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Farmers' Perception and Adaptation Strategies to Climate Change in Wurno Local Government Area, Sokoto State, Nigeria

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Abstract- ***Climate change poses a significant threat to rain-fed agriculture in northwestern Nigeria, where smallholder farmers are increasingly exposed to rising temperatures, erratic rainfall, and declining agricultural productivity. This study assessed farmers' perceptions of climate change, identified adaptation strategies, and examined factors influencing adaptation among crop farmers in Wurno Local Government Area, Sokoto State. A cross-sectional survey design was adopted, involving 400 farmers selected through a multistage sampling technique. Data were collected using structured questionnaires, key informant interviews, and field observations and analyzed using descriptive statistics and linear regression. The findings showed that farmers had a high perception of climate change, with an overall grand mean of 3.18. Rising temperature (3.62) early cessation of rainfall (3.55) delayed rainfall onset (3.48) and declining annual rainfall (3.31) were the most strongly perceived indicators. The most widely adopted adaptation strategies were the use of early-maturing and drought-tolerant crop varieties (78.5%) adjustment of planting dates (71.0%) and crop diversification (66.5%). Regression analysis revealed that education, access to extension services, farmers' association membership, credit access, farming experience, farm size, and annual income significantly influenced adaptation levels. The study concludes that strengthening extension services, improving access to credit and education, supporting farmer cooperatives, and rehabilitating irrigation infrastructure are essential for enhancing climate resilience among smallholder farmers in Wurno LGA.***

Keywords- ***farmers' perception; adaptation strategies; smallholder farmers.***

I. INTRODUCTION

Climate change has become one of the most pressing environmental challenges confronting agricultural systems globally, with profound implications for food security and rural livelihoods. Since the 1850s global temperatures have risen steadily, primarily due to increased greenhouse gas emissions resulting from fossil fuel combustion, agricultural intensification and widespread deforestation undertaken to meet growing energy and food demands (FAO, 2009). This warming trend is expected to continue leading to long-term changes in weather patterns that increasingly threaten climate-sensitive sectors, particularly agriculture. The global agricultural sector is experiencing an unprecedented structural crisis driven by accelerating climate change, with Sub-Saharan Africa emerging as one of the regions most vulnerable to both ecological and socio-economic impacts (Bosekeng, 2020). Agriculture across much of the region remains predominantly rain-fed making farming systems highly susceptible to deviations from historical climatic conditions (Ayanda et al., 2013). Within West Africa, the Sudano-Sahelian zone represents one of the most vulnerable ecological regions having experienced a documented decline in rainfall of approximately 3 – 4% per decade alongside an increasing frequency of extreme weather events (Farauta et al., 2017). In Nigeria, where more than two-thirds of the country's landmass is vulnerable to drought and advancing desertification, climate change has become an active driver of environmental degradation, declining agricultural productivity and rural poverty (Idris et al., 2024).

Northwestern Nigeria shows these climate-related vulnerabilities because of its semi-arid environment and strong dependence on seasonal rainfall. Historically, the region experienced a relatively short rainy season lasting approximately four months from June to September (Elisha, 2021). However, recent meteorological trends indicate increasingly delayed rainfall onset, earlier cessation of the wet season,

prolonged mid-season dry spells and rising temperatures during critical crop-growing periods (File & Nhamo, 2024). These changing climatic conditions directly affect the cultivation of major crops such as millet (Pennisetum glaucum), sorghum (Sorghum bicolor) and maize (Zea mays) which constitute the foundation of household food security in the region (Ogbonnaya, 2015). Premature cessation of rainfall before crops attain physiological maturity frequently results in substantial yield reductions, localized food shortages and severe economic hardship for farming households (File & Nhamo, 2024). The environmental challenges associated with climate variability are particularly evident in Wurno Local Government Area (LGA) of Sokoto State, widely recognized for its susceptibility to desertification (Umar, 2014). Agriculture in Wurno depends on a combination of rain-fed upland cultivation and recession farming within the floodplains of the Sokoto-Rima River Basin, making local farming systems highly sensitive to fluctuations in rainfall and river hydrology (Shuaibu et al., 2015). Recent hydrological changes, including the diversion of the Rima River toward the adjacent Balla Creek and the deterioration of critical water infrastructure such as the Lugu Earth Dam and its irrigation scheme have intensified agricultural vulnerability by disrupting reliable water supply for farming (World Bank, 2021). Consequently, farmers increasingly experience a combination of destructive flash floods, prolonged dry spells, intense heatwaves, elevated evapotranspiration, groundwater depletion and declining soil quality all of which undermine agricultural productivity and household resilience (Oladele et al., 2023).

