



**ECONOMIC EFFECTS OF CLIMATE CHANGE IN RICE PRODUCTION IN
SHANDAM LOCAL GOVERNMENT AREA OF PLATEAU STATE, NIGERIA**

¹Usman, A., ²Bappa, A. A. and ³Sidi, A. F.

¹Department of Agricultural Engineering Technology, Federal Polytechnic N'yak Shendam, Plateau State, Nigeria

²Department of Agricultural technology, Yobe State University Damaturu

³Department of Agricultural technology, college of Agriculture Bauchi State

Correspondence Email: abunabil201018@gmail.com

GSM: +2348051940820

ABSTRACT

The study analysed the economic effects of climate change on rice production in Shendam LGA of Plateau State, Nigeria. Multi-Stage sampling techniques was applied to select 150 rice farmers with 8 years of consistence rice production for the study. Historic climatic data (rainfall and temperature) for the period extending from 2020 to 2024 were collected from Nigerian Meteorological Agency, also rice production data obtained from the respondents. Data were analyzed quantitatively and qualitatively using both descriptive and inferential statistics. The result further reveals that, temperature values show moderate fluctuations, with a noticeable decline around 2021–2022, followed by a slight increase in 2023 and mixed conditions in 2024. The result shows a fluctuating rainfall pattern with a noticeable dip in 2022, followed by a steady increase from 2023 to 2024 across all three indicators (minimum, average, and maximum rainfall). The regression results show a strong explanatory power, with an R^2 value of 0.851, indicating that 85.1% of the variation in rice yield was explained by the independent variables included in the model. The results indicate considerable inter-annual variation in yield losses. Market prices of rice show a consistent upward trend over the study period, increasing from ₦350 in 2020 to ₦700 in 2024. The study concluded that climate variability poses significant risks to rice production in Shendam Local Government Area (LGA) of Plateau State through erratic rainfall, increased frequency of dry spells, and occasional flooding. The study recommends the need for climate-smart agricultural strategies, including improved water management, adoption of heat-tolerant rice varieties, and increased investment in farm inputs. Such measures are essential for sustaining rice production under changing climatic conditions.

Keywords: Economic, Effect, Climate, Change and Production

INTRODUCTION

Climate change has exerted a significant impact on agriculture worldwide and poses a serious threat to global food security (Mubenga-Tshitaka *et al.*, 2023). The United Nations Framework Convention on Climate Change (UNFCCC) defines climate change as a phenomenon resulting from human activities that alter the composition of the global atmosphere, leading to shifts beyond the natural climate variability observed over comparable periods (WHO, 2016). These changes are monitored through key indicators identified by the Global Climate Observing System (GCOS), including surface temperature, ocean heat content, atmospheric CO₂ levels, and sea levels, Arctic and Antarctic Sea ice extent, ocean acidification, and glacier (WMO, 2023). In light of the difficulties in collecting comprehensive climate data, surface temperature is often used to assess the impact of climate change on agriculture. However, climate change is now reconsidered to refer to any alterations in climatic indicators over time, such as temperature or precipitation (Li, 2023). According to NASA (2023), the ten most recent years rank as the warmest on record, and Earth's average temperature in 2023 was approximately 1.36 °C higher than the late



19th century (1850–1900) preindustrial average. This indicates that climate change will continue to be a worrying concern for global agriculture

Nigeria, a sub-Saharan country, is located in the hot tropical climate zone, and bounded by the Sahara Desert to the north and the Atlantic Ocean to the south. The country has two seasons (rainy and dry). Rainy periods range from between two to three months in the extreme north of the country and between 9–12 months in the coastal regions. These seasons largely determine the spatial variation in the mean maximum and minimum temperatures of 41–13 °C and 32–21 °C experienced in the north and south respectively (Adakayi and Ishaya 2016). Moreover, less than 600 mm annual rainfall is recorded in the northern region (Akinsanola and Ogunjobi 2014). Rainfall is so far considered the most vital climate element for agriculture in Nigerian. This also determines the occurrences of either floods or drought events, both of which are a challenge to agriculture. Abiodun *et al.* (2013) observed that rising temperatures, high evaporation rates and ocean currents account for the varying distribution of rainfall, which occurs less towards the extreme north and more along the coast of the country. These changes in the climate system, alongside other non-climate factors, are drivers of the occurrence of climate-related hazards, such as floods and droughts in Nigeria (Fuwape *et al.* 2016).

