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Original Research Article

Analysis of Farmers' Perceived Effects of Climate Change on Rice Production in Benue State, Nigeria

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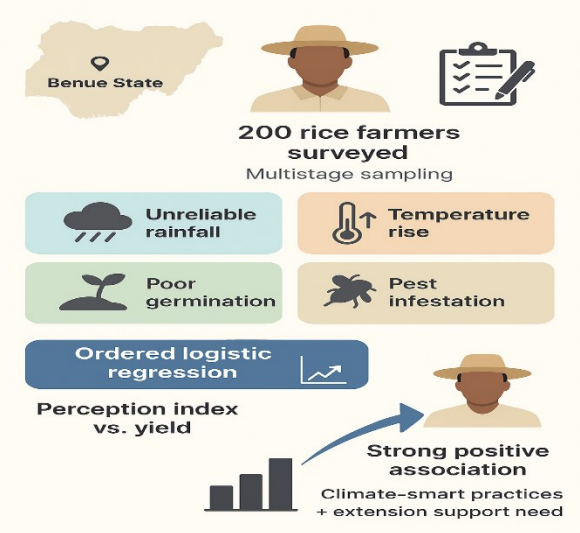
Abstract- Climate change is a major threat to food security in Sub-Saharan Africa, where agriculture is predominantly rain-fed and highly vulnerable to climatic variability. Rice, a staple food in Nigeria, is particularly affected by changing rainfall patterns, temperature fluctuations, and other environmental stresses. This study assessed rice farmers' perceptions of climate change and its effects on rice production in Benue State, Nigeria. A multistage sampling procedure was used to select 200 farmers across three agroecological zones. Data were collected using structured questionnaires and analyzed with descriptive statistics and an ordered logistic regression model. Results showed that most respondents were within the economically active age group (41–60 years), male (72%), and had some formal education (82%). Farmers generally perceived climate change as a major constraint to rice production, reporting challenges such as poor germination, erratic rainfall, declining yields, pest outbreaks, and post-harvest losses. Mean scores across nine perception indicators exceeded 1.5 on a three-point scale, highlighting widespread recognition of climate risks. Regression analysis revealed a positive and statistically significant relationship between the perception index and rice yield category (β = 0.042; OR = 1.043; 95% CI: 1.025–1.061; $p < .001$; Pseudo $R^2 = 0.312$), suggesting that greater awareness of climate change was associated with improved yield outcomes. The study concludes that strengthening farmers' adaptive capacity is crucial for sustaining rice production in Benue State. It recommends enhanced extension services, adoption of climate-smart agricultural practices, and improved access to information to build resilience against climate risks.

Graphical Abstract



Article Key Information

Keywords: climate change, perception, rice farmers, Benue State, adaptation, Nigeria

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1.0 Introduction

Climate change is widely recognized as one of the most pressing global environmental challenges of the 21st century (Minale, Alemayehu, & Adam, 2024). According to the *2021 State of Food Security and Nutrition Report*, between 720 and 811 million people worldwide experienced hunger in 2020, with climate change identified as a major driver of this crisis (Nguyen, 2023). Sub-Saharan Africa (SSA) is among the most vulnerable regions due to its fragile ecosystems, climate-dependent economies, and low adaptive capacity (Yona, Matewos, & Sime, 2024). Approximately 95% of food production in SSA is dependent on rain-fed agriculture, leaving farmers particularly exposed to the adverse impacts of climate variability and extreme weather events (Njeru, 2016). These impacts are especially pronounced in arid and semi-arid areas, where water resources and agricultural yields are highly sensitive to climatic fluctuations (Yadeta, Kebede, & Tessema, 2020).

