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DETERMINANTS OF CLIMATE CHANGE ADAPTATION STRATEGIES AMONG RICE (*ORYZA SATIVA* L.) FARMING HOUSEHOLDS IN BENUE STATE, NIGERIA

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ABSTRACT

The study examined the determinants of climate change adaptation strategies among rice (*Oryza sativa* L.) farmers in Benue State, Nigeria. Multistage sampling technique was used to select 498 rice farmers across 24 rice farming communities, 6 Local Government Areas and 3 Agricultural Zones. Data were collected using structured questionnaires and analysed using descriptive statistics and multinomial logit model. Results showed that fertilizer application (85.94%), multiple plots (69.28%) and improved rice varieties (68.27%) were the major climate change adaptation strategies used. Age negatively influenced the tendency of using multiple plots (-0.030, P<0.05) and education positively influenced the probability of using improved rice varieties (0.119, P<0.01). Also, climate change experience positively influenced the probability of using multiple plots (0.166), crop diversification (0.166), multiple planting dates (0.150), irrigation (0.207), trees planting (0.319) at P<0.01 and improved rice varieties (0.146) at P<0.05. The study concluded that rice farmers in Benue State are actively engaged in adapting to climate change which is driven by experience and influenced by a spectrum of socio-economic factors (sex, age, education, experience, credit access, extension, cooperative membership) that influence the choice of specific climate change adaptation strategies among rice farmers. The study recommended that farmers should be encouraged and supported by government through extension services to scale up the adoption of climate change adaptation strategies. Also, government and relevant organisations should establish user-friendly climate information service systems that provide timely, accurate and context-specific climate forecasts, advisories and early warning signs.

Keywords: Rice, Farmers, Adaptation, Strategies, Climate, Change

INTRODUCTION

Rice is an essential component of food security effort. It is an important staple food in Nigeria accounting for 10.5% of the average caloric intake (FAO, 2024). Climate change poses significant threats to rice production in Nigeria, affecting food security and livelihood. The agricultural sector of Nigeria is predominantly rainfed and is highly vulnerable to climate related risks (FAO, 2024). For instance, rising temperatures, erratic rainfall, drought and flooding have become common resulting in reduced yields (IPCC, 2022). As a result, adaptation strategies are required to reduce the negative impacts of climate change on rice production.

Climate change has general impact on global food production as it is severely affecting the yields of most staple food crop like rice. Climate change threatens rice yields, both directly through changes in growth and production and indirectly through impacts on the crop diseases (Shahzad *et al*., 2021). It has been estimated that changes in climate have already been reducing global agricultural production by 1–5 % per decade over the last 30 years (Porter *et al.*, 2014). The greatest yield reductions have been observed in tropical cereals crops (especially rice). Yields in tropical regions are projected to decrease approximately by 5 % per degree Celsius of global warming in a multi-model ensemble (Franke *et al*., 2020). Given the magnitude of these climate-related threats, attention has been shifted to towards the deployment of climate change adaptation aimed at sustaining rice production efficiency.

Adjustment in agricultural systems is crucial to be implemented in areas that mainly rely on rainfed agriculture and face the changing climate (Belay *et al*, 2017). The conservation of agricultural system avoids further destruction of soil structure, improves the organic content in the soil and retains more water to maximize the crop yield, prevent soil erosion and downstream flooding (Olawuyi, 2020). Modification of agronomic techniques and farm strategies in order to cope with climate change is necessary to meet growing demand of agricultural produces. Adjustment of agricultural practices to reduce vulnerability to climate change involves planting drought resistant crops varieties, altering sowing time, shifting to new crops such as early maturing crops, use of irrigation, crop rotation, income diversification and crop diversification (Kogo *et al*., 2020; Aryal *et al*., 2021). When these adaptation strategies are adequately and effectively adopted, there will be increase in agricultural production of farm households and food security (Zakari *et al*., 2022).

Implementing adaptation strategies will help reduce the effect of climate change (Huang and Sim, 2021). The successful implementation of a country's adaptation strategies needs government involvement at national, regional, and local levels through different projects, programmes, policies or strategies to enhance adaptive capacity and strengthen institutions with regards to reducing climate change impacts (FAO, 2017). Adaptation strategies to climate change are expected to abate the effect of climate change; increase farmers' productivity through new or improved agricultural

practices and increase crop yield and farm income, which will consequently improve farm households' welfare as well as enhance adaptive capacity of the farm firm (Asmare *et al*., 2022). Adaptation strategies in agriculture enable farmers to alleviate the risks of damages and losses in food production (FAO, 2017). It can help improve crop yields for enhancing food security by using environmentally friendly techniques (Ho and Shimada, 2019).

