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Climate Adaptation and Willingness to Adopt Climate-Smart Practices: Micro-Level Evidence from North Central Nigeria

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Abstract

Rural households in Nigeria remain highly vulnerable to climate change risks due to limited adaptive capacity and weak institutional support. This paper argues that climate risk exposure, adaptation behaviour and willingness to adopt climate-smart agricultural practices are jointly determined by socioeconomic conditions, risk perceptions and institutional factors. Using survey data from 1,112 rural households across selected states in North Central Nigeria and employing logistic regression models, the study indicates that education and income consistently reduce exposure to climate risks and significantly increase willingness to adopt adaptation strategies. Risk perception emerges as a strong motivator for adaptation, particularly when combined with climate awareness, highlighting the importance of aligning knowledge with perceived vulnerability. Institutional support positively influences adaptation willingness, although interaction effects with awareness do not exhibit consistent statistical significance in the models. Overall, the findings suggest that effective climate adaptation depends on the combined effect of household capacity, cognitive assessments, and institutional support. Policy interventions that enhance education, improve rural incomes, strengthen risk communication, and reinforce community-based institutions are critical for building resilient rural livelihoods.

Keywords: Climate-Smart Agriculture, Climate Change Adaptation, Risk Perception
JEL Classification Codes: Q57, Q54, O13

1. Introduction

The historical record shows that African countries are increasingly faced with significant risks from the effects of climate change, such as droughts, floods, and other extreme weather conditions. For instance, Akpodiogaga and Odjugo (2020) pointed out that the average temperature in Nigeria has continued to rise by 0.8°C since 1980, with more frequent and intense heatwaves. The average temperature is projected to rise by 1.5°C to 2.5°C by 2050 (World Bank, 2022). Such continuous temperature rise tends to affect the patterns and volume of rainfall in Nigeria. High volumes of rainfall have caused significant damage to human lives and property in recent years. For instance, in 2022, floods displaced over 1.4 million people and caused significant damage to infrastructure and agriculture worth over 4 billion Naira (United Nations Office for the Coordination of Humanitarian Affairs [OCHA], 2022). This continuous rise in temperature, coupled with the increased frequency of extreme weather events, has had negative effects on crop production and food security in the country.

The North Central region of Nigeria, comprising Benue, Kogi, Kwara, Nasarawa, Niger, Plateau and the Federal Capital Territory, has faced severe ecological impacts from climate change. Frequent floods, delayed rain and shortened growing seasons continue to pose significant threats to agriculture, the primary livelihood of about 70 percent of people living in the region (National Bureau of Statistics [NBS], 2024). In addition, environmental pressures such as deforestation and land degradation tend to weaken ecosystem resilience. Notably, the booming charcoal and firewood business coupled with nomadic pastoralism in the region, has contributed to increased deforestation, thus further exposing rural communities to the impact of climate change.

Despite the existence of national policies and initiatives to combat climate change, the response to climate change adaptation remains inadequate in North Central Nigeria due to limited awareness, insufficient institutional support and a lack of adequate adaptation strategies (Alhassan & Haruna, 2024). Farmers often depend on traditional coping strategies that are no longer effective, especially under rapidly changing weather conditions. Thus, strengthening climate adaptation requires that farmers transition toward practices that improve ecosystem resilience and promote rural livelihoods.

Climate-smart agriculture (CSA) offers practical pathways through which farmers can adapt to climate change, enhance productivity and reduce environmental degradation (Kombat et al., 2021; Hussain et al., 2021; Azadi et al., 2021; Terdoo & Adekola, 2014). Climate-smart agriculture (CSA) practices such as conservation tillage, drought-resistant crops, agroforestry and integrated crop-livestock farming are designed to improve soil health and ensure long-run agricultural sustainability (Kabato, et al., 2025). However, the adoption of these practices is influenced by farmers' perceptions and knowledge of these farming techniques. This study therefore argues that, to enhance sustainable agricultural practice it is vital to understand what drives farmers' adaptation behaviour and their willingness to adopt climate-smart agricultural practices, particularly in regions such as North Central Nigeria, where agriculture is highly susceptible to climate variability.

Although research on climate change impacts in Nigeria is expanding, empirical studies that examine the relationship between farmers' adaptation to climate change and willingness to adopt climate-smart practices in the specific context of North Central Nigeria are limited. Existing studies often focus on climate impacts but rarely discuss CSA adaptation and willingness of rural farmers to adjust farming practices and activities in response to changing climatic conditions. In addition, there is insufficient evidence on how community awareness and environmental practices influence adaptation decisions in the region. To address these gaps, this study evaluates the factors that influence household climate change adaptation in North Central Nigeria and examines farmers' willingness to adopt climate-smart agricultural practices in the region.