Evidence from past studies shows that rising global temperatures have already reduced agricultural productivity and food security across many regions (Kurukulasuriya & Mendelsohn, 2006; International Institute for Sustainable Development [IISD], 2007; Lobell et al., 2008). Climate change has negatively affected crop yields in numerous countries (Intergovernmental Panel on Climate Change [IPCC], 2007; Deressa et al., 2008; Building Nigeria's Response to Climate Change [BNRCC], 2008), particularly in low-income settings where agriculture is highly climate-dependent and adaptive capacities are limited (Spore, 2008; Apata et al., 2009).

The relationship between agriculture and climate change is therefore critical and well established in the literature (IPCC, 2014; Pidgeon & Fischhoff, 2011; Pietsch & McAllister, 2010). Climate directly influences agricultural activities by shaping access to vital inputs such as water, solar radiation, and pest dynamics, all of which affect yields and cropping patterns (Dhaka, Chayal, & Poonia, 2010). Since millions of households rely on agriculture for food and livelihoods, changes in climatic conditions pose serious threats to food security and rural well-being (Prantilla & Laureto, 2013).

Rice production, particularly in Nigeria, is highly climate-sensitive because it depends largely on natural weather conditions. Recent climatic disruptions in Nigeria, including desert encroachment and prolonged drought in the northern regions, underscore these vulnerabilities (Akomolafe, Sennuga, Bamidele, Osho-Lagunju, & Alabuja, 2023). Rice remains one of Nigeria's most important staple foods, with annual consumption approaching 7 million metric tons (Malabe & Ango, 2023). Nigeria has emerged as the largest producer of rice in West Africa and the third-largest in Africa, after Egypt and Madagascar. National production rose from 2.1 million metric tons in 2005 to 3.46 million metric tons in 2008 (National Rice Development Strategy [NRDS], 2022). Despite this growth, rice production remains highly dependent on environmental factors such as rainfall, temperature, and humidity, which continue to

fluctuate under climate change (Onyegbula, 2017; Edeh, Eboh, & Mbam, 2011). Studies warn that sustained increases in temperature and erratic rainfall patterns will likely undermine rice yields in Nigeria and across other rice-growing regions (Gumm, 2010).

Farmers' perceptions of climate change are equally important, as they influence how farming households respond to environmental risks. Perception refers to the beliefs and judgments people hold about their environment (Blaikie et al., 1997). Public perception plays a critical role in shaping sociopolitical actions to address climate-related risks (Falaki, Akangbe, & Ayinde, 2013). Indeed, scholars argue that perception is the first step toward adaptation, since individuals cannot take effective measures without recognizing climate change as a reality (Thomas, Twyman, Osbahr, & Hewitson, 2007). Moreover, perceptions strongly influence management decisions at the farm level, shaping whether farmers adopt climate-smart practices. Broader climate change literature has shown that public understanding, levels of concern, and sense of responsibility significantly affect climate action (Bord, O'Connor, & Fisher, 2000; Capstick, Whitmarsh, Poortinga, Pidgeon, & Upham, 2015; Klöckner, 2013; Tobler, Visschers, & Siegrist, 2012).

Understanding smallholder farmers' perceptions is therefore crucial in designing effective adaptation strategies. Perception studies have been identified as necessary precursors to the adoption of adaptation measures in agriculture (Maddison, 2006). Empirical studies across Africa confirm that the success of adaptation interventions often depends on farmers' recognition of climate change and their willingness to adjust practices (Okonya, Syndikus, & Kroschel, 2013; Simelton et al., 2013; Moyo, Mvumi, Kunzekweguta, Mazvimavi, & Craufurd, 2012; Penaranda, Perrino, & Barreras, 2012).

Against this backdrop, this study investigates the perceived effects of climate change on rice production in Benue State, Nigeria. Benue, widely regarded as the "food basket of the nation," has high agricultural potential, with rice being one of its most important staple and commercial crops. Yet, production is increasingly constrained by unreliable rainfall, recurrent droughts, and extreme temperatures linked to climate change. By examining farmers' socioeconomic characteristics, their perceptions of climate change, and the relationship between these perceptions and rice yield, this study provides insights that can inform climate-smart agricultural policy and practice in Benue State.