There has been a growing body of literature on climate change adaptation in Nigeria. There is however, limited research on determinants of climate change adaptation strategies especially among rice farmers in Benue State. Benue State is among major rice producing states but available studies have focused only on national and regional levels (Ikpe and Omede, 2025). Hence, identifying and examining the determinants of climate change adaptation strategies is necessary to inform policies that enhance resilience. As a result, this study addressed the following research questions: What are the socioeconomic characteristics of rice farmers in the study area? What are the climate change adaptation strategies among rice farmers? What are the determinants of climate change adaptation strategies?

METHODOLOGY

Study Area

The study area is Benue State, which is located in the lower River Benue trough in the middle belt region of Nigeria. It lies within Longitude 7°47' and 10°0' East and Latitude 6°25' and 8°8' North (Ogbe, 2015). The total area covered by Benue State is 34,059 Km^2. The estimated population of Benue State for 2024 is 6,523,551 people based on NPC (2006) census record of 4,253,641 people. The State comprises 23 local government areas which are divided into three agricultural zones - Northeast, Northwest and Southern Agricultural Zones. The state shares boundaries with Nasarawa State to the North, Taraba State to the East, Kogi State to the West, Enugu State to the South-West, Ebonyi and Cross River States to the South and an international border with Cameroon to the South-East (Adebayo, 2018).

Benue State possesses a tropical climate with two distinct seasons- wet and dry seasons. The rainy season lasts from April to October with annual rainfall in the range of 900-1,500mm. The dry season begins in November and ends in March (Ocholi, 2020). Temperatures fluctuate between 21°C and 37°C. The south-eastern part of the State adjoining the Obudu-Cameroun Mountain range has a cooler climate similar to that of Plateau State. Benue State has high drainage density but many of the streams are seasonal. Hence, there is an acute water shortage in the dry season in Local Government Areas such as Guma, Okpokwu, Ogbadibo, Gwer West and Oju.

Agriculture is the mainstay of the economy of Benue State, engaging over 75% of the State's workforce. Soil types in the state vary but the dominant ones are sandy loam, clay loam and alluvial soils which support the production of a wide range of crops including yam, rice, beans, cassava, sweet potato, maize, soybean, sorghum, millet, sesame, cocoyam etc (Adebayo, 2018). The vegetation of the southern parts of the state is characterised by forests, which yield trees for timber and provide a suitable habitat for various animals' types and species. The state thus possesses potential for the development of viable forest and wildlife reserves.

The topography of Benue State is characterised by low-lying plains, rolling hills and river valleys, which makes the State vulnerable to environmental challenges such as flooding, soil erosion and desertification (Ijaiya, 2017; Ademiluyi, 2019;). The location of the State in the Niger-Benue River basin makes it prone to flooding which can have devastating effects on agricultural production and human settlements (Odjugo, 2018).

Benue State has high potentials for rice production with suitable land and water resources. The State is one the major rice producing areas in Nigeria (Adebayo, 2018). Efforts to improve rice production Benue State include the use of improved varieties, irrigation and mechanization. Despite the potential, rice production in Benue State is constrained by inadequate infrastructure, limited access to credit and climate change (FMARD, 2020).

Sampling Procedure and Data Collection

This study used a multi-stage sampling procedure; thus, Benue State was divided into 3 Agricultural Zones namely: North West, North East, and Southern Agricultural Zones. The second stage involved the selection of Local Government Areas (LGAs). Simple random sampling was used to select 2 LGAs from each Agricultural Zone, namely; Logo and Konshisha from North East, Guma and Buruku from North West and Agatu and Apa from Southern Agricultural Zone. The third stage involved the selection of rice farming communities. Four communities were selected from each of the selected LGAs purposively based on; accessibility, level of rice production activities, political unrest, conflict and/or instability. The fourth stage involved randomly selecting 505 rice farmers who were used for this study. The farmers were selected from the four communities. Taro Yamane formula with precision error term of 4.1% was used to determine the sample size. The formula is given as:

$$n = \frac{N}{(1+Ne^2)}$$

Where:
n = sample size
N = population of registered rice farmers
e = error term.

Data were collected using questionnaire. The questionnaire focused on socio-economic characteristics and climate change adaptation strategies. The questionnaires were administered by well-trained enumerators and 498 of questionnaires were returned and used in analysis. The questionnaire was tested for validity and reliability using content validity and test-retest reliability respectively.

Analytical Technique

The data collected for this study were analysed using both descriptive and inferential statistical techniques. Descriptive statistics including frequency, percentage and mean were employed to describe the socio-economic characteristics of the respondents and to identify the climate change adaptation strategies used. Multinomial logistic regression model was used to examine the factors influencing the probability of using climate change adaptation strategies.

