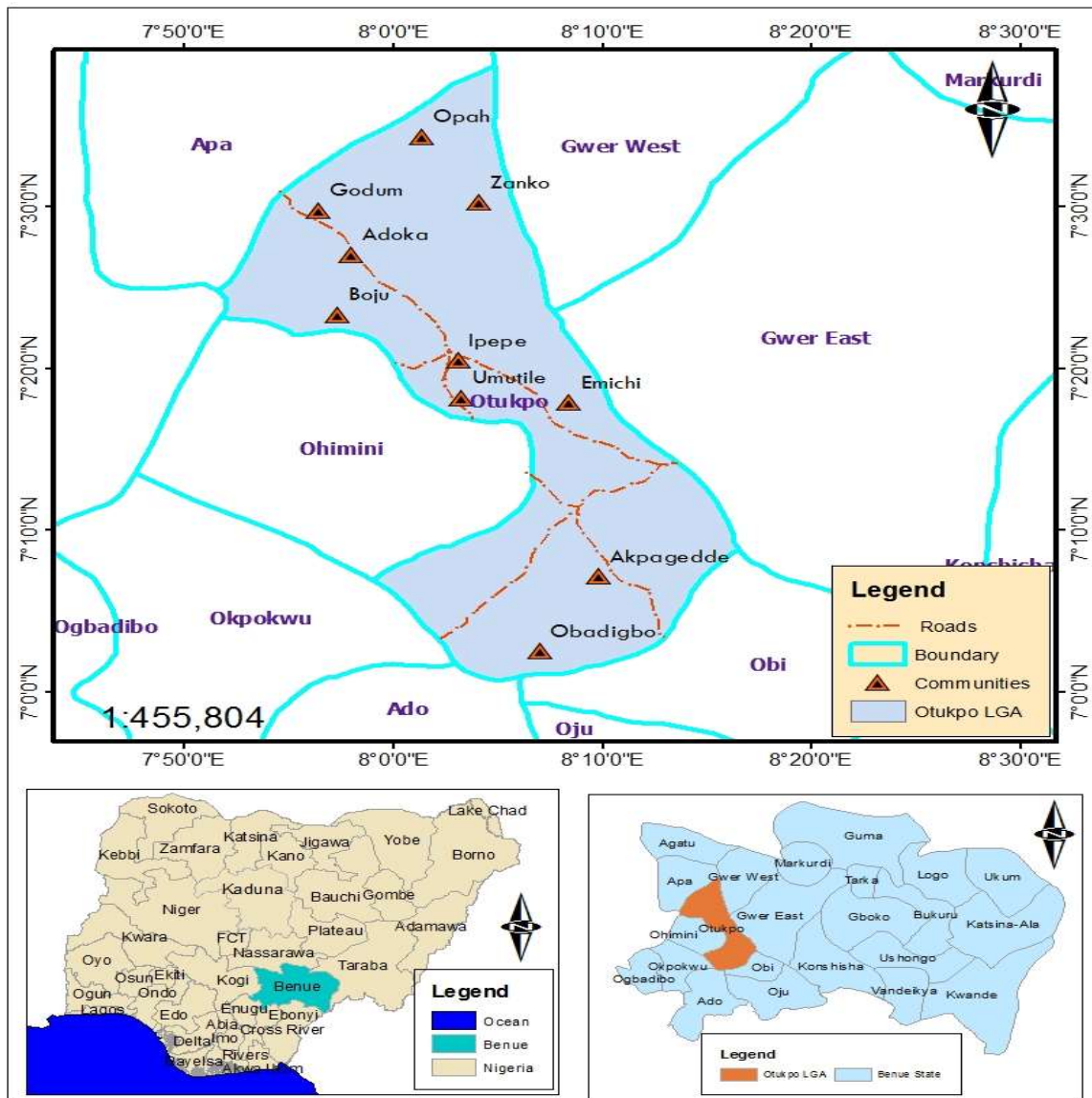


Figure:1. The study area

Source: GIS and Remote Sensing Software, Department of Geography ABU, Zaria

Methodology

A multi-stage sampling technique was employed to select 384 cassava farmers from the study area, using Krejcie and Morgan's (1970) method for determining sample size. A self-structured questionnaire, Cassava Farmers Perception Questionnaire (CFPQ), and a Key Informant Interview guide, Cassava Farmers Perception Interview Guide (CFPIG), were used to gather information on farmers' perceptions of rainfall variability, its impact on cassava yield, and their adaptation strategies.