2.0 Methodology

2.1 Study Area

The study was conducted in Benue State, located in the central region of Nigeria. Geographically, the state lies between latitudes 6°35′ and 8°08′ N, and longitudes 7°47′ and 10°00′ E (Tyubee, 2005). It shares boundaries with Nasarawa State to the north, Taraba State to the northeast, Cross River State to the south, Enugu and Ebonyi States to the southeast, and Kogi State to the west. In addition, Kwande Local Government Area (LGA) shares a short international boundary with the Republic of Cameroon (Figure 1).

Benue State falls within the tropical humid climatic zone, with distinct wet and dry seasons (Aw type, Köppen classification). Rainfall is primarily influenced by two air masses: the moist southwesterly winds that bring rainfall from March/April to October, and the dry northeasterly winds that dominate from November to April. Annual rainfall averages between 1,200 and 1,500 mm, with variations across the state (Adamgbe & Ujoh, 2012). Temperatures remain high year-round, ranging from 23.0 °C to 28.0 °C, with peak values reaching approximately 37.0 °C (Tyubee, 2005).

Hydrology in the state is dominated by River Benue and its tributaries, including Katsina-Ala, Okpokwu, Guma, Gwer, and Aya. The dominant soils are tropical ferruginous, characterized by low organic matter and cation exchange capacity, while hydromorphic soils occur along river valleys. These soil types are suitable for diverse crop cultivation, including rice (Tyubee, 2005).

Agriculturally, Benue State is located within Nigeria's root and grain crop belt, with major crops including yam, cassava, sweet potato, maize, millet, sorghum, rice, soybean, cowpea, beniseed, and groundnut. Farming is predominantly rain-fed and therefore highly climate-dependent. The region also experiences challenges common to semi-arid environments, such as erratic rainfall, droughts, and soil degradation, making it an ideal setting for studying climate change adaptation strategies among smallholder farmers.

