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Impact of Climate Change on Agricultural Productivity and Food Security among Rice Farmers in Oyo State, Nigeria

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Abstract

This study examines the impact of climate change on agricultural productivity and food security among smallholder rice farmers in Oyo State, Nigeria. Using a multi-stage sampling technique, primary data were collected from 200 respondents through structured questionnaires. Results indicated that respondents were predominantly male (73%) with a mean age of 45.6 years, an average of 16.2 years of farming experience, and a mean farm size of 1.95 hectares. Perceived impacts of climate variability include delayed planting and harvesting (mean = 4.42), reduced yields (mean = 4.17), and pest and disease outbreaks (mean = 4.14), while variables such as improved overall rice yield (mean = 2.35) and reduced cost of input use (mean = 2.08) were perceived negatively. Logistic regression analysis revealed that educational attainment and cooperative membership ($p < 0.01$), Age and access to credit ($p < 0.05$), and gender and farming experience ($p < 0.10$) significantly influenced stakeholders' willingness to adopt climate-smart technologies. Other socio-demographic factors, marital status, farm size and contact with extension agents, were not statistically significant. Adaptation strategies ranked highly by farmers include adjusting planting dates (mean rank = 5.36), using drought-tolerant varieties (5.02), and applying organic manure (4.74), with Kendall's $W = 0.614$ indicating moderate consensus. The study contributes empirical insights into climate adaptation behaviour and highlights the need for institutional support to build climate resilience among smallholder farmers.

Keywords: Climate variability, rice farming, adaptation strategies, climate-smart technologies

Introduction

Agriculture remains central to Nigeria's socioeconomic framework, employing approximately 70% of the rural population and contributing significantly to gross domestic product (GDP), food supply, and national development strategies (FAO, 2021) [11]. Within the agricultural sector, rice plays a particularly vital role. As Nigeria's most consumed staple grain, rice accounts for a growing share of caloric intake, dietary energy, and household food expenditure (IFPRI, 2022; Olawumi *et al.*, 2025) [14, 29]. Despite being Africa's leading rice producer, Nigeria has consistently struggled to meet domestic demand, resulting in significant import dependence to bridge supply deficits (Ojo & Akinyemi, 2023) [23]. The productivity of rice farming in Nigeria remains substantially below global averages due to low input use, outdated agronomic practices, poor irrigation infrastructure, and weak extension services (Nwaleji, Igboke and Nsoanya, 2022) [21]. Unpredictable rainfall,

rising temperatures, and frequent extreme weather events have intensified production risks, creating uncertainty in yields and threatening the sustainability of rice-based livelihoods (Ajayi, Salami and Kodaolu, 2023) [6]. Thus, climate change is emerging as a pivotal constraint on Nigeria's food system—disrupting agricultural productivity, straining food supply chains, and exacerbating the vulnerabilities of farming communities that are already marginalised within the national economy (Olaitan *et al.*, 2025) [27].

Recent evidence demonstrates that climate change is no longer a future concern but an immediate driver of agricultural instability across Nigeria. Over the past two decades, Nigeria has experienced steadily rising temperatures—averaging 1.5 °C above pre-industrial baselines—with annual increases now exceeding global averages in many agro-ecological zones (NiMet, 2022). Concurrently, rainfall patterns have grown more erratic,

with delays in the onset of the rainy season, shortened durations, and increased intensity of rain events, often leading to localized flooding or prolonged dry spells (Ajayi *et al.*, 2023)^[6]. These shifts have had pronounced effects on rice production, which is acutely sensitive to changes in water availability, temperature stress, and seasonal timing. For instance, excess heat during the flowering stage can lead to spikelet sterility and reduced grain filling, while erratic rains affect germination, transplanting, and overall crop maturation (Maisule, *et al.*, 2025)^[17]. While Nigeria has initiated some adaptive interventions, such as early warning systems and climate-resilient seed varieties, these remain unevenly distributed and poorly institutionalized at the community level (Ayanlade and Oluwatoyin, 2023)^[7]. As a result, many smallholder rice farmers remain vulnerable to climate shocks, with few assets or institutional supports to mitigate risk or recover from yield losses.