The multinomial logit model was used to specify the relationship between adoption of climate change adaptation strategies (fertilizer [organic/inorganic], multiple plots, improved varieties, integrated pest management, crop diversification, multiple planting dates, water irrigation and trees planting) and socio-economic characteristics of rice farmer (Adams and Merrills, 2022). The model was specified as;

$$Y_j(j = F, MP, IV, IPM, CD, I, MPD, TP) = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \varepsilon_j \quad \ldots (1)$$

Where:

Y_j = climate change adaptation strategies (F, MP, IV, IPM, CD, I, MPD and TP) choice.

X_1 = sex measure (1 for male, 0 otherwise).

X_2 = age measured in years.

X_3 = household size (number of persons living together in household).

X_4 = education (years).

X_5 = farming experience (years).

X_6 = annual income (Naira).

X_7 = climate change years of experience (years).

β_0 = intercept

$\beta_1 - \beta_7$ = coefficients.

ε_j = disturbance term.

F = fertilizer [organic/inorganic] application). Fertilizer application was used as the base or reference category.

MP = multiple plots.

IV = improved varieties of rice.

IPM = integrated pest management.

CR = crop diversification.

MPD = multiple planting dates.

I = irrigation.

TP = trees planting.

Also, 1 if an adaptation strategy was used by a rice farmer, 0 otherwise.

The probability of a rice farmer using climate change adaptation strategy following Greene (2018) is given by:

$$P(Y = j) \frac{\varepsilon^{\beta_j X_j}}{1+\sum_{m=0}^{7} \varepsilon^{\beta_m X_j}} \quad \ldots (2)$$

$$j = 0,1, \ldots, 7$$

where β_j is a vector parameter that relates the socio-economic characteristics (X) to the probability that Y = j. Because the probability of the climate adaptation strategies must sum up to one, a convenient normalisation rule is to set one of the vector parameters to zero.

Insight into the influence that the socio-economic characteristics had on the climate change adaptation strategies decisions were captured by examining the derivative of the probabilities with respect to the element of the vector of socio-economic characteristics.

$$P_j \equiv P(Y = j) = \frac{\varepsilon^{\beta_j X_j}}{1+\sum_{m=0}^{7} \varepsilon^{\beta_m X_j}} \quad \ldots (3)$$

$$j = 0,1,2, \ldots, 7$$

$$P_0 \equiv P(Y = j) = \frac{1}{1+\sum_{m=0}^{7} \varepsilon^{\beta_m X_j}} \quad \ldots (4)$$

The marginal effect in the multinomial logit model represented the change in the probability of using a climate change adaptation strategy in response to a unit change in the socio-economic characteristics of a rice farmer while holding other socio-economic characteristics constant (Greene, 2018). The marginal effect was given as:

$$\frac{\partial p(y=j)}{\partial x_i} = P_j\left[\beta_j - \sum_{m=0}^{7} p\,(y = m)\beta_j\right] j = 0, 1, \ldots, 7; i = 1, \ldots, 7 \quad \ldots (5)$$

The signs of the marginal effects did not bear any relationship to the sign of coefficients and were hence assumed to be absolute values.

RESULTS AND DISCUSSION

Socio-economic Characteristics

Table 1 reveals that 62.85% of respondents were male while 37.15% were female, indicating male dominance in rice production in the study area. Male dominance suggests that current production gains from climate change adaptation strategies may be skewed toward male farmers due to relatively better access to land and capital. Male farmers are more likely to adopt resource-intensive adaptation measures that improve productivity. However, the substantial female participation indicates untapped potential. If female farmers are provided equal access to adaptation technologies, credit and extension, overall productivity of rice production in Benue State will improve. This implies the need for gender-inclusive adaptation policies. This result is consistent with Agyo and Ornan (2021) and Banseka *et al*., (2023), who reported male dominance in rice farming in Taraba State and associated it with differential resource access affecting production efficiency.

Also, 36.14% of respondents were aged 31-40 years, 28.92% were 41-50 years, 22.09% were 21-30 years, 8.84% were 50-60 years and 4.01% were 61 years and above. The mean age was 39.15 years. The mean age of farmers indicates an economically active and physically strong labour force. Farmers of this age are more receptive to information and are more likely to adopt and correctly implement climate change adaptation strategies such as improved rice varieties, multiple planting dates and improved frequency of irrigation. This enhances productivity because innovations are adopted faster, inputs are applied at optimal rates and

climatic variations are managed with fewer errors. Thus, the age structure of rice farmers in Benue State is favourable for increasing rice output per unit of input. This finding agrees with Obianefo *et al*. (2020) and Orifah *at al*. (2021), who reported mean ages of 42 years and 40.79 years for rice farmers in Anambra and Jigawa States respectively and linked this productive age to higher efficiency.