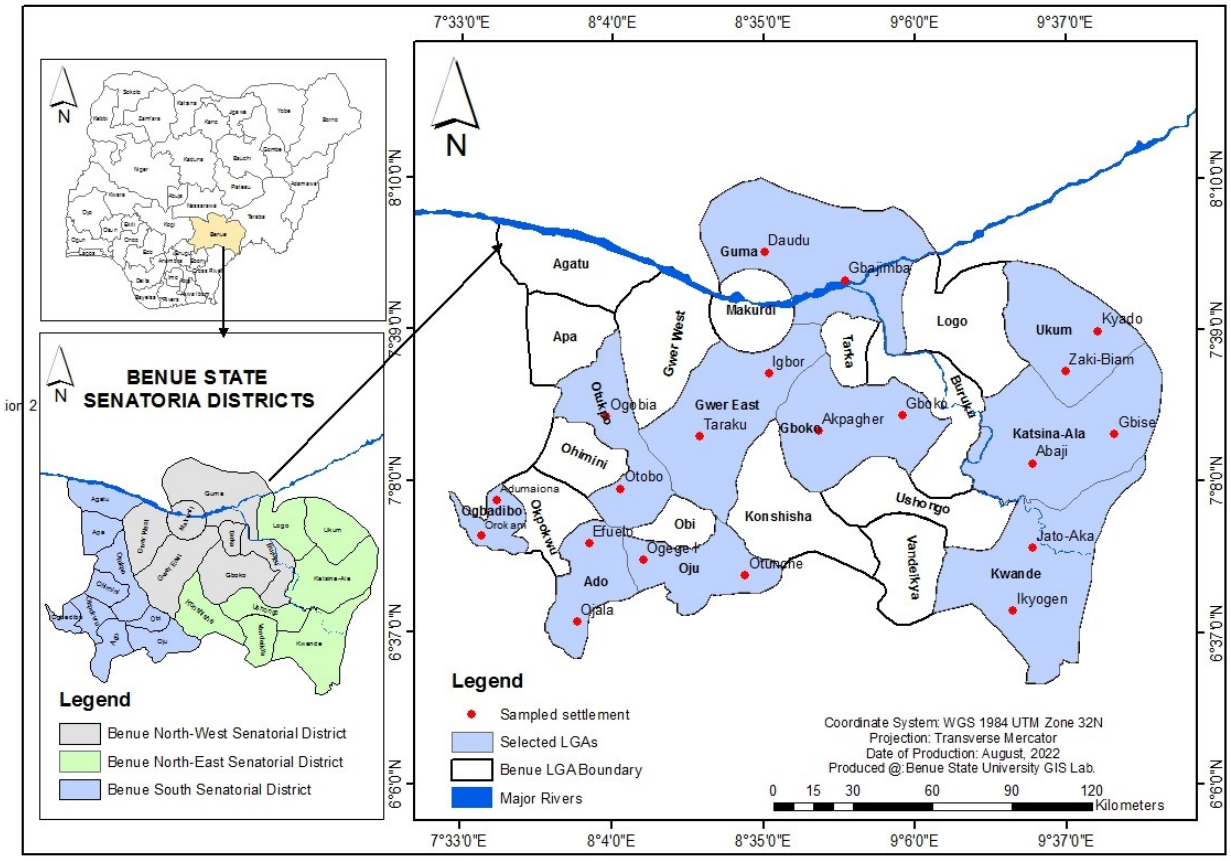

Fig. 1: Location of the Study Area

2.2 Method of Data Collection

A multistage sampling technique was used to select respondents. In the first stage, Benue State was stratified into three agroecological zones (A, B, and C). In the second stage, 10 LGAs were purposively selected: three from Zone A, three from Zone B, and four from Zone C. At the third stage, two rice-farming communities were selected from each of the 10 LGAs, giving a total of 20 communities. Finally, at the fourth stage, 10 rice-farming households were randomly selected from each community, yielding a total sample size of 200 respondents.

The household head was the primary respondent; however, in cases where the head was unavailable, the spouse or another adult household member actively engaged in rice farming was interviewed. Structured questionnaires were used to collect data on socioeconomic characteristics, perceptions of climate change, and rice yields.

The sample size of 200 was considered adequate based on statistical principles for homogeneous populations. Bailey (1994) recommended a minimum of 200 respondents for survey research to ensure robust analysis. Similarly, Martinez-Abrain (2014) noted that homogeneous farming populations can be reliably represented with relatively small random subsamples. To minimize bias, random selection was maintained at the community and household levels, and participation was voluntary.

2.3 Method of Data Analysis

Data collected were analyzed using both descriptive and inferential statistics. Descriptive statistics (frequency counts, percentages, ranges, and means) were used to summarize farmers' socioeconomic characteristics.

Farmers' perceptions of climate change were measured using nine statements rated on a three-point Likert scale: 1 = No effect, 2 = Low effect, 3 = Severe effect. A perception index was constructed by summing responses across the nine items. Higher values indicated stronger perceptions of adverse climate change effects on rice production. Internal consistency of the index was assessed using Cronbach's alpha (α).

For inferential analysis, the relationship between farmers' perceptions and rice yield was examined. Rice yield was self-reported by farmers and categorized into three levels: *low = 1, medium = 2, and high = 3*. Given the ordinal nature of the dependent variable, an ordered logistic regression model was adopted.

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i$$

Where:

- Y_i = rice yield category for farmer i (low/medium/high)
- X_i = perception index score
- β_0 = intercept
- β_1 = regression coefficient
- ε_i = error term

Model outputs included odds ratios, standard errors, 95% confidence intervals, pseudo-R2R^2R2, and exact *p*-values ($p < .001$ reported where appropriate). Results were interpreted as associations rather than causal effects, consistent with the cross-sectional design.