The ramifications of these climate-induced disruptions extend beyond the farm gate to deeply impact food security and rural welfare. In the Nigerian context, food security is not merely about national production totals but the ability of households to access sufficient, safe, and nutritious food on a consistent basis (Joel *et al.*, 2025)^[16]. When climate shocks reduce rice yields or destroy harvests, households suffer immediate declines in food availability and income, particularly in communities where rice functions as both a staple food and cash crop (Okonkwo, Okoli and Agwu, 2021; Idu, Sennuga and Owoicho 2025)^[24, 13]. According to the Cadre Harmonisé food security analysis, more than 17 million Nigerians experienced food insecurity in 2023, with rural farming populations disproportionately affected due to climate-related yield shocks (FAO, 2023; Adeyemi *et al.*, 2025)^[12, 3]. In areas where floods displaced farming households or prolonged droughts suppressed multiple planting seasons, food insecurity increased in both severity and frequency. These impacts are most acutely felt by vulnerable groups such as women, the elderly, and youth-headed households, who often have limited access to land, credit, extension services, or climate adaptation technologies (Onwualu, Akpan and Dim, 2022; Adeyemi *et al.*, 2025)^[32, 3]. Despite ongoing efforts to implement climate-smart agriculture and resilience-focused policies at national and sub-national levels, there remains a significant gap in context-specific, data-driven research that links climatic changes to productivity and food security outcomes in a disaggregated manner. This study aims to evaluate the impact of Climate Change on Agricultural Productivity and Food Security among Rice Farmers in Oyo State, Nigeria. To accomplish this, the following objectives are put forward to:

1. describe the socio-economic characteristics of farmers affected by climate change in the study area.
2. assess the impact of climate variability on agricultural production in the study area.
3. investigate the factors influencing stakeholders' willingness to adopt climate-smart technologies for climate change mitigation in the study area.
4. examine farmers' adaptation strategies to climate change in the study area.

Literature review

Theoretical Framework

Sustainable Livelihoods Framework (SLF)

Originally developed by the UK Department for International Development (DFID), the Sustainable Livelihoods Framework (DFID, 1999)^[9] conceptualizes how people, especially in rural settings, use various forms of capital—natural, human, social, physical, and financial—to pursue livelihood strategies and achieve improved livelihood outcomes. The framework recognizes the centrality of vulnerability contexts—such as climate variability, economic shocks, and natural disasters—in shaping livelihood trajectories.

In the context of this study, the SLF is used to examine how climate change affects smallholder rice farmers' access to key livelihood assets and how this, in turn, influences their agricultural productivity and food security. For instance, natural capital (e.g., land, water) is directly impacted by droughts or floods, financial capital is constrained by crop failures and market fluctuations, while human capital (e.g., knowledge of climate-smart practices) is critical to resilience. By applying the SLF, the study can systematically analyze how climate-induced disruptions alter livelihood strategies and compromise food access and availability in rice-producing communities.

The SLF also provides a platform for evaluating the effectiveness of adaptive strategies such as crop diversification, irrigation, and adoption of climate-resilient seed varieties. These adaptations are mediated by institutional and policy factors (e.g., extension services, subsidies, access to markets), which influence how different farmers respond to climate risks. Thus, the SLF not only supports a multi-dimensional analysis of vulnerability but also offers a policy-relevant framework for identifying leverage points to improve farmer resilience and food security.

Conceptual Framework

The conceptual framework for this study, exploring the relationship between the independent variables (climate change indicators) and the dependent variable (agricultural productivity and household food security) being mediated by the intervening variables. The independent variables in this study are external stressors hypothesized to directly affect agricultural productivity which are temperature variability and heat stress, rainfall variability, extreme weather events (e.g., flooding, droughts, storms) and seasonal shifts. The intervening variables influence the strength and direction of the relationship between climate stressors and the outcomes of interest. They include access to resources, local governance and disaster response systems, and knowledge and awareness of climate change.

Materials and Methods

Study Area

Oyo State, located in the southwestern region of Nigeria, provides a compelling and contextually relevant setting for investigating the impacts of climate change on agricultural productivity and food security, particularly among rice

farmers. Geographically, Oyo State lies between latitudes 7°3' and 9°12' N and longitudes 2°3' and 4° E, covering a total land area of approximately 28,454 square kilometers. The state is bordered to the north by Kwara State, to the east by Osun State, to the south by Ogun State, and to the west by the Republic of Benin. Oyo is made up of 33 Local Government Areas (LGAs), many of which are predominantly agrarian, with a significant portion of the population engaged in small-scale farming activities, including rice cultivation (Oyo State Ministry of Agriculture, 2022).