The major climate-related hazards experienced in Nigeria are droughts, extreme temperatures, floods and storms. Due to the location of the country, there is a high variability in rainfall that often leads to either a deficit or an overflow. While drought is an identified period of low precipitation within an area leading to prolonged shortages of either atmospheric, surface or ground water, flooding refers to the overflow of water into areas, which are usually dry. Droughts and floods are ranked highest in terms of the impact on human and economic activities. Although there are no records of extreme drought in the past few years, hotter and drier conditions are lowering water levels and shrinking water bodies leading to hydrological and agricultural droughts (Abiodun *et al.*, 2013). This agrees with the assertion by Ashton (2002) who projected that rising temperatures and high evaporation rates would heighten water demand for various purposes, including agricultural use. Also, Rindap (2015) suggested that current water shortages and consequent droughts commonly experienced during the dry season do not only extend the fight against hunger but also trigger conflict in Nigeria. How climate change will affect the yield of water sources and the ability to meet water demand will have implications for irrigation agriculture since the sector is currently the largest consumer of water in Nigeria. Recent research has shown that rice can be used to offset the major impacts of climate change because of its potentials and unique properties as a food crop for urban poor and rural rice-growing populations (Manneh *et al.* 2007).

Rice is a major cereal in Nigeria in terms of its output and land area. The crop is currently grown in more than 70% of the states in the country. In spite of availability of cultivable land area, the current level of demand for rice in Nigeria is about 5 million metric tones which is more than twice the quantity produced (2.2 metric tones). At present about 4.9 millions hectares are suitable for rice production but just about 1.8 (37%) are currently utilized for cultivation. To amend the problem, West African Rice Development Association (WARDA), International Institute for Tropical Agriculture (IITA) and ministry of agriculture are frequently improving adaptation measures in rice agriculture in Nigeria. In addition, Nigeria governments have invested more to increase rice production than other cereals. In 2009 for instance, the nation spent more than 10 billion Naira in public-private partnership schemes to improve the irrigation systems and set up about 17 new rice processing mills.



The major problems associated with rice production include drought, flooding, salt stress and extreme temperatures, all of which are expected to worsen with climate change. Drastic changes in rainfall patterns and rise in temperatures will introduce unfavourable growing conditions into the cropping calendars thereby modifying growing seasons which could subsequently reduce the crop productivity. So far, there has not been any study to address the economic effects of climate change on rice production in Shendam LGA of Plateau State, Nigeria. The specific objectives of the study were to; examine trend in temperature and rainfall pattern between 2020-2024 in Shendam LGA; Assess the effects of climate variability on rice yield and production cost, estimate income losses suffered by rice farmers due to climate change; recommend adaptation strategies to mitigate risk.

MATERIALS AND METHODS

The Study Area

Plateau state, shendam local government area located in North-Central Nigeria is an ecological transition zone that divides the semi-arid north from the forest south. The area has two distinct dry and rainy seasons. It experiences cool, semi-temperate weather with up to 1400 mm annual rainfall (Olaniran 2002), and a wide temperature range of between 8–25 °C (Odunuga and Badru 2015). Plateau varies geographically with highlands reaching 1200 m above the mean sea level and low lands at approximately 200 m.