Beyond the physical manifestations of climate change, farmers' responses are strongly influenced by their perception of environmental risks. Behavioural risk perception has been widely recognised as a critical catalyst for climate adaptation because farmers are unlikely to invest in adaptive practices unless they correctly interpret long-term changes in rainfall and temperature patterns (Ayanda et al., 2013). Studies across Northern Nigeria indicate that while many farmers recognise visible indicators of climate change, including increasing daytime temperatures and more erratic rainfall patterns, their understanding of the underlying causes is often shaped by cultural narratives, limited access to scientific weather forecasts and low levels of formal education (Farauta et al., 2017). This gap between recognizing climatic changes and understanding their broader implications can delay the adoption of effective long-term adaptation strategies. Where adaptation occurs, farmers often employ a combination of indigenous knowledge and locally developed practices to minimise climate-related risks. Common adaptation strategies documented across the semi-arid zone include the adoption of early-maturing and drought-tolerant crop varieties (Bosekeng, 2020) crop diversification and multiple cropping systems (Elisha, 2021) the application of organic manure, utilisation of fadama floodplains for dry-season cultivation (Mertz et al., 2009) and the integration of crop production with livestock rearing to stabilise household income. Nevertheless, these adaptation decisions rarely occur independently; instead, they are shaped by socio-economic and institutional factors such as land tenure security, access to agricultural extension services, participation in farmers' associations and the availability of credit facilities (Oladele et al., 2023).

Despite growing evidence on climate change impacts across the Sudano-Sahelian zone, significant knowledge gaps remain regarding the interactions between hydro-climatic variability, river-channel dynamics, irrigation infrastructure failure and farmers' behavioural responses within Wurno LGA. Existing studies have largely focused on broad regional climate trends while providing limited understanding of how microclimatic variations, geomorphological changes associated with river-channel diversion and institutional constraints collectively influence farmers' vulnerability and adaptive capacity in this compromised river-basin ecosystem (AEO, 2016). Furthermore, relatively few studies have explicitly examined how farmers' cognitive perception of climate risks affects the adoption of integrated climate-smart agricultural practices under these locally specific environmental conditions. Addressing these gaps through community-level empirical research is essential for developing targeted adaptation policies capable of strengthening the resilience of smallholder farming

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systems in Wurno LGA and similar semi-arid environments (Oladele et al., 2023).

II. MATERIAL AND METHODS

a. Study Area

The study was conducted in Wurno Local Government Area of Sokoto State, northwestern Nigeria. Wurno is located between latitudes 13°00'N and 13°30'N and longitudes 5°00'E and 5°30'E. The LGA shares boundaries with Kware, Rabah and Goronyo Local Government Areas of sokoto state (Fig 1). The area lies within the Sudan Savanna ecological zone, characterized by a semi-arid climate with distinct wet and dry seasons. Annual rainfall ranges from approximately 500 to 800 mm, occurring mainly between June and September. Temperatures are generally high throughout the year, often exceeding 40°C during the hot season. Agriculture constitutes the major economic activity with farmers cultivating crops such as millet, sorghum, rice, maize, cowpea and vegetables. Livestock rearing is also common. The dependence of the population on rain-fed agriculture makes the area particularly vulnerable to climate variability and climate change.