Oyo State lies within the tropical rainforest and derived savanna zones, which provide suitable agro-ecological conditions for diverse crop production. Rice farming in Oyo has grown in prominence in recent years due to increased demand, state-supported agricultural initiatives, and the ecological potential for both upland and lowland rice production. The choice of Oyo State for this study is also justified by its growing relevance in national rice development strategies. This strategic positioning makes it a focal area for assessing how climate variability interacts with agricultural development efforts and food systems transformation. Oyo also offers a blend of upland and lowland rice ecologies, allowing for comparative analysis of climate impacts across different production systems. By focusing on rice farmers in Oyo State, this study can generate actionable insights into how localized climate risks intersect with socio-economic vulnerabilities and institutional responses, thereby contributing to the formulation of tailored climate adaptation strategies for smallholder farmers in Nigeria.

Population of the Study and Research Design

The study targets rice farming households in selected Local Government Areas (LGAs) of Oyo State, Nigeria. The population includes smallholder farmers who have cultivated rice for at least three consecutive years, ensuring reliable experience with climate variability and productivity outcomes.

A mixed-methods cross-sectional design is employed to assess the impact of climate change on productivity and food security. The quantitative component involves structured questionnaires administered to a representative sample of rice farmers. Data collected include socio-economic characteristics, climate perceptions, and adaptation strategies.

Sample Size and Sampling Techniques

This study adopted a multi-stage sampling technique to systematically select a total of 200 rice farming households across major rice-producing Local Government Areas (LGAs) in Oyo State. The multi-stage method was chosen to ensure balanced representation of the state's ecological and socio-economic diversity in rice production, while also enabling focused analysis of areas particularly exposed to climate change impacts.

In the first stage, five LGAs were purposively selected based on their prominence in rice cultivation, susceptibility to climate variability (e.g., rainfall irregularity, flooding), and availability of both upland and lowland rice ecologies. These LGAs include Iseyin, Atisbo, Saki East, Afijio, and Ogbomosho North.

In the second stage, two rural communities were randomly

selected from each of the five LGAs. The selected communities are as follows: from Iseyin LGA—*Oke-Ogun* and *Ajgunle*; from Atisbo LGA—*Tede* and *Ofiki*; from Saki East LGA—*Ago-Amodu* and *Sepeteri*; from Afijio LGA—*Ilora* and *Fiditi*; and from Ogbomosho North LGA—*Arowomole* and *Okelerin*. These communities were chosen because they have active rice farming populations and are accessible for field data collection.

In the third stage, 20 rice farming households were randomly selected from each of the ten identified communities using stratified random sampling. Stratification was based on relevant socio-demographic and farming variables such as gender of household head, farm size, and rice production system (upland vs. lowland). This strategy ensured a diverse sample reflective of varying experiences with climate change, levels of adaptive capacity, and food security status. Overall, the selected sample size of 200 respondents is statistically adequate for both descriptive and inferential analysis, while remaining manageable for in-depth field engagement.

Data Collection

The primary data collection instrument for this study was a structured questionnaire designed to gather detailed information from respondents in Oyo State. The questionnaire was administered to a representative sample of 200 smallholder rice farmers. Each session lasted approximately one hour, allowing respondents ample time to provide well-considered responses. To enhance validity and reliability, the questionnaire underwent pre-testing through a pilot study with a small group of participants who were not part of the main study. Based on feedback, necessary adjustments were made to improve its effectiveness. Additionally, trained enumerators facilitated the administration of the questionnaire, ensuring that respondents fully understood each question, thereby promoting accuracy and consistency in data collection for analyzing the impact of climate change on Oyo State's agricultural productivity and food security.

Data Analysis

The data collected in this study were analyzed using a combination of descriptive and inferential statistical techniques to address the study's objectives. Descriptive statistics, including percentages, frequency counts, and mean scores, were utilized to address Objective (i), which seeks to profile the socio-economic characteristics of rice farmers affected by climate change. To address Objective (ii)—which focuses on assessing the impact of climate variability on agricultural productivity—a 5-point Likert scale was used to capture farmers' perceptions and experiences regarding changes in rainfall, temperature, and other climatic variables, as well as their observed effects on yield, input costs, and planting cycles. Objective (iii), which aims to investigate the factors influencing stakeholders' willingness to adopt climate-smart agricultural (CSA) technologies, was analyzed using logit regression analysis. Additionally, Kendall's Coefficient of Concordance was used to examine the adaptation strategies employed by rice farmers to cope with climate change (Objective iv). The analysis was conducted using SPSS (Statistical Package for the Social Sciences), version 24, ensuring accuracy and efficiency in data processing.