Odumodu (1983) observed that this geographical variation is responsible for the wide variation of rainfall and temperature distribution, which means the area is at high risk of climate-related events. The state, similar to the surrounding Nigerian region, experiences changes in weather patterns and notable adverse events. Floods and droughts are two distinct climate-related hazards experienced in the state due to the wide variation in elevation, and its location within the ecological transition zone. These features are similar to those in other African regions (Van der Geest and Warner 2014). Floods, as a result of heavy rainfall and attendant surface run-off, are more frequent occurrences, particularly in the plateau lowlands. Research by Adewuyi and Olofin (2014) calculated that the central region alone, where Plateau state is located, recorded 31% of the 52 major flood incidences in Nigeria in 2012. Alongside climate variations, Plateau State has a population of over 3.2 million (NPC 2006), and 51% in rural areas engage in one form of agrarian activity. The area is endowed with both natural and man-made resources, and experiences weather which is conducive for the production of a variety of exotic fruits, vegetables and grain in the upland and tubers and rice in the lowlands. With the advantage of rice farming, these crops are grown all year round, thereby contributing to the economic position of the country (Chuktu 2002). These already have implications for rice farming in Plateau State.

Sampling Techniques

Multi-Stage sampling techniques was applied for the study. In the first stage shendam LGA was purposively selected due to notable for high rice production. In second stage, eight villages were purposively selected from ward level. Finally, 150 rice farmers with 8 years of consistence rice production were selected for the study.

Method of Data Collection

Historic climatic data (rainfall and temperature) for the period extending from 2020 to 2024 were collected from Nigerian Meteorological Agency, also rice production data obtained from the respondents.



Data Analysis

The data for this study were been processed and analyzed quantitatively and qualitatively. The quantitative data were analyzed using both descriptive and inferential statistics. Linear trend as well as table were used to analyze and present the trend of climatic variables and rice production. Linear regression analysis was adopted and express as

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + \dots + b_nX_n + e \quad \dots(1)$$

where,

Y = Rice yield in ton/ha

a = constants

b = is the rise or falls as X increases

X₁ = Maximum temperature °C

X₂ = Minimum temperature °C

X₃ = Average Annual temperature °C

X₄ = Maximum Rainfall (mm)

X₅ = Minimum Rainfall (mm)

X₆ = Average Annual Rainfall (mm)

X₇=Cost of production (Naira/ha)

E= error term

RESULTS AND DISCUSSION

Trends of temperature pattern between 2020-2024 in Shendam LGA

The result in figure I shows the annual minimum, maximum, and average temperatures from 2020 to 2024 in Shendam LGA., highlighting year-to-year variability. The result further reveals that, temperature values show moderate fluctuations, with a noticeable decline around 2021–2022, followed by a slight increase in 2023 and mixed conditions in 2024. Minimum temperature decreased from 25 °C in 2020 to 23 °C in 2021 and 2022, indicating cooler night or early-morning conditions during this period. It then rose slightly to 24 °C in 2023 before dropping to its lowest value of 22 °C in 2024, suggesting increased variability in minimum temperatures toward the end of the period. Maximum temperature declined from a peak of 37 °C in 2020 to 35 °C in 2021 and 2022, reflecting slightly less intense heat during these years. A small increase to 36 °C occurred in 2023, followed by a return to 35 °C in 2024, indicating relatively stable but consistently high maximum temperatures. Average temperature followed a similar pattern, decreasing from 30 °C in 2020 to 29 °C in 2021 and reaching its lowest value of 27 °C in 2022. It then increased to 29 °C in 2023 and 30 °C in 2024, suggesting a recovery to earlier temperature levels. The cooler conditions observed in 2022 across all temperature measures may reflect short-term climatic influences or anomalous weather patterns. The rebound in 2023 and 2024, especially in average temperature, suggests a return to warmer conditions. Abiodun *et al.* (2013) observed that rising temperatures, high evaporation rates and ocean currents account for the varying distribution of rainfall.