Furthermore, 69.88% of respondents were married, 20.48% were single, 7.83% were widowed, and 1.81% were divorced. Married farmers constituted the majority. The high proportion of married respondents implies greater availability of family labour. Family labour reduces dependence on costly hired labour and enables timely execution of farm operations such as land preparation, planting, weeding and climate change adaptation strategies. Timeliness is critical for efficiency in rice production. Married farmers are also more willing to adopt labour intensive climate change adaptation strategies because household labour can be mobilized without increasing monetary cost, thereby improving output per unit cost and overall productivity. This finding corroborates Banseka *et al*. (2023) in a study on on socio-economic and constraints analysis of FARO-44 rice farmers under FADAMA III additional finance II in Taraba State, Nigeria that majority of rice farmers in Taraba State were married. The result also aligns with the findings of Wabi *et al*. (2022) that majority of rice farmers in Benin Republic were married.

Also, 53.82% of respondents had 6-10 household members, 38.35% had 1-5 members, 7.23% had 11-15 members and 0.60% had 16 members and above. The mean household size was 6 persons. A mean household size of 6 persons represents a relatively large labour pool. This reduces labour bottlenecks and transaction costs associated with hired labour. Large households can effectively use labour intensive climate change adaptation strategies such as organic manure application, land leveling, and manual water control, which improve productivity by ensuring operations are carried out at the optimal time and with adequate quality. Consequently, this household structure supports higher rice yield per unit of input used. This result aligns with Adekunmi (2022) and Issa and Adiyu (2020), who reported mean household sizes of 7 and 8 persons for rice farmers in Ondo and Kaduna States respectively.

Table 1 also shows that, 43.57% of respondents had 6-10 years' experience, 31.33% had 1-5 years, 16.06% had 11-15 years, 5.22% had 16-20 years, and 3.82% had 21 years and above. The mean farming experience was 8.62 years. The average experience of 8.62 years indicates that respondents possess adequate practical knowledge of rice production systems in Benue State. Experienced farmers are better able to identify climate risks and select appropriate adaptation strategies. They also apply inputs more effectively, avoid wastage, and minimize losses from trial-and-error. This improves productivity because maximum output is obtained from a given set of inputs. Moderate experience also implies that farmers are receptive to new adaptation technologies, unlike very aged farmers who may be more risk-averse. This finding is consistent with Alabi and Anekwe (2022), who reported 7 years average experience among rice farmers in Federal Capital Territory, Abuja.

Additionally, 47.59% of respondents had secondary education, 30.52% had tertiary education, 11.45% had no formal education and 10.44% had primary education. Respondents spent an average of 10.61 years in formal education. The average of 10.61 years of formal education, equivalent to secondary school completion, indicates that most respondents are literate. Literate farmers can read and interpret climate forecasts, extension bulletins and agronomic recommendations on climate-smart practices such as integrated soil fertility management and water-saving technologies. This improves productivity because inputs are applied correctly and adaptation measures are used as recommended, reducing wastage. Education also lowers the cost of acquiring new knowledge, thereby increasing efficiency in resource use. This finding agrees with Agyo and Ornan (2021), who reported that rice farmers in Taraba State had an average of 10.27 years of formal education and were able to read, write, and understand printed media on climate adaptation.

Furthermore, 41.37% of respondents earned ₦1 - ₦1,000,000 annually, 28.71% earned ₦1,000,001 - ₦2,000,000, 17.47% earned ₦2,000,001 - ₦3,000,000, 6.22% earned ₦3,000,001 - ₦4,000,000 and 6.22% earned ₦4,000,001 and above. Mean annual income was ₦1,789,660.60. The average annual income of ₦1,789,660.60 indicates moderate financial capacity. Higher income enables farmers to purchase improved inputs such as improved rice varieties seeds, fertilizers and small-scale irrigation equipment needed for climate change adaptation. This improves productivity by ensuring timely and adequate input use. Income also reduces credit constraints, allowing farmers to adopt profitable adaptation strategies without delay. However, income variation suggests that low-income farmers may lag in adoption, creating efficiency gaps within the study area. This result is similar to estimates by Counseal Team (2024), which reported that rice farmers in Nigeria can earn between ₦3,000,000 and ₦4,800,000 annually depending on scale and management.