Model specification

Model for Likert Scale Rating

The Likert scale was employed to assess perceptions of climate variability and its effects on rice production (Objective ii), as well as the extent of adoption of specific adaptation strategies (Objective iv). The 5-point Likert scale used was structured as follows:

- Strongly Agree (SA) - 5
- Agree (A) - 4
- Neutral (N) - 3
- Disagree (D) - 2
- Strongly Disagree (SD) - 1

The decision rule for interpreting the mean response was set at 2.5. A mean score ≥ 2.5 was interpreted as agreement (moderate to strong), while a mean < 2.5 indicated disagreement or low perception/impact.

To calculate the mean Likert score (X_s), the following formula was used:

$$X_s = \frac{\sum fn}{Nr}$$

Where:

- X_s = Mean score
- $\sum fn$ = Summation of the frequency of each response multiplied by its Likert weight
- n = Likert scale value (1-5)
- Nr = Total number of respondents

Logit Regression Model

To address Objective (iii)—which aims to examine the determinants influencing rice farmers' willingness to adopt climate-smart agricultural (CSA) technologies for mitigating the effects of climate change—a logistic regression model was employed. This econometric approach is appropriate for modelling binary outcome variables, where the dependent variable reflects the probability that a farmer adopts (or does not adopt) CSA technologies. The dependent variable Y is binary, taking a value of 1 if the farmer adopts CSA practices, and 0 otherwise. The implicit functional form of the logistic regression model is expressed as:

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})$$

The explicit form of the model is given as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + e$$

Where:

Y = Probability of adoption of climate-smart agricultural technologies (1 = adopt, 0 = not adopt)

X_1 = Age of the farmer

X_2 = Farming experience

X_3 = Gender

X_4 = Marital status

X_5 = Educational attainment

X_6 = Farm size

X_7 = Access to credit

X_8 = Membership in farmer associations or cooperatives

X_9 = Access to extension services

β_0 = Constant (intercept)

e = Error term

Kendall's Coefficient of Concordance

To address Objective (iv)—which seeks to examine the adaptation strategies employed by rice farmers in response to climate change—the study utilized Kendall's Coefficient of Concordance (W). Kendall's W was then calculated to measure the level of consensus among the farmers regarding which strategies were perceived as most effective.

The coefficient value of Kendall's W ranges from 0 to 1, where 0 indicates no agreement among respondents and 1 reflects perfect agreement. Higher values suggest stronger consensus on preferred adaptation responses. The formula for Kendall's W is as follows:

$$W = \frac{12 \sum (R_i - \bar{R})^2}{m^2 (n^3 - n)}$$

Where:

W = Kendall's Coefficient of Concordance,

R_i = Sum of ranks for each identified challenge,

$\bar{R}$ = Average rank,

m = Number of respondents (traditional medicine practitioners),

n = Number of ranked challenges.

Results and Discussion

Socio-Economic Characteristics of Respondents

The study revealed that 73% of the respondents were male, while 27% were female, indicating male dominance in rice farming in the study area. This aligns with common agricultural gender roles in Nigeria, where land access, decision-making, and financial control are often male-centered (Ayanlade & Oluwatoyin, 2023)^[7].

The average age of respondents was 45.6 years, with 36% aged 40-49. This suggests a mature and economically active farming population, though the presence of only 12.5% in the 18 - 29 age bracket indicates limited youth involvement. The aging farmer population raises concerns about generational transition and innovation adoption, as younger farmers are typically more responsive to modern agricultural technologies (Ojo & Akinyemi, 2023)^[23].

A significant proportion of farmers (78%) were married, followed by 14% single. Marital status often enhances household labour availability and stability in rural farming. Married farmers typically have more access to shared labour and are more likely to invest in long-term farm improvements (Afolami, Obayelu and Agbonlahor, 2020)^[4]. Most farmers had formal education: 42% had secondary education, and 19% had tertiary education. Only 15% had no formal schooling. Education is a strong predictor of climate change adaptation, as it improves awareness, decision-making, and the ability to interpret extension information (Ajayi *et al.*, 2023)^[6].