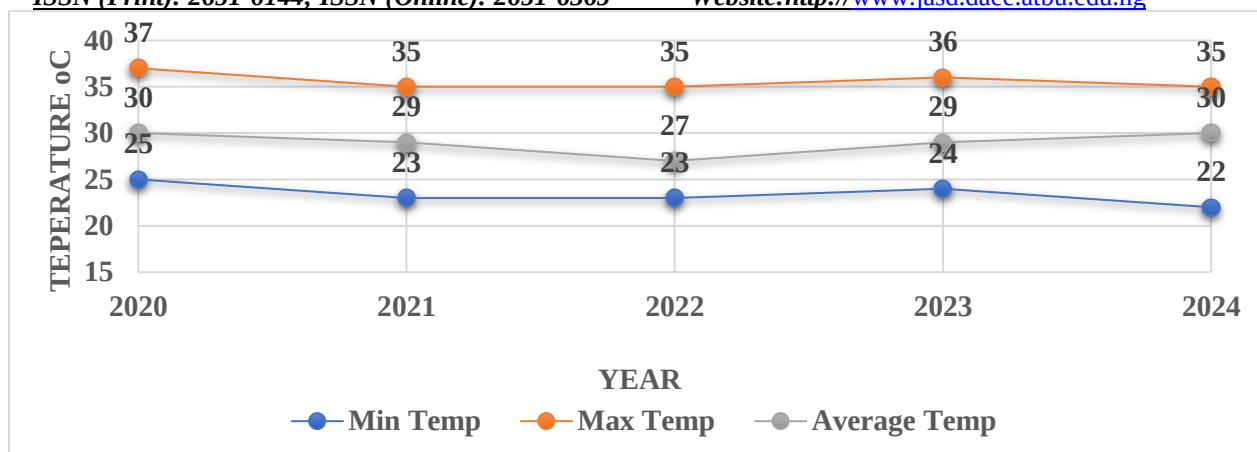


Figure i: Trends of temperature pattern between 2020-2024 in Shendam LGA

Trend in Rainfall Pattern Between 2020-2024 in Shendam LGA

The result in figure II presents the minimum, maximum, and average annual rainfall from 2020 to 2024, revealing clear temporal variations and an overall increasing trend toward the later years. Overall, rainfall shows a fluctuating pattern with a noticeable dip in 2022, followed by a steady increase from 2023 to 2024 across all three indicators (minimum, average, and maximum rainfall). Minimum rainfall increased from 914 mm in 2020 to 1,041 mm in 2021, then dropped sharply to its lowest value of 762 mm in 2022. After this decline, it recovered to 965 mm in 2023 and further increased to 1,118 mm in 2024, indicating improving rainfall conditions in recent years. Maximum rainfall followed a similar trend. It rose from 1,295 mm in 2020 to 1,397 mm in 2021, declined to 1,143 mm in 2022, and then increased substantially to 1,448 mm in 2023, reaching the highest value of 1,549 mm in 2024. This suggests a growing intensity of peak rainfall events after 2022. Average rainfall mirrors these patterns, increasing from 1,105 mm in 2020 to 1,219 mm in 2021, decreasing to 953 mm in 2022, and then rising consistently to 1,207 mm in 2023 and 1,334 mm in 2024. The sharp reduction in 2022 across all rainfall measures may indicate an anomalous dry year, possibly linked to climatic variability. Conversely, the consistent rise from 2023 to 2024 suggests a return to wetter conditions and potentially increasing rainfall variability.