3.0 Results and Discussion

3.1 Socioeconomic Characteristics of Rice Farmers in Benue State

The socioeconomic profile of respondents is presented in Table 1 and also illustrated in Figure 2. Variables analyzed include age, gender, marital status, education, household size, farming experience, and estimated annual income from rice farming.

Table 1. Distribution of Respondents by Socioeconomic Characteristics

Variable	Frequency	Percentage (%)
Gender		
Male	144	72.0
Female	56	28.0
Age (years)		
< 20	8	4.0
20–40	34	17.0
41–60	120	60.0
≥ 61	38	19.0
Marital Status		
Single	48	24.0
Married	148	74.0
Widowed	4	2.0
Education		
None	36	18.0
Primary	44	22.0
Secondary	72	36.0
Tertiary	48	24.0
Household Size		
< 5	40	20.0
5–9	60	30.0
10–14	68	34.0
≥ 15	32	16.0
Farming Experience (years)		
< 10	28	14.0
10–19	44	22.0
20–29	92	46.0
≥ 30	36	18.0
Annual Rice Income (₦)		
< 100,000	32	16.0
100,000–300,000	84	42.0
301,000–500,000	40	20.0
501,000–1,000,000	28	14.0
> 1,000,000	16	8.0

Source: Field survey, 2024

Age distribution shows that most respondents (60%) were between 41 and 60 years, 19% were above 60, 17% were 20–40, and 4% were under 20. This indicates that rice farming in the study area is dominated by individuals in their economically active years. These findings align with Adebayo et al. (2012), who reported that most farmers in Adamawa State were in the 31–50 age range, a demographic group with both experience and the physical ability to adopt climate change adaptation measures.