Also, 50.80% of respondents had 1-5 years of climate change experience, 36.14% had 6-10 years, 8.03% had 11-15 years, 4.02% had 16-20 years and 1.00% had 21 years of climate change experience and above. Mean climate change experience was 6.50 years. This indicates that most farmers are aware of climate variability and have observed its impact on rice yields. This awareness motivates adoption of adaptation strategies such as multiple planting dates, using

improved rice varieties and water conservation. Experienced farmers are more likely to select appropriate adaptation measures and avoid maladaptation, thereby improving efficiency by minimizing yield losses. Climate experience therefore enhances decision-making and resource allocation efficiency in rice production. This aligns with Madaki *et al*., (2023), who found that farmers in North Central and Northwest Nigeria are aware of climate change with years of experience.

Table 1: Distribution of Respondents Based on Socio-Economic Characteristics

Socio-Economic Characteristics	Frequency	Percentage	Mean
Sex			
Male	313	62.85	
Female	185	37.15	
Age			**39.153**
21-30	110	22.09	
31-40	180	36.14	
41-50	144	28.92	
51-60	44	8.84	
≥61	20	4.02	
Marital status			
Single	102	20.48	
Married	348	69.88	
Widowed	39	7.83	
Divorced	9	1.81	
Household size			**6.466**
1-5	191	38.35	
6-10	268	53.82	
11-15	36	7.23	
≥16	3	0.60	
Level of education			**10.608**
No formal education	57	11.45	
Primary	52	10.44	
Secondary	237	47.59	
Tertiary	152	30.52	
Farming experience			**8.618**
1-5	156	31.33	
6-10	217	43.57	
11-15	80	16.06	
16-20	26	5.22	
≥21	19	3.82	
Annual income			**1789660.600**
1-1000000	206	41.37	
1000001-2000000	143	28.71	
2000001-3000000	87	17.47	
3000001-4000000	31	6.22	
≥4000001	31	6.22	
Climate change years of experience			**6.504**
0-5	253	50.80	
6-10	180	36.14	
11-15	40	8.03	
16-20	20	4.02	
≥21	5	1.00	

Source: Field Survey Data, 2025

Climate Change Adaptation Strategies

Climate change adaptation strategies are the actions the respondents taken to manage the risks and opportunities associated with climate change. The aim of using the strategies is to enable farmers cope with the impacts of climate change (Asmare *et al*., 2022).

Table 2 shows that 85.94% of farmers used fertilizer application as a climate change adaptation strategy. The widespread use indicates recognition of the role of soil fertility in buffering rice yields against climate stress such as erratic rainfall and high temperature. Optimal fertilizer use improves productivity by ensuring that nutrient limitations do not constrain yield response to other inputs. When combined with climate adaptation

practices, fertilizer increases output per unit of land and labour, reducing yield gaps caused by climate-induced soil nutrient depletion. This enhances resource-use efficiency and economic returns. This result agrees with Emmanuel *et al*. (2024), who observed that 83.0% of farmers in Jos-South, Plateau State applied fertilizer as a coping strategy to maintain yields under climate change.

Also 68.27% of farmers used improved rice varieties that can withstand flooded conditions, resist drought, and/or mature early. Adoption of climate-resilient varieties improves efficiency by reducing crop failure and stabilizing yields under stress. Early-maturing varieties allow farmers to escape late-season drought, while flood- and drought-tolerant varieties maintain physiological performance under stress, increasing output per unit of input. This reduces risk and improves input productivity. This finding aligns with Gbemavo *et al*. (2022), who reported that 76.4% of rice farmers in Benin used flood-tolerant varieties to manage negative impacts of climate change.

Similarly, 69.28% of farmers cultivated multiple plots in different locations to reduce risk and increase resilience to climate-related shocks. Multiple plots enhance efficiency by reducing total crop loss when one plot is affected by flood or drought. This risk-spreading strategy stabilizes farm output and improves average yield per unit of labour and input. It also allows farmers to exploit variations in soil moisture and fertility increasing overall resource-use efficiency across the farm holding. This result aligns with Adeagbo *et al*. (2023), who found that 70.1% of smallholder farmers in Southwestern Nigeria used multiple plots to adjust to changes in climatic conditions.

Also, 53.21% of respondents used integrated pest management including cultural, biological and chemical control methods to manage climate-related pest and disease pressures. Integrated pest management improves productivity by minimizing crop losses to pests and diseases while reducing over-reliance on chemical pesticides. Targeted pesticide use lowers input cost and environmental damage, increasing output per unit cost. By maintaining plant health under changing climate conditions, integrated pest management stabilizes yields and improves efficiency of resource utilization. This result is consistent with Erekalo and Yadda (2023), who reported that 52.2% of farmers in Ethiopia applied integrated pest management to control pests associated with climate change.