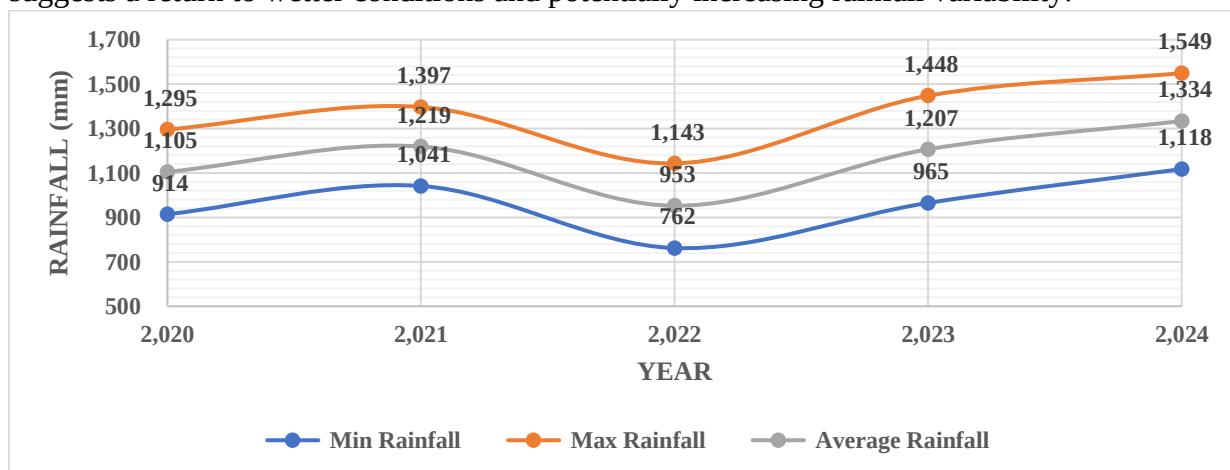


Figure ii: Trend in Rainfall Pattern Between 2020-2024 in Shendam LGA

Effects of climate variability on rice yield and production cost

The study analysed the influence of selected climatic variables and cost of production on rice yield using a multiple regression model. The findings indicate that temperature, rainfall, and production cost are important determinants of rice yield. The regression results show a strong explanatory power, with an R^2 value of 0.851, indicating that 85.1% of the variation in rice yield was explained by the independent variables included in the model. This suggests that the model is well specified and captures the major factors influencing rice production. In addition, the F-statistic value of 72.255 confirms that the model is statistically significant, implying that the explanatory variables jointly exert a significant influence on rice yield (Gujarati and Porter, 2009).

Average temperature exhibits a positive coefficient ($\beta = 0.0115$), indicating that an increase in average temperature is associated with a marginal increase in rice yield. However, the small magnitude of the coefficient suggests that average temperature may have a limited influence on rice yield. This finding is consistent with previous studies which report that moderate temperature increases may support rice growth without substantially affecting yield (Lobell and Gourdj, 2012).

Maximum temperature shows a positive relationship with rice yield ($\beta = 0.3224$), suggesting that higher daytime temperatures enhance rice productivity. This may be attributed to increased photosynthetic activity and faster crop development, provided that temperatures remain within the optimal physiological range for rice growth (Yoshida, 1981). Conversely, minimum temperature is negatively related to rice yield ($\beta = -0.1808$). This indicates that higher night-time temperatures reduce rice yield, likely due to increased respiration losses that reduce net assimilate accumulation. This result supports earlier findings that elevated night temperatures adversely affect rice grain filling and yield (Peng *et al.*, 2004).

Average rainfall is negatively associated with rice yield ($\beta = -0.1571$), implying that excessive rainfall may reduce productivity. Excess rainfall can lead to flooding, waterlogging, and nutrient leaching, which adversely affect rice growth and yield (FAO, 2011). Similarly, minimum rainfall has a negative coefficient ($\beta = -0.2832$), suggesting that inadequate rainfall during critical growth stages leads to moisture stress and yield reduction. Adequate water availability is therefore essential for optimal rice production (Bouman *et al.*, 2007). In contrast, maximum rainfall has a positive effect on rice yield ($\beta = 0.1505$). This finding indicates that sufficient peak rainfall, particularly during the vegetative and reproductive stages, supports rice growth and enhances yield outcomes. This result aligns with studies emphasising the importance of timely and adequate rainfall for rice cultivation (Sarker *et al.*, 2012).