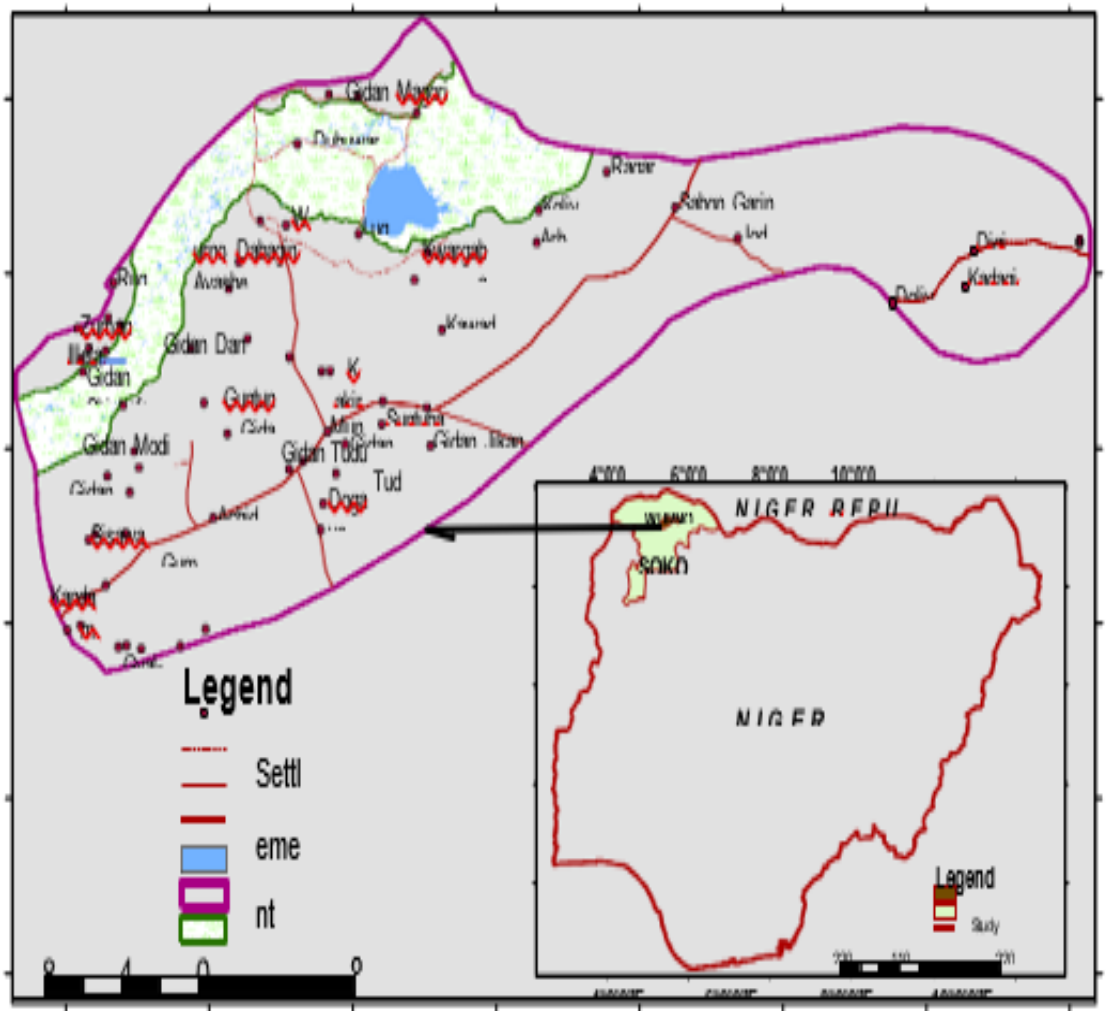

Figure 1: map of Nigeria showing the study area

b. Research Design

This study adopted a cross-sectional survey research design. The survey approach facilitated the assessment of farmers' perceptions, experiences and adaptation practices regarding climate change across different communities within the study area. Both

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quantitative and qualitative methods were employed. Quantitative data was collected through structured questionnaires administered to farmers, while qualitative information wasobtained through key informant interviews and field observations (Dhanya and Ramachandran 2016).

c. Sampling Technique

A multistage sampling technique was employed for this study. A number of wards were selected from Wurno LGA using simple random sampling techniques. From each selected ward, farming communities were purposively selected based on the predominance of agricultural activities and exposure to climate-related challenges. Household farmers within the selected communities were chosen using systematic random sampling. Lists of farmers obtained from village heads, agricultural extension officers and farmer associations served as sampling frames. Respondents were selected proportionately from each community to ensure adequate representation.