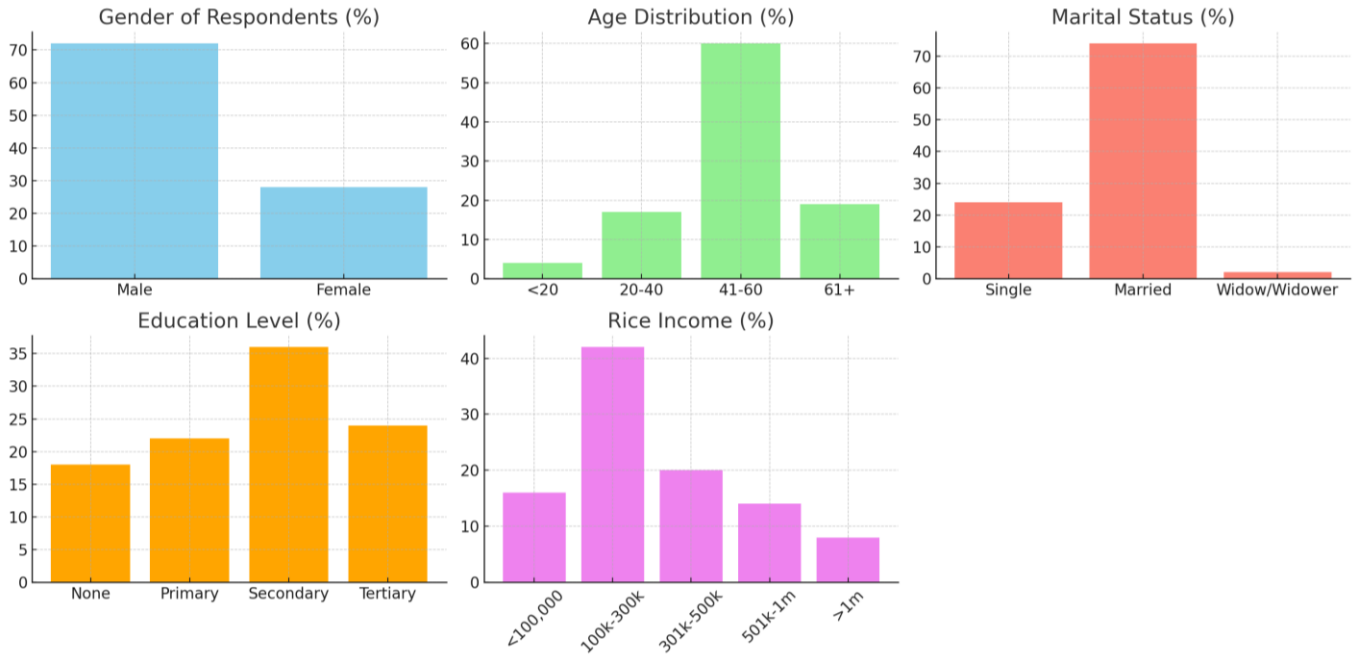

Figure 2. Socioeconomic characteristics of rice farmers in Benue State, Nigeria. The figure illustrates the distribution of respondents by gender, age group, marital status, education level, and estimated annual income from rice farming. Results show that most farmers are male, within the economically active age range (41–60 years), married, and have at least some formal education. Annual rice income is concentrated between ₦100,000 and ₦300,000, reflecting moderate commercial engagement in rice farming.

Gender analysis revealed that 72% of respondents were male, while 28% were female. This suggests that rice farming in Benue State is male-dominated, consistent with Abraham et al. (2012), who noted that men typically carry out labor-intensive farming and adaptation activities.

Marital status showed that 74% of farmers were married, 24% single, and 2% widowed or widowers. Marriage may provide social and economic support that facilitates decision-making on climate adaptation.

Household size varied, with 34% of respondents having 10–14 members, 30% with 5–9, 20% with fewer than 5, and 16% with 15 or more members. Large households are often associated with access to family labor and information sharing, which may strengthen adaptive capacity (Abaje, Sawa, & Ati, 2014).

Educational attainment revealed that 36% had secondary education, 24% tertiary education, 22% primary education, and 18% no formal education. Thus, 82% of respondents had some level of formal education, a factor linked with higher awareness and adoption of climate-smart practices (Anyoha et al., 2013; Adebayo et al., 2012).

Farming experience indicated that 46% had 20–29 years of experience, 22% had 10–19 years, 18% had 30 years or more, while only 14% had fewer than 10 years. This shows that most farmers were highly experienced, which is critical for recognizing climate change impacts and developing adaptation responses (Mudzonga, 2012; Maddison, 2006).

Income distribution showed that 42% earned ₦100,000–₦300,000 annually from rice, 20% earned ₦301,000–₦500,000, 16% earned below ₦100,000, 14% earned ₦501,000–₦1,000,000, and 8% earned above ₦1,000,000. These figures suggest that rice is a significant source of livelihood, though most farmers remain smallholders with modest incomes.

3.2 Perceived Effects of Climate Change on Rice Production

Table 2 summarizes farmers' perceptions of climate change effects. Overall, the mean values across all nine statements exceeded 1.5 (on a scale of 1–3), indicating that most respondents recognized climate change as negatively affecting rice production.

Table 2. Farmers' Perceptions of Climate Change Effects on Rice Production

Perceived Effect	No Effect	Low Effect	Severe Effect	Mean
Climate change poses risks to rice production	22	40	138	2.73
Climate change presents more risks than benefits	92	48	60	1.84
Continuous rise in temperature reduces rice yield	99	51	50	1.76
Yearly rains no longer support rice production	48	56	96	2.24
Infestation of rice with pests is due to climate change	78	62	60	1.99
Climate change reduces working hours of farmers	102	64	34	1.66
Poor germination of rice due to climate change	40	64	96	2.28
Climate change responsible for lower rice yield	92	44	64	2.01
Climate change affects rice storage	70	36	94	2.12

Source: Author's computations, 2024

The most strongly perceived effect can easily be visualized in Figure 3 that climate change poses risks to rice production (mean = 2.73). Other widely reported perceptions included unreliable rainfall reducing production (mean = 2.24), poor germination rates (mean = 2.28), lower rice yields (mean = 2.01), and challenges in rice storage (mean = 2.12). Pest infestations (mean = 1.99) and reduced working hours due to heat stress (mean = 1.66) were also noted.