Table 1: Effects of climate variability on rice yield and production cost

Variable	Coefficient	SE	P-Value
Avg Temp (°C)	0.0115	0.0523	4.5516
Avg Rainfall (mm)	-0.1571	0.3529	-2.2466
Max Temp (°C)	0.3224	0.5619	1.7429
Min Temp (°C)	-0.1808	1.4912	-8.2478
Min Rainfall (mm)	-0.2832	0.5553	-1.9607
Max Rainfall (mm)	0.1505	0.3957	2.6294
Cost (₦/ha)	0.1041	0.3573	3.4321
F-statistic	72.255		
R-square value	0.851		

Source: Field Survey, 2024

The coefficient of cost of production is positive ($\beta = 0.1041$), indicating that increased expenditure per hectare leads to higher rice yield. This suggests that investment in improved seeds, fertilisers, agrochemicals, irrigation, and labour contributes positively to rice productivity. Similar



findings have been reported in previous studies, which highlight the role of input use and capital investment in enhancing agricultural output (Olayide *et al.*, 2016).

Estimated Income Losses Suffered by Rice Farmers Due to Climate Change

Table 2 presents the estimated yearly yield losses and corresponding income losses per hectare for rice production between 2020 and 2024. The estimates incorporate observed yield losses and prevailing market prices, thereby providing insight into the economic implications of yield variability over time. The results indicate considerable inter-annual variation in yield losses. In 2020, yield loss was estimated at 0.299%, which increased substantially to 0.451% in 2021. This rise suggests the presence of adverse production conditions during the 2021 production season, potentially linked to unfavourable climatic factors or production constraints. In 2022, yield loss declined sharply to 0.167%, indicating a relative improvement in production conditions. However, yield losses increased again in 2023 (0.361%) and reached the highest level in 2024 (0.483%). The upward trend observed towards the end of the period suggests increasing production risks, possibly associated with climate variability and extreme weather events.

Market prices of rice show a consistent upward trend over the study period, increasing from ₦350 in 2020 to ₦700 in 2024. This doubling of price reflects broader market dynamics, including inflationary pressures, rising input costs, and increasing demand for rice. Rising market prices amplify the economic consequences of yield losses, as each unit of lost output translates into higher forgone revenue (FAO, 2021). Income losses per hectare increase markedly over time, reflecting the combined effect of yield losses and rising market prices. In 2020, income loss was estimated at ₦104,650 per hectare. This figure increased to ₦180,000 in 2021 despite a moderate increase in yield loss, largely due to higher market prices. Although yield loss was lowest in 2022, income loss remained substantial at ₦83,250, indicating that even relatively small yield reductions can result in significant financial losses when prices are elevated.

In 2023 and 2024, income losses rose sharply to ₦216,600 and ₦338,100 per hectare, respectively. The exceptionally high-income loss recorded in 2024 can be attributed to the combination of the highest yield loss (0.483%) and the highest market price (₦700). This finding highlights the compounding effect of climate-induced yield losses and price increases on farmers' income. The results demonstrate that yield variability has significant economic consequences for rice farmers, particularly in periods of high market prices. Increasing income losses over time suggest growing vulnerability of rice production systems to production shocks. This underscores the need for policies aimed at reducing yield losses through climate adaptation strategies, such as improved irrigation, drainage systems, and the adoption of stress-tolerant rice varieties (Lobell *et al.*, 2011).

Table 2: Estimated Income Losses Suffered by Rice Farmers Due to Climate Change

Year	Market price (₦)	Yield Loss (%)	Income Loss (₦)
2020	350	0.299	104,650
2021	400	0.451	180,000
2022	500	0.167	83,250
2023	600	0.361	216,600
2024	700	0.483	338,100

Source: Field Survey, 2024



Adaptation Strategies for Mitigating Climate Variability Risks on Rice Production in Shendam LGA

Climate variability poses significant risks to rice production in Shendam Local Government Area (LGA) of Plateau State through erratic rainfall, increased frequency of dry spells, and occasional flooding. To enhance the resilience of rice-based farming systems in the area, a combination of farm-level, institutional, and policy-driven adaptation strategies is required.