Thirty-three years (1988-2021) of rainfall and cassava yield data were obtained for the study. The limited data availability prior to 1988 constrained the analysis to this period. Rainfall data were sourced from the Nigerian Meteorological station, Oshodi, Lagos, while cassava yield data were collected from the Benue State Agricultural and Rural Development Agency (BNARDA).

The rainfall and cassava yield data were used to characterize the response of cassava yield to rainfall patterns. A trend-line equation was used to illustrate rainfall trends, while Pearson's Correlation Coefficient (r) was employed to determine the relationship between rainfall and cassava yield. A Likert-scale questionnaire was used to collect data from farmers, which were analyzed using mean distribution. The results were presented in charts and tables.

Results and Discussion

Socio-economic characteristics of the respondents

The socio-economic characteristics of the respondents captured in this study were: sex, age, marital status, educational attainment, religion and number of children of the respondents.

Table 1: Distribution of respondents according to their socio-demographic variables

Variable	Frequency (N=384)	Percentage
Sex		
Males	207	53.9
Females	177	46.1
Age (Years)		
35 above	197	51.3
26-34	151	39.3
25 below	36	9.4
Marital Status		
Married	207	53.9
Single	152	39.6
Divorced/Separated	25	6.5
Educational Attainment		
Tertiary	45	11.7
Secondary	154	40.1
primary and below	185	48.2
Religion		
Christianity	298	77.6
Islam	5	1.3
Traditional	81	21.1
Number of Children		
1-3	103	26.8
4-6	199	51.8
7 and above	82	21.4

Source: Field Survey, 2023

Table 1 presents the socio-economic characteristics of respondents. The results show that:

Sex Distribution: 54% (207) of respondents were males, while 46% (177) were females, indicating a slightly higher participation of males in cassava farming.

Age Distribution: 51% (197) of respondents were 35 years and above, 39.6% (152) were between 26-34 years, and 6.5% (25) were 25 years and below, revealing that most cassava farmers were middle-aged and older.

Marital Status: 53.3% (202) of respondents were married, 40.1% (152) were single, and 6.6% (25) were divorced/separated, showing a higher participation of married individuals in cassava farming.

Educational Attainment: 48.2% (185) of respondents had primary education, 40.1% (154) had secondary education, and 11.7% (45) had tertiary education, indicating a high illiteracy rate in the study area.

Religious Distribution: 77.6% (298) of respondents were Christians, 1.3% (5) were Muslims, and 21.1% (81) practiced traditional religions, revealing Christianity as the dominant religion in the study area.

Family Size: 26.8% (103) of respondents had 1-3 children, 51.8% (199) had 4-6 children, and 21.4% (82) had 7 children or more, indicating that most respondents had moderate-sized families.

These socio-economic characteristics provide valuable insights into the demographics of cassava farmers in the study area.

Rainfall trend of the study area

Trend in the Total Annual Rainfall (TAR) of the study area for the period of study is presented in Figure 2.