The respondents had an average of 16.2 years of farming experience. Most (34%) had 11-20 years, and 31% had over 20 years. This long-term experience suggests familiarity with local climatic conditions and agricultural practices (Eze, Onubuogu and Henri-Ukoha, 2022)^[10].

The average farm size was 1.95 hectares, with most respondents (38%) cultivating between 1.0-2.0 hectares. Limited landholding can restrict productivity, hinder mechanization, and constrain climate-smart investments (Agwu & Anyanwu, 2020)^[5].

About 60.5% of respondents were members of agricultural cooperatives. Cooperatives play a vital role in accessing credit, extension services, and collective resources for climate adaptation (Okpachu, Oladimeji and Ayanwale,

2023)^[25].

Approximately 63.5% of farmers had contact with extension agents. Farmers with regular extension contact are more likely to adopt climate-smart practices and technologies (Nnadi, Chikaire and Echetama, 2022)^[20].

Only 44.5% of respondents reported access to credit. The low credit access among respondents may limit their resilience to climate shocks and ability to scale up production (Adeola & Oluwatayo, 2021)^[2].

Table 1: Socio-Economic Characteristics of Respondents (n = 200)

Variable	Freq (n=200)	Percent
Gender		
Male	146	73.0
Female	54	27.0
Marital status		
Single	28	14.0
Married	156	78.0
Widowed	10	5.0
Divorced	6	3.0
Educational level		
No formal education	30	15.0
Primary school	48	24.0
Secondary school	84	42.0
Tertiary education	38	19.0
Age (Mean = 45.6 yrs)		
18 - 29 years	25	12.5
30 - 39 years	60	30.0
40 - 49 years	72	36.0
50 years and above	43	21.5
Farming Experience (Mean = 16.2)		
1 - 5	24	12.0
6 - 10	46	23.0
11 - 20	68	34.0
Above 20	62	31.0
Farm Size (Mean = 1.95 ha)		
Less than 1.0	39	19.5
1.0 - 2.0	76	38.0
2.1 - 3.0	53	26.5
Above 3.0	32	16.0
Cooperative Membership		
Member	121	60.5
Non-Member	79	39.5
Extension Agent Contact		
Yes	127	63.5
No	73	36.5
Access to Credit		
Yes	89	44.5
No	111	55.5

Source: Field Survey, 2025

Perceived Impacts of Climate Variability on Agricultural Production

The study found that irregular rainfall patterns significantly disrupted the planting season, as reflected in a mean score of 4.42. Consistent with Ajayi *et al.* (2023)^[6], erratic rainfall patterns shift the onset of the farming season, delay land preparation, and reduce yield potential by pushing planting beyond optimal agronomic windows.

The study found that higher temperatures have contributed to a reduction in rice yields, with a mean score of 4.17. Ajayi *et al.* (2023)^[6] observed that excessive temperatures during flowering and grain-filling stages limit physiological development, increase evapotranspiration, and reduce both

grain size and quantity in rainfed rice systems.

The study found that erratic weather patterns have increased pest and disease outbreaks, evidenced by a mean score of 4.14. This aligns with Eze *et al.* (2022)^[10], who reported that changing humidity and temperature levels accelerate pest cycles and disease incidence.

The study found that flooding was widely recognized as a major climatic threat, with a mean score of 3.86. Adebayo *et al.* (2021)^[1] affirm that heavy rains often exceed soil infiltration capacity, especially in lowland fields, leading to erosion and crop mortality before establishment or during critical early growth stages.

The study found that respondents rejected the notion that

climate variability had improved rice yield, with a mean score of 2.35. Musa and Danladi (2024) ^[18] reported similar outcomes, noting that yield fluctuations due to heat, drought, or untimely rainfall are predominantly detrimental, especially where adaptive technologies or early warning systems are absent.

The study found moderate agreement that warmer temperatures may accelerate rice maturity, as reflected in a mean score of 2.91. Ajayi *et al.* (2023) ^[6] explained that heat can reduce the number of days to maturity, allowing earlier harvesting, though sometimes at the cost of reduced grain weight and lower nutritional content due to shortened grain-filling periods.

The study found that climate change was not seen as reducing input costs, with a mean score of 2.22. This rejection suggests that climate variability has instead increased the need for costly inputs (Adeola and Oluwatayo, 2021) ^[2].