The target population comprises of all crop farmers in Wurno Local Government Area. The sample size was determined using Yamane's (1967) formula was used to determine the required sample size at 95% confidence level;

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

$$n = \frac{162307}{1+ 162307\ (0.05)^2} = 400$$

d. Data Analysis

Data collected were analyzed using Descriptive statistics, mean and linear regression. Farmers' perception of climate change was assessed using a four-point Likert-type questionnaire (Strongly Agree = 4, Agree = 3, Disagree = 2, Strongly Disagree = 1). A mean score of 2.50 was used as the benchmark decision rule, such that any item with a mean score of 2.50 and above was considered to be perceived by the respondents, while a mean score below 2.50 was considered not perceived. All statistics were done using spss version 20.0

III. RESULT

3.1 Socio-economic and Demographic Characteristics of Respondents

The socio-economic and demographic characteristics of the sampled farmers in Wurno Local Government Area are presented in Table 1. Results show that the majority of respondents (62.0%) fell within the active and productive age bracket of 31–50 years, with a mean age of 41.6 years, indicating that farming in the study area is dominated by adults within their economically productive years who are still relatively agile and capable of coping with climate-induced farm labour demands. Regarding marital status, 82.0% of the respondents were married, The mean household size was approximately 9 persons, with 46.0% of households having between 6 and 10 members. Farmers had considerable farming experience, with a mean of 19 years, which is expected to enhance their ability to detect long-term deviations in rainfall and temperature patterns. The mean farm size was 1.8 hectares, characteristic of smallholder production systems, while the mean annual farm income was ₦268,400. About 62.0% of respondents belonged to a farmers' association or cooperative group, but only 41.0% had access to agricultural extension services and 34.0% had access to credit facilities. On educational attainment, 32.0% of respondents had no formal education while only 8.0% had attained tertiary education (Fig 2).

Table 1: Socio-economic and Demographic Characteristics of Respondents (n = 400)

Variable	Category	Frequency (n=400)	Percentage (%)
Age (years)	≤30	72	18.0
	31–40	136	34.0
	41–50	112	28.0
	51–60	56	14.0

	>60	24	6.0
	Mean age = 41.6 years		
Sex	Male	344	86.0
	Female	56	14.0
Marital status	Single	36	9.0
	Married	328	82.0
	Widowed	24	6.0
	Divorced	12	3.0
Household size	1–5	96	24.0
	6–10	184	46.0
	11–15	88	22.0
	>15	32	8.0
	Mean household size = 9 persons		
Farming experience (years)	≤10	64	16.0
	11–20	152	38.0
	21–30	120	30.0
	>30	64	16.0
	Mean = 19 years		
Farm size (ha)	<1.0	80	20.0
	1.0–2.0	160	40.0
	2.1–3.0	104	26.0
	>3.0	56	14.0
	Mean = 1.8 ha		
Annual farm income (₦)	<100,000	88	22.0
	100,000–300,000	160	40.0
	301,000–500,000	96	24.0
	>500,000	56	14.0
Farming system	Rain-fed only	192	48.0
	Recession/fadama only	48	12.0
	Both rain-fed and recession	160	40.0
Membership of farmers' association	Yes	248	62.0
	No	152	38.0
Access to extension services	Yes	164	41.0
	No	236	59.0
Access to credit facility	Yes	136	34.0
	No	264	66.0

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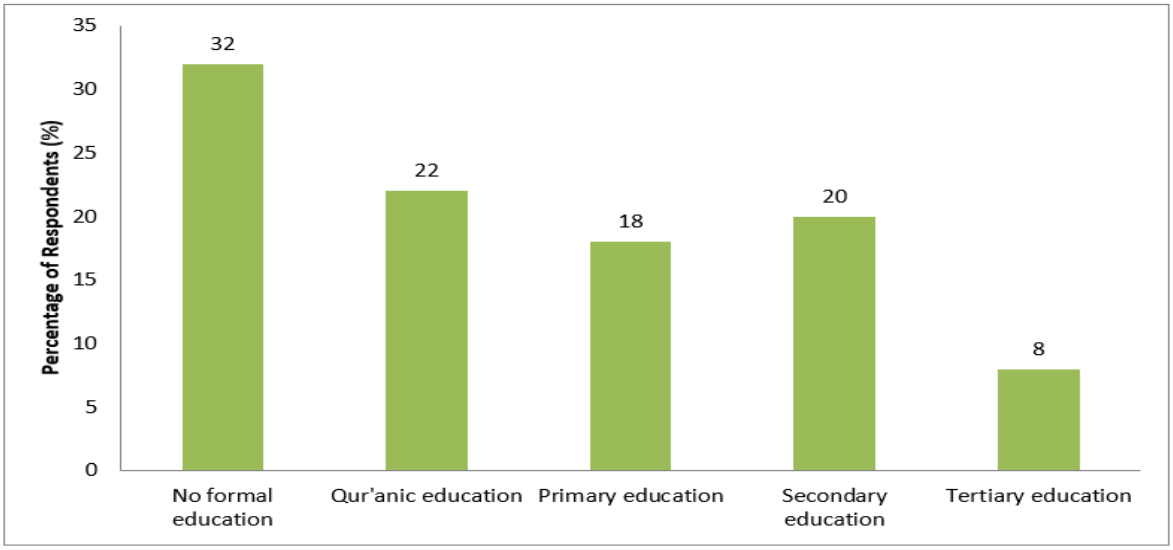