These findings are consistent with Adebayo et al. (2012), who found that farmers in Adamawa State perceived climate change to be adversely affecting their farming activities. Similar conclusions were drawn by Simelton et al. (2013), who emphasized that perception is the critical first step in adaptation. Without recognition of climate change as a threat, farmers are less likely to adopt appropriate coping mechanisms (Falaki, Akangbe, & Ayinde, 2013).

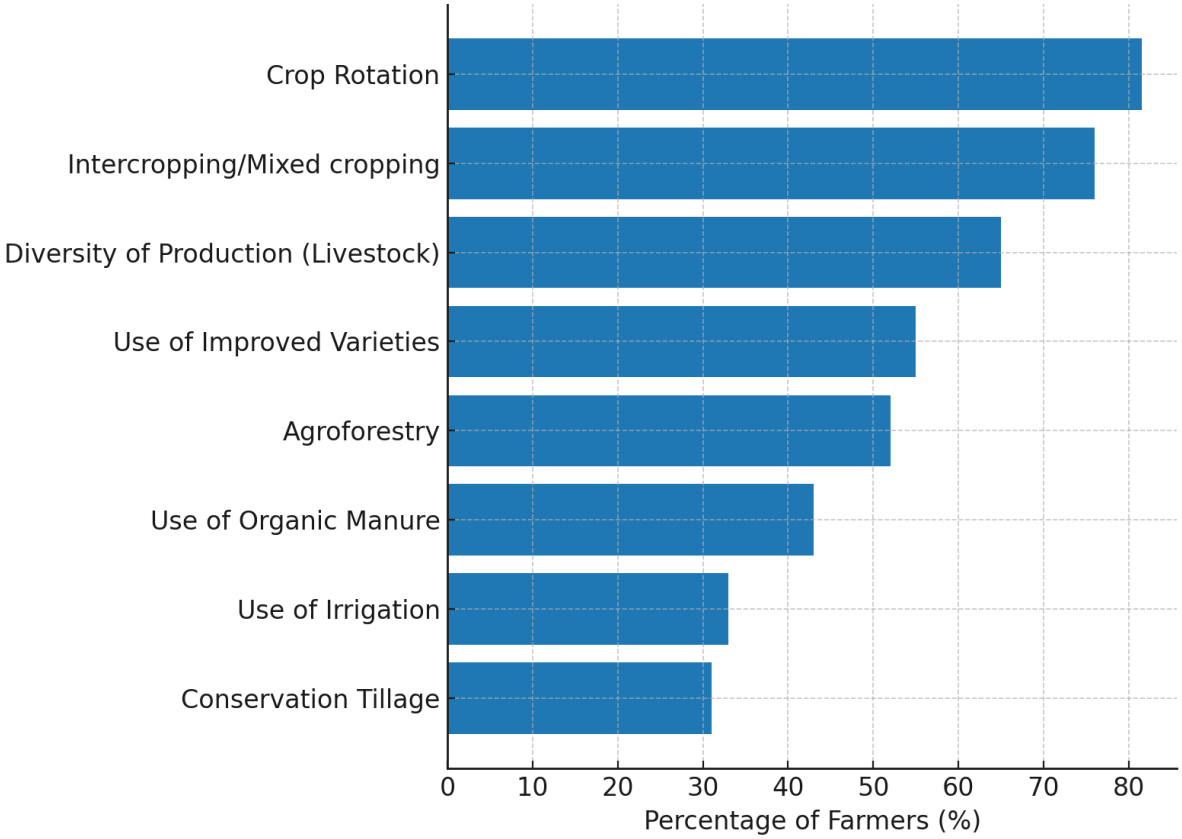

Figure 3**.** *Farmers' perceptions of climate change effects on rice production in Benue State, Nigeria.* The figure presents mean scores (1 = no effect, 2 = low effect, 3 = severe effect) for nine identified effects of climate change on rice farming. Farmers most strongly perceived climate change as posing risks to rice production (M = 2.73), followed by poor germination (M = 2.28) and unreliable rainfall patterns (M = 2.24). Lower-ranked effects included reduced working hours (M = 1.66) and continuous temperature rise (M = 1.76).