The study found that some farmers experienced total crop failure in certain years due to climate variability, with a mean score of 3.15. Chukwuezi, Anyanwu and Oparaocha (2024) ^[8] observed that such failures undermine household food security and income stability, particularly in poorly drained fields or where early warning and recovery mechanisms are limited.

Table 2: Perceived Impacts of Climate Variability on Agricultural Production (n = 200)

Statements	SA (5)	A (4)	N (3)	D (2)	SD (1)	Mean Score (Xs)	Decision
Irregular rainfall patterns have delayed planting seasons	118 (59.0%)	62 (31.0%)	10 (5.0%)	6 (3.0%)	4 (2.0%)	4.42	ACCEPTED
Increased temperatures have reduced rice yields	94 (47.0%)	70 (35.0%)	18 (9.0%)	12 (6.0%)	6 (3.0%)	4.17	ACCEPTED
Unpredictable weather increases pest and disease outbreaks	85 (42.5%)	78 (39.0%)	20 (10.0%)	12 (6.0%)	5 (2.5%)	4.14	ACCEPTED
Flooding has washed away planted crops	69 (34.5%)	75 (37.5%)	26 (13.0%)	18 (9.0%)	12 (6.0%)	3.86	ACCEPTED
Climate variability has improved overall rice yield	14 (7.0%)	24 (12.0%)	40 (20.0%)	61 (30.5%)	61 (30.5%)	2.35	REJECTED
Warmer climate has improved rice maturity time and shortened harvest period	25 (12.5%)	44 (22.0%)	48 (24.0%)	53 (26.5%)	30 (15.0%)	2.91	ACCEPTED
Climate change has reduced cost of input use	13 (6.5%)	21 (10.5%)	30 (15.0%)	70 (35.0%)	66 (33.0%)	2.22	REJECTED
Climate variability has led to complete crop failure in some years	42 (21%)	54 (27.0%)	31 (15.5%)	38 (19.0%)	35 (17.5%)	3.15	ACCEPTED

Source: Field Survey, 2025

Factors Influencing Willingness to Adopt Climate-Smart Technologies

The model statistics in Table 3 suggest that the model's Chi-Square statistic is statistically significant ($p < 0.01$), indicating that the independent variables collectively contribute to explaining the variation in stakeholders' willingness to adopt climate-smart technologies. The Nagelkerke R^2 value of 0.287 suggests that about 28.7% of the variance in the dependent variable is explained by the model. Among the nine (9) factors tested, six (6) factors had coefficients that were statistically meaningful: gender, age, educational level, farming experience, cooperative membership, and access to credit, while marital status, farm size, and contact with extension agents were not statistically significant.

The study found that gender was statistically significant at the 10% level, with a positive coefficient, indicating that male farmers were more likely to adopt climate-smart technologies. According to Adebayo, Olaniyi and Akintunde (2021) ^[1], men often have greater exposure to extension services and decision-making autonomy, which influences technology uptake.

The study found that age had a significant negative influence ($p < 0.05$) on the likelihood of adopting climate-smart technologies. This is consistent with Oladele and Papojuwu (2023) ^[26], who found that younger farmers are generally more receptive to innovations, possess higher digital literacy, and are more adaptable to changing

agricultural practices.

The study found that educational attainment was highly significant ($p < 0.01$) and positively associated with willingness to adopt climate-smart technologies. Farmers with higher levels of education were more likely to adopt innovations, likely due to increased understanding and better interpretation of extension messages (Ajayi *et al.*, 2023) ^[6].

The study found that farming experience had a negative coefficient and was significant at the 10% level, implying that more experienced farmers were less likely to adopt new climate-smart technologies. This may indicate reliance on traditional methods. Ajayi *et al.* (2023) ^[6] suggest that older, more experienced farmers may be risk-averse, preferring familiar practices over unproven innovations.

The study found that cooperative membership was highly significant ($p < 0.01$) with a strong positive influence on adoption. This supports findings by Irohibe and Agwu (2022) ^[15], who noted that cooperatives serve as platforms for information dissemination, collective input acquisition, and shared learning that enhances innovation uptake among smallholder farmers.

The study found that access to credit was statistically significant at the 5% level, positively affecting farmers' willingness to adopt climate-smart technologies. Musa and Danladi (2024) ^[18] emphasized that credit enables farmers to overcome capital constraints, particularly when adopting practices requiring initial investment, such as improved seed

varieties or irrigation.