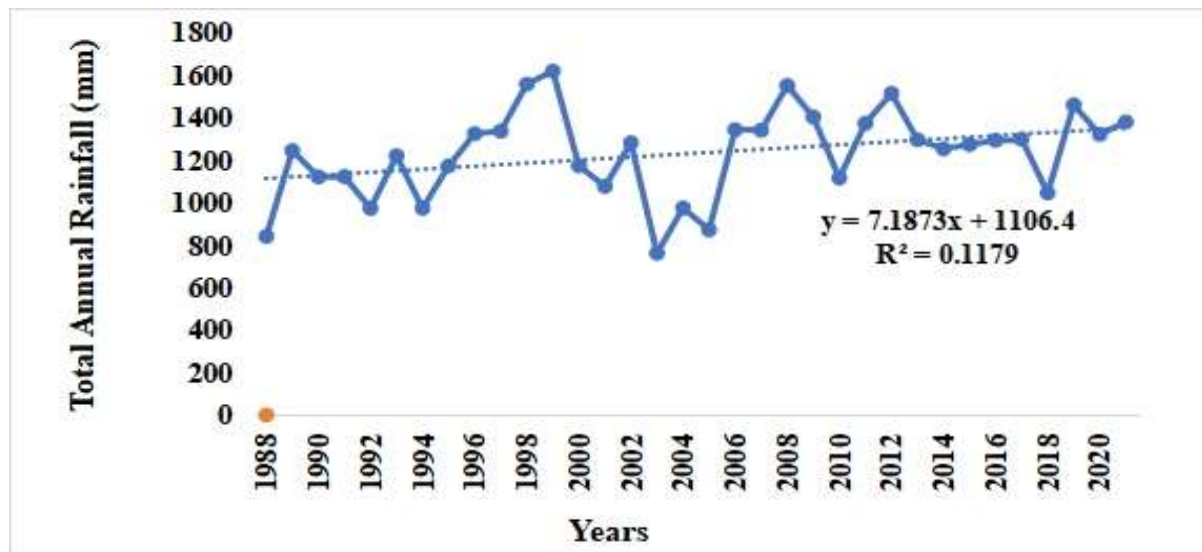


Figure 2: Trend in Total Annual Rainfall (1988 – 2021)

The trendline analysis of the Total Annual Rainfall (TAR) for the 33-year period reveals a fluctuating pattern, indicating rainfall variability. Despite this variability, the best-fit trendline

shows a positive equation ($y = 7.1873x + 1106.4$), suggesting an overall increase in TAR. The trendline's oscillations represent the variability of rainfall, with 2003 recording the lowest TAR (761 mm) and 1999 experiencing the highest amount of rainfall (1618 mm).

These findings align with previous studies, such as Adamgbe and Ujoh (2013), which reported an increase in rainfall amount in Gboko LGA of Benue State. Similarly, Iornongo (2021) found that farmers in Benue State perceived an increasing trend in annual rainfall, while observed variability showed an increasing trend in all rainfall variables.

Rainfall plays a crucial role in determining crop yields, particularly in tropical environments (Ayoade, 2004). As the most variable climatic element, rainfall determines the growing season in developing countries like Nigeria, where agriculture is predominantly rain-fed. Accurate and timely weather forecasting is essential for improving farming activities (Ikpe et al., 2016).

While adequate rainfall is essential for crop growth, its irregularity can significantly impact yields if rains fail to coincide with critical growing stages (Iornongo, 2021). Water availability is the most critical climatic factor influencing the pattern and productivity of rain-fed agriculture in Nigeria (Ayoade, 2004). Rainfall distribution also plays a significant role in determining the geographical location of specific crops (Ariko et al., 2024).

Cassava yield trend in the study area

Figure 3 indicates an increasing trend in cassava yield in the study area with the trend-line equation $y = 4.5408x + 257.61$. The highest yield was recorded in 2021 (428.6 tons/ha), the lowest yield was recorded in 1989 (211.3 tons/ha).

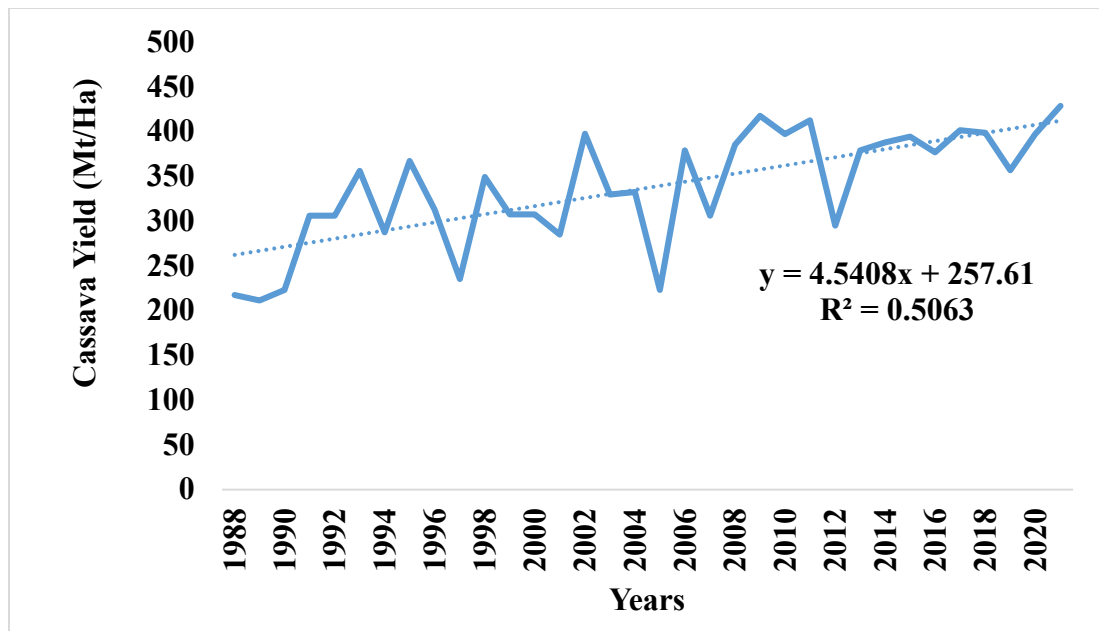


Figure 3: Trend in the yield of Cassava (1988 – 2021)