First, adjustment of planting calendars is a critical adaptation measure. Aligning planting dates with observed changes in rainfall onset and cessation can reduce crop exposure to moisture stress or flood damage during sensitive growth stages such as flowering and grain filling. Studies across Nigeria have shown that flexible planting schedules significantly improve rice yield stability under variable climatic conditions (Ojo and Sadiq, 2019).

Second, improved water management practices are essential in mitigating both drought and excess rainfall risks. The development of small-scale irrigation schemes, rainwater harvesting systems, and on-farm water storage facilities can supplement rainfall during dry spells, while effective drainage systems can reduce yield losses from waterlogging during periods of intense rainfall. Efficient water management has been identified as a key adaptation strategy for rice farmers in rain-fed systems across the Middle Belt region of Nigeria (FAO, 2021).

Third, the adoption of climate-resilient rice varieties including drought-tolerant, flood-tolerant, and early-maturing varieties offers a viable pathway for reducing climate-related yield losses. Early-maturing varieties, in particular, enable farmers in Shendam LGA to complete the rice growth cycle within shorter and increasingly unpredictable rainy seasons. Empirical evidence indicates that improved rice varieties significantly enhance productivity under climatic stress conditions (Nwalieji and Onwubuya, 2020).

Fourth, soil and water conservation practices such as mulching, minimum tillage, and the use of organic amendments can enhance soil moisture retention and reduce erosion. Healthy soils act as buffers against climate shocks by improving water infiltration and nutrient availability, thereby sustaining rice productivity under variable weather conditions (Lal, 2015).

Fifth, crop diversification and livelihood diversification serve as important risk-spreading strategies. Integrating rice with other crops such as legumes or engaging in complementary livelihood activities can reduce household vulnerability to climate-induced crop failure. Diversification has been widely recognized as an effective adaptation mechanism among smallholder farmers in sub-Saharan Africa (Asfaw *et al.*, 2019).

Finally, strengthening institutional support systems is crucial for the successful implementation of adaptation strategies. Improved access to agricultural extension services, timely climate information, credit facilities, and farmer-based organizations can enhance adaptive capacity by facilitating knowledge transfer and resource mobilization. Access to climate information and extension services has been shown to significantly influence farmers adaptation decisions in Nigeria (Oluwatusin, 2014). However, a holistic approach that combines agronomic innovations, infrastructure development, and institutional support is necessary to build climate-resilient rice production systems in Shendam LGA. Such integrated adaptation strategies will not only stabilize rice yields but also enhance food security and livelihoods in the face of increasing climate variability.

CONCLUSION AND RECOMMENDATIONS

The results indicate that while temperatures fluctuated over the five-year period, they remained within a relatively narrow range. The persistence of high maximum temperatures



alongside variable minimum temperatures may have implications for thermal stress, energy demand, and agricultural productivity in the study area. However, the results indicate that while rainfall experienced short-term fluctuations, particularly a decline in 2022, the overall trend points toward increasing rainfall amounts and extremes in recent years, which may have important implications for water resource management, agriculture, and flood risk planning. The results demonstrate that rice yield is significantly influenced by both climatic factors and economic investment. While higher maximum temperature and adequate rainfall improve rice yield, excessive rainfall and higher minimum temperatures exert negative effects. Increased production cost positively influences yield, underscoring the importance of access to farm inputs and improved management practices. The study recommends the following

- i. These findings highlight the need for climate-smart agricultural strategies, including improved water management, adoption of heat-tolerant rice varieties, and increased investment in farm inputs. Such measures are essential for sustaining rice production under changing climatic conditions.
- ii. The magnitude of income losses highlights the importance of risk management mechanisms, including crop insurance schemes and price stabilization policies, to protect farmers' incomes against production and market shocks.

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