Furthermore, 47.19% of respondents diversified to other crops to cope with adverse effects of climate change. Diversification to other crops improves productivity by reducing dependence on a single crop whose yield may be depressed by climate shocks. It ensures income stability and allows better utilization of family labour across the cropping calendar. While rice remains the focus, intercropping or rotation with compatible crops can improve soil health and input-use efficiency, contributing to sustainable production efficiency. The result of this study similar to that of Erekalo and Yadda (2023) in a study on climate-smart agriculture: adoption of multiple crop production practices as sustainable adaptation and mitigation strategies in Ethiopia, that over 58.31 % of the farmers in Ethiopia used crop diversification to mitigate climate change related risks.

Also, 42.17% of farmers used multiple planting dates to reduce risk of crop failure due to irregular rainfall patterns. Multiple planting date improves productivity by increasing the probability that at least one planting date coincides with favourable moisture conditions. This reduces risk of total crop failure and stabilizes yield across seasons. It also allows better distribution of labour, reducing peak-load constraints and improving labour productivity. Farmers who monitor weather forecasts can capitalize on favourable conditions, increasing output per unit input. This result aligns with Diallo *et al*. (2020) who used percentage to identify farm-level climate change coping strategies and soil management practices in southern Mali reported that close to half of the farmers adopted changes in planting dates across the planting season.

Additionally, 12.65% of rice farmers used irrigation as climate change adaptation strategies to control insufficient water during periods of dry spells. The low adoption rate suggests resource constraints such as limited access to irrigation facilities, pumps and capital. Where used, irrigation improves productivity by preventing yield losses from moisture stress. It ensures optimal soil moisture for rice growth, increasing water productivity and output per unit input. Promoting low-cost irrigation practices can therefore yield significant efficiency gains in the study area. This result is in line with Zagre *et al*. (2024), who observed that 6.0% of rice farmers in Senegal's Semi-Arid Zone practiced irrigation to reduce climate impacts.

Finally, 11.04% of rice farmers used trees planting to provide shade, improve soil health, and reduce erosion. Low adoption suggests limited awareness and technical knowledge. Where practiced, trees planting improves productivity by enhancing soil organic matter, reducing erosion losses, and moderating microclimate. Trees also provide alternative income, reducing pressure on rice yields. Integrating trees planting with rice can improve long-term productivity per unit of land and input, contributing to sustainable rice production. This result aligns with Okon *et al*. (2020), Mbow *et al*. (2019), and Nguyen *et al*. (2021), who reported 20.0% adoption in Southeast Nigeria, 5.0% in West Africa and 15.0% in Asia respectively, indicating that trees planting adoption remains low but beneficial for climate adaptation.

Table 2: Distribution of Respondents according to Climate Change Adaptation Strategies Used

Climate Change Adaptation Strategies	Frequency*	Percentage
Fertilizer application (FA)	428	85.94
Multiple plots (MP)	345	69.28
Improved varieties (IV)	340	68.27
Integrated pest management (IPM)	265	53.21
Crop diversification (CD)	235	47.19
Multiple planting dates (MPD)	210	42.17
Irrigation (I)	63	12.65
Trees planting (TP)	55	11.04

Source: Field Survey Data, 2025 * = multiple responses

Determinants of Climate Change Adaptation Strategies

Ability farmers to adapt to climate change depends largely on their socio-economic characteristics. Understanding these factors is critical for designing effective policies that promote adoption of output-enhancing adaptation strategies. This section determines the effect of socio-economic characteristics on the use of various climate change adaptation strategies among rice farmers in Benue State, Nigeria.

A multinomial logit (MNL) model was used, with fertilizer application as the base/reference category. The coefficients in Table 3 indicate the direction of effect of each socio-economic variable on the choice of a particular adaptation strategy relative to fertilizer application. Negative coefficients imply higher tendency to use fertilizer application. The marginal effects in Table 4 represent the change in probability of adopting a given strategy resulting from a unit change in a socio-economic variable, holding other factors constant. Table 3 shows that the chi-square statistic (χ^2 = 177.075, P<0.01) was significant, indicating that the socio-economic variables included in the model jointly influenced farmers' decision to use climate change adaptation strategies.

Table 3 also shows that, age had a negative and significant effect on the likelihood of using multiple plots (-0.030) at P<0.05. The marginal effect shows that a unit increase in age decreases the probability of using multiple plots by 0.001. This implies that older farmers tend to prefer fertilizer application over multiple plots. Older farmers' preference for fertilizer over multiple plots suggests reliance on input intensification rather than risk-spreading. While fertilizer improves output by addressing nutrient constraints, younger farmers who adopt multiple plots improve output through risk diversification and better use of heterogeneous land. Promoting labour saving multiple plot management for older farmers can help maintain productivity with farmers' age. The result corroborates Khalid *et al*. (2022), who found a negative relationship between age and the use of cultivation of plots located in different locations to cope with climate change.