Figure 2: Distribution of Respondents by Educational Level

3.2 Farmers' Perception of Climate Change

The result of the farmers perception of climate change is presented in Table 2, respondents perceived all the listed climate change indicators with an overall grand mean of 3.18. Increase in temperature over the past 10–20 years ($\bar{x}$ = 3.62) and early cessation of rainfall before crop maturity ($\bar{x}$ = 3.55) ranked highest among the perceived indicators, followed closely by delayed onset of rainfall ($\bar{x}$ = 3.48) and a general decline in total annual rainfall ($\bar{x}$ = 3.31). Farmers also strongly perceived an increasing frequency of drought ($\bar{x}$ = 3.15) and dry spells during the cropping season ($\bar{x}$ = 3.24) consistent with the documented 3–4% per-decade decline in rainfall within the Sudano-Sahelian zone (Farauta et al., 2017). Diversion of the Rima River and its effect on water availability for recession farming was rated moderately high ($\bar{x}$ = 3.05), Declining soil fertility ($\bar{x}$ = 2.92) and increasing flood frequency/intensity ($\bar{x}$ = 2.87) and pest and disease outbreaks ($\bar{x}$ = 2.78) were the lowest-ranked.

Table 2: Farmers' Perception of Climate Change Indicators

Perception Indicator	Mean ($\bar{x}$)	Std. Dev.	Decision	Rank
Increase in temperature over the past 10–20 years	3.62	0.49	Perceived	1
Early cessation of rainfall before crop maturity	3.55	0.55	Perceived	2
Delayed onset of rainfall	3.48	0.58	Perceived	3
Decrease in total annual rainfall amount	3.31	0.63	Perceived	4
Increased frequency of dry spells during cropping season	3.24	0.66	Perceived	5
Increasing incidence/frequency of drought	3.15	0.71	Perceived	6
River diversion reducing water availability for recession farming	3.05	0.74	Perceived	7
Declining soil fertility/quality	2.92	0.69	Perceived	8
Increasing frequency and intensity of flooding	2.87	0.77	Perceived	9
Increased incidence of crop pest and disease outbreak	2.78	0.72	Perceived	10
Grand Mean	3.18		Perceived	

Source: Field Survey, 2026. Decision rule: Mean ≥ 2.50 = Perceived; Mean < 2.50 = Not Perceived.

3.3 Adaptation Strategies Employed by Farmers

The results of the adaptation strategies employed by farmers is presents in Table 3.The use of early-maturing and drought-tolerant crop varieties was the most widely adopted strategy (78.5%) followed by adjustment of planting dates (71.0%) and crop diversification/mixed cropping (66.5%). Application of organic manure (61.0%) and utilisation of fadama floodplains for dry-season cultivation (55.5%) were also widely practised. About 48.0% of respondents integrated crop production with livestock rearing as a risk-spreading strategy, while soil and water conservation practices such as ridging, terracing and mulching were adopted by 42.5% of farmers. Fewer farmers engaged in irrigation using pumps or wells (37.0%) tree planting/agroforestry (29.0%) and migration or off-farm income diversification (24.5%),

Table 3: Adaptation Strategies Employed by Farmers in Response to Climate Change

Adaptation Strategy	Frequency*	Percentage (%)	Rank
Use of early-maturing/drought-tolerant crop varieties	314	78.5	1
Adjustment/change of planting dates	284	71.0	2
Crop diversification and mixed cropping	266	66.5	3
Application of organic manure/fertilizer	244	61.0	4
Utilisation of fadama floodplain for dry-season farming	222	55.5	5
Integration of crop production with livestock rearing	192	48.0	6
Soil and water conservation practices (ridging, mulching, terracing)	170	42.5	7
Irrigation using pumps/wells	148	37.0	8
Tree planting/agroforestry	116	29.0	9
Migration/off-farm income diversification	98	24.5	10

Source: Field Survey, 2026. *Multiple responses recorded.