Correlational trend chart for rainfall (mm) and cassava yield (mt)

The correlational trend chart for rainfall and cassava yield are presented in Figure 4. The results show that rainfall amount influences the yield of cassava in the area. The results show that as rainfall increases or decreases, it pulls or push the yield of cassava.

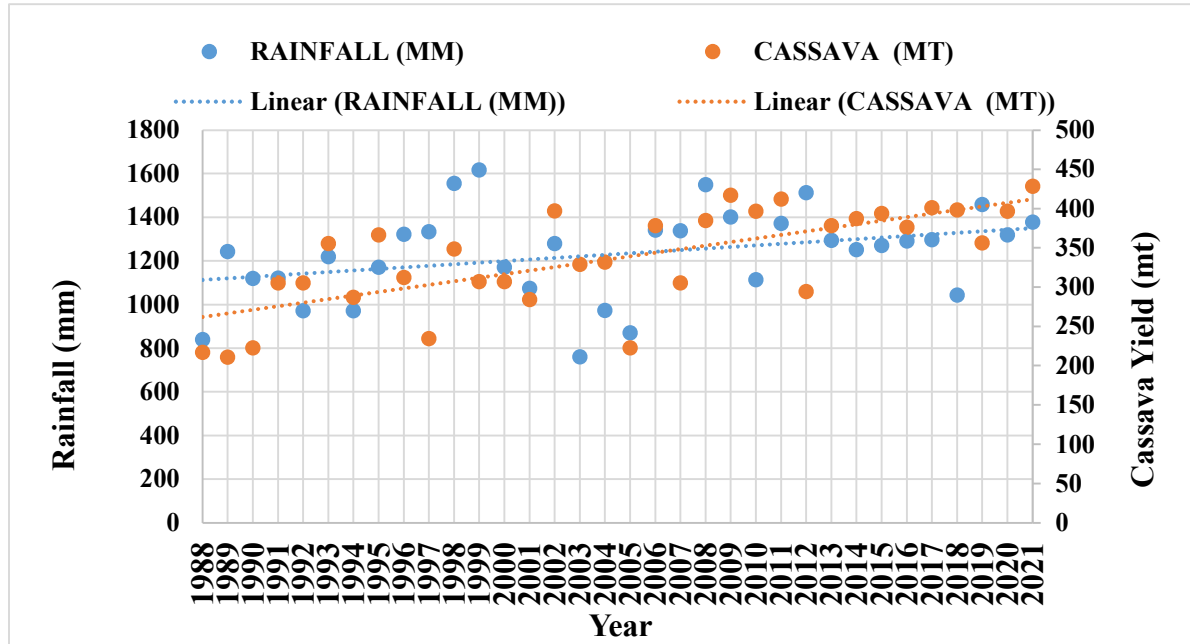


Figure 4: Interactive trend chart for rainfall (mm) and cassava yield (mt)

The analysis of correlation between rainfall and cassava in Otukpo LGA of Benue State (1988 – 2021) is presented in Table 2.

Correlation between Rainfall and Cassava in the study area

Table 2 presents the relationship between years, rainfall amount, and cassava yield in Benue State. The results reveal positive and significant relationships among the parameters.

Specifically, rainfall amount exhibits a moderate positive correlation with years, with a coefficient of 0.34. Cassava yield demonstrates a strong positive correlation with years, with a coefficient of 0.71. Rainfall amount and cassava yield display a positive moderate significant relationship, with a coefficient of 0.38. Rainfall variability could be responsible for the low coefficient between rainfall and cassava yield. These findings indicate that increased rainfall in the study area significantly enhances cassava yield at a moderate rate.

Table 2: Rainfall and Yield Data for Cassava (1988-2021)

Variables	Years	Rainfall (mm)	Cassava yield (mt)
Years	1.00		
Rainfall (MM)	0.34*	1.00	
Cassava yield (MT)	0.71**	0.38*	1.00

*: Correlation is significant at the 0.05 level (5 %).