Furthermore, household size had a significant negative effect on the likelihood of using integrated pest management (-0.174) at P<0.05 and trees planting (-0.024) at P<0.05. Marginal effects indicate that an increase in household size by one person decreases the probability of adopting integrated pest management and trees planting by 0.008 and 0.001 respectively. This implies that farmers with larger households are more likely to adopt fertilizer application than integrated pest management and trees planting. Large households prioritize immediate food production through fertilizer use to meet consumption needs, often at the expense of long-term sustainability strategies like integrated pest management and trees planting. While fertilizer boosts short-term productivity, underinvestment in integrated pest management and trees planting may reduce long-run productivity due to pest buildup and soil degradation. Policies that integrate food security support with incentives for sustainable practices can balance immediate and long-term productivity. This result confirms Baffour-Ata *et al*. (2025), who reported that household size had a negative influence on the decision to use integrated pest management as a climate-smart agricultural practice.

Also, level of education had a significant positive effect on the probability of using improved rice varieties (0.119) at P<0.01 but a significant negative effect on tendency of using multiple plots (-0.114) at P<0.05). Marginal effects show that a unit increase in years of schooling increases the probability of using improved varieties by 0.003 and decreases the probability of using multiple plots by 0.003. This means that as education increases, farmers are more likely to use fertilizer application and improved varieties to reduce climate change effects. Education enhances output by improving farmers' ability to understand and correctly apply information on climate-resilient varieties. Educated farmers select improved rice varieties that maximize output per unit input under stress, reducing yield gaps. Their preference for fertilizer and improved rice varieties over multiple plots indicates focus on input productivity rather than multiple plots, which can improve economies of scale. This result confirms Khalid *et al*. (2022), who found that level of education had a positive influence on

the use of improved varieties to cope with climate change.

Similarly, farming experience had a significant positive effect on the likelihood of using integrated pest management (0.226) at P<0.01 and a significant negative effect on probability of using crop diversification (-0.010) at P<0.05. Marginal effects show that an additional year of experience increases the probability of using integrated pest management by 0.003 and decreases the probability of crop diversification by 0.001. This means that experienced farmers are more likely to use integrated pest management and fertilizer application rather than crop diversification. Experience improves efficiency by enhancing farmers' ability to identify pest problems and apply integrated pest management correctly, reducing crop losses and input waste. Experienced farmers' focus on rice intensification with fertilizer and integrated pest management, rather than diversification, suggests specialization that can improve input-use efficiency and yield per unit land. However, reduced diversification may increase risk, so balancing specialization with minimal diversification can sustain long-term efficiency. The result aligns with that of Atube *et al*. (2021) that adoption of fertilizer application to improve soil nutrient is positively influenced by farming experience.

Also, annual income had a significant negative effect on the likelihood of using integrated pest management (-0.128) at P<0.01 and a significant positive effect on tendency of using irrigation (0.380) at P<0.05. Marginal effects show that a unit increase in income changes the probability of using integrated pest management and irrigation by -0.019 and 0.006 respectively. This implies that higher-income farmers are less likely to use integrated pest management but more likely to use fertilizer application and irrigation. Higher income enables investment in capital-intensive strategies like irrigation that directly improve output through better moisture control. The reduced use of integrated pest management among high-income farmers may reflect substitution of labour-intensive integrated pest management with chemical control, which can be efficient in the short term but may reduce environmental efficiency over time. Income thus drives adoption of strategies with immediate returns. This result agrees with Petros *et al*. (2025), who found that income had a positive influence on the decision to use soil fertility management and bunding as climate-smart agriculture practices.

Finally, climate change experience had a positive and significant effect on the likelihood of using multiple plots (0.166) at P<0.01, improved rice varieties (0.146) at P<0.05, crop diversification (0.166) at P<0.01, multiple planting dates (0.150) at P<0.01, irrigation (0.207) at P<0.01 and trees planting (0.319) at P<0.01. Marginal effects show that an additional year of climate experience increases adoption probabilities by 0.004 to 0.007 across strategies. Climate change experience enhances farmers' perception of risk and motivates the use of multiple adaptation strategies. This improves output by reducing exposure to climate shocks and stabilizing yields. Experienced farmers combine input-based strategies like improved rice varieties with risk-spreading strategies like multiple plots and multiple planting dates, achieving higher output per unit input and greater resilience. Climate experience is therefore a key driver of productivity in rice production. This result aligns with Abdussalam and Mohammed (2023), who found that farmers' experience with climate change over the years informed their decision to adopt adaptation strategies along River Benue in Adamawa State, Nigeria.