3.4 Factors Influencing Farmers' Level of Adaptation to Climate Change

The results of the linear regression analysis was shown in table 4. The results shows a multiple correlation coefficient (R) of 0.671 and a coefficient of determination (R^2) of 0.450, indicating that the nine explanatory variables jointly accounted for about 45.0% of the variation in farmers' level of adaptation to climate change in the study area (Adjusted R^2 = 0.437). The overall model was statistically significant ($F(9, 390) = 34.86$, $p < 0.01$) confirming that the model provides a good fit for explaining adaptation behaviour among the sampled farmers.

As presented in Table 5, educational level ($\beta = 0.187$, $p < 0.01$), access to extension services ($\beta = 0.243$, $p < 0.01$), membership of a farmers' association ($\beta = 0.198$, $p < 0.01$), access to credit facility ($\beta = 0.156$, $p < 0.01$), and annual farm income ($\beta = 0.129$, $p < 0.01$) were positive and statistically significant at the 1% level, indicating that farmers with more formal education, better access to extension advice, association membership, credit and higher income were significantly more likely to adopt a wider range of adaptation strategies. Farming experience ($\beta = 0.112$, $p < 0.05$) and farm size ($\beta = 0.096$, $p < 0.05$) were also positive and significant at the 5% level, suggesting that more experienced farmers and those cultivating relatively larger farms adapted more readily. Age ($\beta = -0.004$, $p > 0.05$) and household size ($\beta = 0.061$, $p > 0.05$) were not statistically significant predictors of adaptation level.

Table 4: Model Summary of the Regression Analysis

Model Summary	Value
R	0.671
R Square	0.45
Adjusted R Square	0.437

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Std. Error of the Estimate	0.312
F-value	34.86
Degrees of freedom (df)	9, 390
p-value	0.000**

Table 5: Regression Coefficients of Factors Influencing Farmers' Level of Adaptation to Climate Change

Variable	B	Std. Error	t-value	Sig.
(Constant)	0.842	0.215	3.916	0.000**
Age (years)	-0.004	0.006	-0.667	0.505 (ns)
Educational level	0.187	0.052	3.596	0.000**
Farming experience (years)	0.112	0.049	2.286	0.023*
Household size	0.061	0.034	1.794	0.074 (ns)
Farm size (ha)	0.096	0.041	2.341	0.020*
Access to extension services (1=Yes, 0=No)	0.243	0.058	4.19	0.000**
Membership of farmers' association (1=Yes, 0=No)	0.198	0.061	3.246	0.001**
Access to credit facility (1=Yes, 0=No)	0.156	0.055	2.836	0.005**
Annual farm income	0.129	0.047	2.745	0.006**

Source: Field Survey, 2026. **Significant at 1%; *Significant at 5%; ns = not significant. Dependent variable: Level of adaptation to climate change.

IV. DISCUSSION

The predominance of male respondents (86.0%) and married household heads (82.0%) in this study reflects the male-controlled land-ownership and household-headship structures that characterize farming communities across the semi-arid north of Nigeria. This finding differs somewhat from Elum and Snijder (2023) who reported a largely female farming population in the coastal communities of Bayelsa State, highlighting the fact that gender participation in agriculture in Nigeria is strongly mediated by agro-ecological and cultural context rather than being uniform across the country. The mean age of 41.6 years and mean farming experience of 19 years recorded among respondents in Wurno LGA are comparable to the age and experience profiles reported for farmers in Kano State by Yakubu et al. (2026) suggesting that climate-exposed rain-fed farming in the Sudano-Sahelian belt is still largely undertaken by middle-aged, experienced household heads rather than younger farmers. The relatively high proportion of respondents with no formal education (32.0%) is consistent with the wider pattern of low literacy reported among farming households in Northwestern Nigeria (Suleiman et al., 2021) and aligns with the observation of Madaki et al. (2023) who work across six agro-ecological zones of Nigeria, found that formal education levels among farmers remain generally low and vary systematically with agro-ecological zone with the northern zones recording the lowest attainment.

Similarly, low access to extension services and credit facilities mirrors constraints reported by Olutumise (2023) among food-crop farmers in Southwest Nigeria and by Akinkuolie et al. (2024) who identified poor extension outreach and credit inaccessibility as recurring structural constraints to climate adaptation across Nigeria's farming systems. Taken together, these socio-economic characteristics indicate that farmers in Wurno LGA share the broad resource-poor, institutionally under-served profile that typifies smallholder agriculture across much of semi-arid Nigeria.