The study found that marital status was not statistically significant in predicting willingness to adopt climate-smart technologies. Similar findings were reported by Eze *et al.* (2022) ^[10], who concluded that marital status does not necessarily shape farmers' perception or acceptance of agricultural innovations.

The study found that farm size did not significantly influence willingness to adopt climate-smart technologies. Olaniyi and Okonkwo (2020) ^[28] reported similar findings,

indicating that both small and large-scale farmers face adoption constraints such as input costs and information gaps, regardless of land size.

The study found that contact with extension agents did not significantly influence adoption in this context. While extension services are expected to support knowledge transfer, their effectiveness may be limited by access frequency or content relevance (Ojo and Akinyemi, 2023) ^[23].

Table 3: Logit Regression Estimates of Factors Influencing Willingness to Adopt Climate-Smart Technologies

Variable	Coefficient	Standard error	Odds Ratio (Exp(β))	P-value
Constant (β ₀)	-0.1398***	0.322	2.543	0.000
Gender	0.485*	0.260	1.625	0.065
Age	-0.034**	0.016	0.967	0.037
Marital Status	0.218	0.303	1.243	0.471
Educational Level	0.542***	0.193	1.719	0.006
Farming Experience	-0.059*	0.031	0.943	0.057
Farm Size	0.089	0.104	1.093	0.392
Cooperative Membership	0.661***	0.201	1.937	0.003
Extension Contact	0.334	0.227	1.396	0.141
Access to Credit	0.473**	0.195	1.604	0.015
Number of Observation	200.00			
LR Chi ² (9)	38.94			
Pseudo R ² (Nagelkerke)	0.287			
P-Value	0.000			
Log likelihood	-102.67			

Note: ***, ** and * indicate significance at 1%, 5% and 10% probability level respectively

Source: Field Survey, 2025

Rice Farmers' Adaptation Strategies to Climate Change Using Kendall's Coefficient of Concordance

The Kendall's *W* value of 0.614 indicates a moderate-to-strong level of agreement among farmers in their ranking of climate change adaptation strategies. The highly significant Chi-square value ($p < 0.01$) confirms that this agreement is statistically valid.

The study found that adjusting planting and harvesting dates had the highest rank (Mean Rank = 5.36), indicating it is the most widely adopted adaptation strategy. This aligns with findings by Ajayi *et al.* (2023) ^[6], who emphasized calendar adjustment as a practical, low-cost method for reducing risks posed by seasonal climate variability in Nigeria.

The study found that farmers ranked the use of drought-tolerant, early-maturing rice varieties second (Mean Rank = 5.02). This reflects the growing preference for resilient seed technologies to cope with erratic rainfall (Ajayi *et al.*, 2023) ^[6].

The study found that increased use of organic fertilizers ranked third (Mean Rank = 4.74). This corresponds with Musa and Danladi (2024) ^[18], who found that organic amendments enhance crop tolerance to drought and improve long-term productivity, especially under conditions of fluctuating rainfall and rising temperatures in southern Nigerian agro-ecological zones.

The study found that crop and livelihood diversification ranked fourth as an adaptive response (Mean Rank = 4.29). Eze *et al.* (2022) ^[10] highlighted diversification as a strategic

mechanism for building resilience among smallholders facing uncertain weather patterns and increased production volatility in Nigeria's food-producing regions.

The study found that irrigation was ranked fifth (Mean Rank = 4.08). While recognized as an important buffer against erratic rainfall, adoption was lower—likely due to cost and infrastructure barriers (Adebayo *et al.*, 2021; Olusanya *et al.*, 2025) ^[1, 30].

The study found that mulching and soil conservation were moderately adopted, ranking sixth (Mean Rank = 3.83). Ayanlade and Oluwatoyin (2023) ^[7] reported similar results, noting that soil conservation is crucial for rainfed agriculture, though adoption is often influenced by farmers' awareness levels and labour availability for implementing such physical conservation measures.

The study found that agroforestry ranked seventh (Mean Rank = 3.51), suggesting limited adoption. Irohibe and Agwu (2022) ^[15] observed that although agroforestry is climate-resilient, its complexity and capital requirements can discourage uptake, especially among farmers seeking more immediate, short-term coping strategies in vulnerable areas.

The study found that engaging in non-farm income activities ranked lowest. Ogundele, Akinola and Alamu (2023) ^[22] noted that while off-farm diversification supports resilience, barriers such as limited capital, skills, and rural job availability constrain participation in such adaptive livelihood options.