** : Correlation is significant at the 0.01 level (1 %).

According to NAERLS (2009), Benue State is one of Nigeria's leading cassava producers. Cassava is not only a staple food crop but also has various industrial applications. Its cultivation has expanded into the country's drier regions, thanks to the introduction of drought-resistant, early-maturing varieties.

Farmers' perceived adaptation strategies on cassava farming

To mitigate the adverse effects of climate change, various adaptation strategies can be employed. Effective adaptation measures can minimize the impacts of climate change, reducing exposure to damage risks, enhancing coping capacity, and capitalizing on new opportunities (IPCC, 2014). Proactive adaptation strategies complement mitigation efforts, particularly in agriculture, where adapting to changing climate patterns is crucial (Ikpe, 2014).

Effective adaptation enables responsive measures to climate change impacts, emphasizing the importance of strategic planning. The results of cassava farmers' perceived adaptation strategies are presented in Table 3.

Table 3: Farmers' Perceived Strategies on Cassava farming

Variables	Mean ($\bar{X}$)
1. Early planting	4.5
2. Mixed cropping	4.6
3. Use of herbicide, insecticide etc.	4.2
4. Increase in number of weeding	4.1
5. Use of pest and disease resistant varieties	4.6
6. Use of early maturing crop varieties	4.7
7. Preservation of seedlings for planting	3.7
8. Use of recommended planting distance	3.8
9. Changing harvesting dates	4.1

*Average Mean ≥ 3.0

Field Survey 2023

Table 3 presents nine indigenous and emerging strategies employed by farmers in the study area to adapt to climate change. The results show that farmers utilize various adaptation strategies, including: the use of early planting as a strategy of adapting to rainfall variability in the area (4.5 $\bar{X}$); 4.6 $\bar{X}$ uses mixed cropping; 4.2 $\bar{X}$ uses herbicide, insecticides and other relevant chemicals. Other adaptation strategies are increase in number of weeding (4.1 $\bar{X}$), use of pest and disease resistant varieties (4.6 $\bar{X}$); use of early maturing crop varieties (4.7 $\bar{X}$); preservation of seedlings for planting (3.7 $\bar{X}$); use of recommended planting distance (3.8 $\bar{X}$) and changing harvesting dates (4.1 $\bar{X}$). These findings align with Kemi and Olusegun (2020), who noted that cassava farmers are forced to modify their planting and harvesting schedules to accommodate the increasingly unpredictable weather patterns. Ikpe (2021) also identified the use of early-maturing crop varieties, mixed cropping, and pest- and disease-resistant varieties as effective adaptive strategies

employed by farmers to mitigate the impacts of rainfall variability. Moreover, mixed cropping has been reported (Ikpe, 2014) to be a farmer-friendly approach, enabling farmers to plant multiple crops simultaneously and harvest them, thereby enhancing food security.

Given the devastating impacts of rainfall variability on cassava production and food security, bolstering farmers' resilience is crucial for enhancing productivity and food security. To address the threats posed by variability, farmers and governments must perceive and respond to its effects (Ariko et al., 2024). Adopting effective adaptation strategies is vital to mitigate the adverse effects of rainfall variability on crop yields, ensuring soil sustainability and optimal productivity (National Agricultural Extension Liaison Service [NAERLS], 2009).

Conclusion

This study examined the relationship between rainfall variability and cassava yield, as well as farmers' adaptation strategies in Otukpo Local Government Area (LGA) of Benue State, Nigeria. The results revealed a positive correlation between Total Annual Rainfall (TAR) and cassava yield, indicating that increased rainfall in the area leads to higher cassava yields. Farmers in the study area employ various adaptation strategies to cope with climate change. These strategies include early planting, using early-maturing varieties, and planting according to recommended spacing, among others.

Recommendations

To enhance cassava production and resilience, the following recommendations are made:

- i. Agricultural research institutes should provide farmers with access to improved seed varieties and viable seedlings, building on the existing adoption of improved stem and early-maturity varieties among farmers.
- ii. The Nigerian Meteorological Agency (NiMET) should enhance its seasonal forecasting services, providing farmers with accurate and timely information on onset and cessation dates of the rainy season, length of the rainy season, and annual number of rain days. Farmers should be encouraged to utilize these forecasts to inform their crop production decisions.

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