The finding that farmers in Wurno LGA strongly perceived rising temperature, delayed and shortened rainy seasons and declining total rainfall corroborates a substantial body of recent evidence that Nigerian farmers are highly attuned to long-term shifts in temperature and rainfall, even where their

understanding of the underlying drivers of these changes is limited. This result is consistent with Suleiman et al. (2021) who found widespread farmer recognition of shifting rainfall patterns across Northwestern Nigeria and aligns closely with Ikpe's (2021) study of grain-farming households in Sokoto State, which similarly reported high perception scores for delayed rainfall onset and premature cessation as the dominant climate signals affecting local crop yields. The grand mean perception score obtained is also comparable to the composite perception index of 3.11 reported by Yakubu et al. (2026) among 369 farmers in neighbouring Kano State, reinforcing the consistency of high climate-risk perception across the wider Sudano-Sahelian zone of Northwestern Nigeria.

However, some indicators in the present study, notably increasing flood frequency and pest/disease outbreak were perceived less strongly than temperature- and rainfall-related indicators. This gradation is broadly consistent with Akinkuolie et al. (2024) who observed that Nigerian farmers more readily perceive slow-onset, cumulative climatic shifts than episodic or compound hazards such as flooding and pest outbreaks whose causal link to climate change is less immediately obvious to farmers without technical guidance. The comparatively high perception score for river-diversion-related water scarcity in this study, however, is a locally distinctive finding not commonly reported elsewhere in the literature and reflects the specific hydro-geomorphological disruption associated with the diversion of the Rima River and the deterioration of the Lugu Earth Dam irrigation infrastructure. This suggests that, in addition to the generic climatic stressors documented across Nigeria and West Africa, farmers in Wurno LGA face a compounded, locally specific vulnerability arising from the interaction of climate change with degraded water infrastructure, a dimension that is comparatively under-represented in the wider literature.

The dominance of early-maturing/drought-tolerant varieties, adjusted planting dates and crop diversification as the leading adaptation strategies in this study is strongly consistent with the finding of Tambo and Abdoulaye (2013) for the wider Nigerian savanna, who identified varying planting dates and the use of drought-tolerant, early-maturing varieties as the two most widespread autonomous adaptation measures among smallholder farmers in the region. The same ordering of strategies has been reported more recently by Ikpe (2021) for grain farmers in Sokoto State and by Olagunju (2022) for arable crop farmers in Ondo State, suggesting that, despite differing agro-ecological contexts across Nigeria, farmers tend to adopt low-cost, knowledge-based agronomic adjustments before capital-intensive measures. This is corroborated in the present study by the comparatively low uptake of irrigation using pumps or wells and tree planting/agroforestry, both of which require either capital outlay or a longer investment horizon.

The moderate uptake of fadama floodplain cultivation and crop-livestock integration reflects the particular importance of the Sokoto-Rima floodplain to local livelihoods and is broadly in line with findings from other Nigerian savanna and Sahelian contexts, where diversification into livestock and dry-season floodplain farming has been documented as a key risk-buffering strategy (Tambo and Abdoulaye, 2013). A similar reliance on livelihood diversification was reported among cocoa farmers in Adansi South, Ghana (Anning et al., 2022) and among rice farmers in the Builsa South district of Ghana (Adeboa and Anang, 2024) although the specific form of diversification in those studies differed from the floodplain and livestock-based diversification observed in Wurno LGA, reflecting the influence of local agro-ecological endowments on the choice of adaptation pathway.

The comparatively low adoption of migration or off-farm income diversification in this study contrasts with several recent Nigerian studies that have identified migration and off-farm diversification as an increasingly important adaptation response, particularly in areas experiencing severe resource degradation (Akinkuolie et al., 2024). This divergence may indicate that farmers in Wurno LGA still perceive on-farm agronomic and floodplain-based adjustments as viable or alternatively that limited non-farm opportunities and infrastructure in

the study area constrain migration as a feasible adaptation option a possibility that warrants further site-specific investigation.