Table 4: Ranking of Farmers' Adaptation Strategies to Climate Change Using Kendall's Coefficient of Concordance (W)

Adaptation Strategy	Mean Rank	Rank
Adjusting planting and harvesting periods to align with changing rainfall patterns	5.36	1 st
Adoption of drought-tolerant and early-maturing rice varieties to cope with erratic weather conditions	5.02	2 nd
Increased application of organic manure and fertilizers to enhance soil resilience and productivity	4.74	3 rd
Diversification into alternative crops or complementary livelihoods to reduce climate-related risks	4.29	4 th
Utilization of small-scale irrigation systems to mitigate irregular rainfall distribution	4.08	5 th
Practicing mulching, cover cropping, and soil conservation to reduce moisture loss and erosion	3.83	6 th
Integrating agroforestry practices such as planting trees and shrubs alongside crops	3.51	7 th
Engaging in non-farm income-generating activities as a buffer against agricultural income fluctuations	3.17	8 th
Number of Respondents (m) = 200 Number of Strategies Ranked (n) = 8 Kendall's W = 0.614 Chi-Square (χ^2) = 860.04 Degrees of Freedom (df) = 7 p-value = 0.000		

Source: Field Survey, 2025

Conclusion and recommendations

This study examined the impact of climate change on agricultural productivity and food security among rice farmers in Oyo State, Nigeria, through four objectives: profiling socio-economic characteristics, assessing the impact of climate variability on agricultural production, identifying the determinants of willingness to adopt climate-smart technologies, and evaluating farmers' adaptation strategies.

The analysis of socio-economic data revealed that the farming population is predominantly male (73%) and middle-aged (mean age = 45.6 years), with a high percentage married (78%) and moderately educated—42% having attained secondary education. Farmers had an average of 16.2 years of farming experience and cultivated an average farm size of 1.95 hectares. Cooperative membership (60.5%), access to extension agents (63.5%), and agricultural credit (44.5%) were notable institutional attributes influencing their adaptive potential.

Climate variability was perceived as having both direct and indirect consequences on rice production. Empirical results showed that delayed planting and harvesting (mean = 4.42), reduced yields (mean = 4.17) and pest and disease outbreaks (mean = 4.14) were among the most significant adverse impacts. In contrast, factors such as improved overall rice yield (mean = 2.35) and reduced cost of input use (mean = 2.22) were rated below the decision threshold of 2.5 and thus considered negligible or unfavourable.

The logistic regression model identified key socio-economic and institutional variables influencing farmers' willingness to adopt climate-smart technologies. Educational attainment and cooperative membership were significant at the 1% level, demonstrating their strong predictive power. Age and access to credit were significant at the 5% level, while gender and farming experience were statistically significant at the 10% level. Variables such as marital status, farm size and contact with extension agents were not significant in this context. The model's statistical strength was supported by a Log-Likelihood of -89.531, a Pseudo R² of 0.643, and a highly significant Chi-square value ($\chi^2 = 122.88$, $p < 0.001$), indicating strong explanatory validity.

Farmers' adaptation strategies to climate change revealed a moderate consensus (Kendall's W = 0.614). The most highly ranked strategies were adjusting planting dates (mean rank = 5.36), using drought-tolerant and early-maturing

varieties (5.02), and applying organic inputs (4.74). Other adaptive responses such as crop diversification and irrigation were moderately prioritized, while strategies like agroforestry (3.51) and non-farm income generation (3.17) were less favoured.

Based on the findings from the study, the following recommendations are proposed to enhance the impact of climate change on agricultural productivity and food security among rice farmers:

1. Given the significant role that contact with extension agents plays in both awareness and adoption of climate-smart technologies, the government and development partners should scale up the number and capacity of extension personnel.
2. With access to credit emerging as a significant determinant of climate-smart technology adoption, financial institutions and agricultural programs should design low-interest, farmer-friendly loan schemes. These should be tailored to support investments in improved seed varieties, irrigation infrastructure, and other climate-resilient inputs.
3. As educational level significantly influenced the willingness to adopt adaptive practices, literacy and climate-smart agriculture (CSA) training should be integrated into rural capacity-building programs.
4. Local governments and stakeholders should develop participatory climate adaptation policies that integrate smallholder farmers' indigenous knowledge and practices.

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