3.3 Relationship Between Perceived Climate Change Effects and Rice Yield

To examine the relationship between perceptions and rice yield, an ordered logistic regression model was estimated, reflecting the ordinal nature of the dependent variable (low, medium, high yield). The perception index was used as the predictor.

Results showed a positive and statistically significant association between perception scores and rice yield categories ($p < .001$). This suggests that farmers who reported stronger perceptions of climate change impacts were more likely to report higher yield categories, possibly because awareness of risks motivates adaptation practices. However, given the cross-sectional design, these findings should be interpreted as **associative, not causal**.

Table 3. Ordered Logistic Regression of Perceptions on Rice Yield

Variable	Coefficient (β)	Std. Error	Odds Ratio	95% CI	p-value
Perception index	0.042	0.009	1.043	1.025–1.061	< .001

Model fit: Pseudo $R^2 = 0.312$; N = 200

Source: Author's computations, 2024

The positive association may indicate that farmers with stronger perceptions of climate change are also those actively engaging in adaptation practices such as adjusting planting times, using improved seeds, or pooling resources for inputs. Similar findings were reported by Hassan and Nhemachena (2008), who showed that farmers' awareness of climate change increased the likelihood of adopting adaptive strategies.

4.0 Conclusion and Recommendations

4.1 Conclusion

This study examined rice farmers' perceptions of climate change and its effects on rice production in Benue State, Nigeria. The findings reveal that the majority of farmers are in their economically active years, possess significant farming experience, and have attained varying levels of formal education, all of which enhance their ability to recognize and respond to climate variability. Farmers generally perceived climate change as a major threat to rice production, identifying reduced yields, poor germination rates, erratic rainfall, pest infestations, and post-harvest storage challenges as key impacts. The regression results further confirmed a strong positive relationship between farmers' perception of climate change and rice yield, underscoring the central role of perception in shaping adaptation strategies.

Based on these findings, the study concludes that improving farmers' awareness and perception of climate change is critical for strengthening adaptive responses in rice farming. The results reaffirm the need for policies that support climate-smart agriculture and farmer education, particularly in regions heavily reliant on climate-sensitive livelihoods.

4.2 Recommendations

i Extension and awareness programs: Agricultural extension services should intensify campaigns on climate change awareness to improve farmers' perception and adoption of climate-smart practices.
ii Climate-resilient farming practices: Farmers should be encouraged and supported to adopt practices such as improved seed varieties, irrigation technologies, and soil fertility management to mitigate yield losses.
iii Policy support: Government and relevant agencies should formulate and implement policies that prioritize smallholder farmers' access to climate information, farm inputs, and financial support for adaptation.
iv Research and innovation: Further studies should focus on locally adapted climate-resilient technologies and provide evidence-based recommendations that can be scaled up across other regions of Nigeria.
v Capacity building: Training programs should target farmers' technical capacity in post-harvest management to address the adverse effects of climate change on rice storage and processing.

By strengthening farmers' adaptive capacity through education, policy support, and technological innovation, rice production in Benue State can be safeguarded against the increasing threats posed by climate change, thereby contributing to food security and poverty reduction in Nigeria.

Declarations

Funding
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

Ethical Approval

All procedures performed in this study involving human participants were in accordance with institutional ethical standards. Participation was voluntary, and informed consent was obtained from all respondents prior to data collection.

Data Availability

The datasets generated and analyzed during the current study are available from the corresponding author on reasonable request.

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