The regression results showing that educational level, access to extension services, membership of a farmers' association, access to credit facility, farming experience, farm size and annual income significantly and positively influenced farmers' level of adaptation are strongly consistent with the wider empirical literature on the determinants of climate change adaptation in Nigeria and across Sub-Saharan Africa. The significant positive effect of extension access corroborates Olagunju (2022) who found a significant relationship between farmers' access to information/extension services and their adaptation strategies in Ondo State, and is further reinforced by Akinkuolie et al. (2024) who identified inadequate extension outreach as one of the principal structural constraints limiting the depth of climate adaptation among Nigerian farmers. Likewise, the significant, positive coefficient obtained for access to credit facility aligns closely with Olutumise (2023) whose endogenous treatment Poisson regression model showed that credit-unconstrained food-crop farmers in Southwest Nigeria utilised significantly more climate adaptation strategies than their credit-constrained counterparts and with earlier evidence from the Nigerian savanna that lack of credit constitutes a binding barrier to adaptation (Tambo and Abdoulaye, 2013).

The positive and significant influence of educational level on adaptation is consistent with Yakubu et al. (2026) who reported that education, alongside age, income and farming experience, significantly shaped farmers' perception and by extension, their adaptive response to climate variability in neighbouring Kano State. It is also in agreement with Madaki et al. (2023) who observed that farmers with higher formal education were better able to translate climate risk perception into appropriate on-farm adjustments across Nigeria's agro-ecological zones. The significant positive effect of association membership found in this study reflects the role of farmer groups and cooperatives as conduits for information exchange, input access and collective risk-sharing, a mechanism similarly emphasised by Adeboa and Anang (2024) in their Poisson regression analysis of adaptation determinants among smallholder farmers in Builsa South, Ghana, where group membership significantly increased the number of adaptation strategies adopted. Similarly, the significant effect of farm size is in line with Olagunju (2022), who reported that farm size significantly influenced adaptation strategy adoption among arable crop farmers in Southwest Nigeria and with Aroyehun et al. (2024) whose multivariate probit analysis of melon farmers in south-south Nigeria identified farm size as a significant driver of the joint adoption of multiple adaptation strategies.

However, the non-significant effect of age observed in this study departs from Yakubu et al. (2026) and Terdoo and Adekola (2014) both of whom reported that age significantly influenced farmers' perception of and response to climate variability in Northern Nigeria with older, more experienced farmers generally are more familiar to long-term climatic shifts. This divergence may be explained by the fact that, in the present study, farming experience-which was itself significant-may have absorbed much of the explanatory power otherwise attributed to age, since the two variables are typically highly correlated among household heads in stable farming communities. The non-significant effect of household size is broadly consistent with mixed findings in the literature: while Olagunju (2022) found household size to significantly influence adaptation strategy choice in Ondo State, other studies, such as Adeboa and Anang (2024) in Ghana, found household size to be a comparatively weak predictor once extension access, credit and association membership were accounted for, suggesting that the influence of household size on adaptation may operate more strongly through labour availability for specific labour-intensive strategies than through the general adaptation index used in this study.

V. CONCLUSION

This study concludes that strengthening farmers' access to education, extension services, credit and collective organizations represents the most direct pathway to enhancing the adaptive capacity and resilience of smallholder farming systems in Wurno

LGA and comparable semi-arid river-basin communities in Northwestern Nigeria.

VI. RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made;

1. Sokoto State Agricultural Development Programme (ADP) and relevant non-governmental organisations should expand the coverage and frequency of extension visits to Wurno LGA, with specific emphasis on disseminating science-based climate information alongside indigenous knowledge to strengthen farmers' understanding of the underlying causes of observed climatic changes.
2. Since access to credit facility significantly enhanced farmers' level of adaptation, deposit money banks, microfinance institutions and government agricultural credit schemes should design flexible, low-interest credit packages tailored to smallholder farmers, to enable investment in capital-intensive adaptation measures such as irrigation infrastructure and improved planting materials.
3. Relevant government agencies and development partners should encourage and support the formation and strengthening of farmers' cooperatives in Wurno LGA.
4. Government and community-based organisations should prioritise adult literacy and functional education programmes for farmers to improve their capacity to interpret climate information and adopt appropriate adaptation technologies.
5. In view of farmers' strong perception of water scarcity arising from the diversion of the Rima River and the deterioration of the Lugu Earth Dam irrigation scheme, the Sokoto-Rima River Basin Development Authority, in collaboration with the State Government, should prioritise the rehabilitation of the dam and associated irrigation infrastructure to restore reliable water supply for both rain-fed and recession farming in the area.

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