Table 3: Determinants of Climate Change Adaptation Strategies

Variables	MP	IV	IPM	CD	MPD	WM	AF
Age	-0.030 (-2.17**)	-0.009 (-0.42)	0.011 (0.53)	-0.030 (0.66)	-0.014 (-0.63)	-0.045 (-1.60)	0.001 (0.03)
Household size	-0.027 (-0.34)	0.095 (1.45)	-0.174(-2.07**)	-0.027 (0.36)	-0.083 (-1.15)	-0.013 (-0.17)	-0.024(-2.06**)
Level of education	-0.114(-2.53**)	0.119 (4.61***)	0.047 (1.19)	-0.004 (-0.55)	0.038 (1.00)	0.012 (0.29)	0.015 (0.20)
Farming experience	-0.010 (-0.19)	-0.060 (-1.36)	0.226 (3.30***)	-0.010(-2.05**)	0.006 (0.14)	0.022 (0.47)	-0.061 (-0.86)
Annual income	0.028 (0.16)	-0.014 (-0.09)	-0.128(-2.78***)	0.028 (-0.65)	0.228 (1.54)	0.380 (2.35**)	-0.120 (-0.37)
Climate change experience	0.166 (3.01***)	0.146 (2.80**)	0.070 (1.25)	0.166 (2.69***)	0.150 (3.00***)	0.207 (3.75***)	0.319 (4.46***)
Constant	-0.556 (-1.04)	-0.800 (-1.04)	-1.993(-2.16**)	-0.556 (-1.30)	-1.614 (-1.85*)	-2.205 (-2.14**)	-4.348(-2.65**)
Number of observations			**498**				
Chi-square			**177.075**				
Prob > chi-square			**0.000**				
Pseudo r-squared			**0.091**				
Log likelihood			**-888.5424**				

Source: Field Survey Data, 2025
**** P<0.01, ** P<0.05, * P<0.10*
MP, IV, IPM, CD, MPD, I and TP respectively Stand for Multiple Plots, Improved Varieties, Integrated Pest Management, Crop Diversification, Multiple Planting Dates, Irrigation and Trees Planting. Values in Parentheses Stand for Z-scores.

Table 4: Marginal Effects of Determinants of Climate Change Adaptation Strategies

Variables	MP	IV	IPM	CD	MPD	WM	AF
Age	0.001 (0.20)	0.003 (1.34)	-0.001 (-0.35)	0.002 (1.07)	-0.003 (-1.60)	0.001 (0.35)	-0.002 (-1.11)
Household size	0.016 (2.30**)	0.004 (0.058)	-0.008 (-1.27)	-0.015 (-2.33**)	0.001 (0.04)	0.001 (0.38)	-0.001 (-0.25)
Level of education	-0.003 (-1.00)	-0.003 (-0.86)	0.004 (1.27)	0.004 (1.30)	0.001 (0.15)	0.001 (0.12)	-0.001 (-0.27)
Farming experience	-0.005 (-0.99)	-0.009 (-1.83*)	0.003 (0.96)	-0.001 (-0.04)	0.004 (1.34)	-0.001 (-0.60)	0.001 (0.40)
Annual income	-0.009 (-0.55)	-0.022 (-1.26)	0.019 (1.49)	0.006 (0.55)	0.025 (2.49**)	-0.006 (-0.670)	0.003 (0.20)
Climate change experience	0.005 (0.92)	0.004 (0.85)	0.004 (0.96)	-0.004 (-1.03)	0.007 (2.17**)	0.005 (2.95***)	0.005 (1.32)

Source: Field Survey Data, 2025
****** P<0.01, ** P<0.05, * P<0.10***
MP, IV, IPM, CD, MPD, I and TP respectively Stand for Multiple Plots, Improved Varieties, Integrated Pest Management, Crop Diversification, Multiple Planting Dates, Irrigation and Trees Planting. Values in Parentheses Stand for Z-scores.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study concludes that rice farmers in Benue State are actively engaged in adapting to climate change. This is driven by their experiences and influenced by a spectrum of socio-economic factors (sex, age, education, experience, credit access, extension, cooperative membership) that influence the choice of specific climate change adaptation strategies among rice farmers.

Recommendations

Based on the findings and conclusion of the study, the following recommendations were made:

i. Support for farmers' associations and cooperatives by government should be strengthened, as they can serve as platforms for knowledge sharing and collective action.
ii. Financial institutions and government programs should develop and promote accessible financial services, including targeted loans and credit facilities with clear information on sourcing options to overcome poor access to credit.
iii. Farmers should be encouraged and supported by government through extension services to scale up the adoption of climate change adaptation strategies.
iv. Government and relevant organisations should establish user-friendly climate information service systems that provide timely, accurate and context-specific climate forecasts, advisories and early warning signs. This information should be disseminated through accessible channels.

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