2. Literature Review

This study is anchored on Expected Utility Theory (EUT), propounded by von Neumann and Morgenstern (1944), which provides a behavioural foundation for understanding farmers' adaptation and adoption decisions under climate uncertainty. The theory posits that individuals facing uncertain outcomes make decisions by evaluating the expected utility or gains from the different available choices. The study emphasises that a rational individual would select the option that maximises their perceived utility. In the context of this study, farmers compare the expected utility of adopting climate-smart agricultural practices with the utility of continuing with

traditional farming methods. Adoption depends on farmers' perceptions of risks and benefits such as expected yield, cost of inputs, uncertainty about rainfall, probability of crop failure and related factors. A Farmer will adopt a CSA practice if the expected utility outweighs that of non-adoption.

Several studies have shown that farmers' perceptions of climate change play a significant role in adaptive behaviour. For instance, Manh and Ahmad (2021) found that farmers' understanding of climatic changes in rainfall patterns and temperature variations is often affected by their years of experience and knowledge of the ecological changes in their local environment. Similar findings by Nguyen et al. (2021) observed that experiential knowledge strongly affects how rural farmers interpret climate risks and choose adaptive strategies.

In Ghana, Limantol et al. (2016) reported that Ghanaian farmers' perceptions of climate change directly affect their agricultural practices and resilience-building efforts. Studies in Zimbabwe (Nhemachena et al., 2014; Nyahunda & Tirivangasi, 2019) indicated that perceptions of climate change directly inform rural communities' adaptation decisions and their ability to formulate effective adaptation strategies. Their findings indicate that perceptions and adaptation to climate change in rural communities represent a critical aspect of understanding how local populations respond to environmental changes.

Research has also shown that social, cultural and economic characteristics tend to influence perceptions and interpretations of climate change and adaptation strategies within communities. For instance, Boon (2014), in a study of rural Australian towns, showed that political affiliations shape perceptions of climate change, affecting overall willingness to adopt risk-mitigation practices. This notion is echoed in the findings of Cheng et al. (2017), which highlight the importance of addressing social vulnerability when planning climate action. Communities characterised by low social capital demonstrate a heightened risk perception, necessitating tailored communication strategies to foster effective adaptation.

Similarly, cross-regional comparisons reveal notable divergences in how rural populations perceive climate change risks. A study focusing on Ghana indicates that climate adaptation interventions often fail when local culture and community participation are not sufficiently incorporated into the strategies

(Adaawen, 2021). This finding aligns with studies from Nigeria, where rural farmers' cultural views significantly influence their climate adaptation responses (Ayanlade et al., 2017). Both studies assert the importance of acknowledging local frameworks of understanding. Perceptions of climate change significantly influence how rural communities in North Central Nigeria adapt to its impacts. Understanding these perceptions is vital, as they directly affect the adoption of sustainable adaptation strategies.

Research shows that prevailing sociocultural beliefs among farmers shape their responses to climate variability. For instance, farmers who have experienced adverse weather events are more likely to acknowledge climate change and its implications, which in turn influences their willingness to engage in adaptive measures (Fasina et al., 2021; Pickson & He, 2021). Similarly, Antwi-Agyei and Nyantakyi-Frimpong (2021) found that planting of drought-tolerant crop varieties, the use of indigenous knowledge, irrigation, migration, adjusting the planting calendar, crop diversification, mixed farming, and sustainable land management practices were the basic strategies used by farmers to adjust to climate change.

Beyond perception, institutional constraints hinder effective adaptation outcomes. Jat et al. (2025) identified inadequate access to climate information regarding climate impacts, inadequate access to agricultural inputs and poor extension services as a major constraint preventing farmers from adopting modern adaptation strategies. Sallawu et al. (2020) similarly pointed out that limited institutional support is a key barrier to farmers' adaptation practices among farmers in Nigeria. They noted that weak system leaves farmers vulnerable to climate risks.

Lakshmi et al. (2025) found that institutional limitations, especially poor access to credit and extension services, are among the most critical constraints to adaptation in rural settings. The finding aligns with Bhattarai et al. (2020), who argued that inadequate institutional frameworks increase farmers' vulnerability as it restricts their access to timely climate information and adaptive technologies. These studies demonstrate that climate-smart agriculture adoption depends not only on farmers' perception but also on the institutional structure that determines their adaptive capacity.

Overall, the literature establishes several important patterns regarding climate perception, adaptation behaviour and the influence of institutional factors on farmers' response to climate change.

However, the literature remained fragmented, as most studies examine climate change perception or adaptation behaviour in isolation, while only a few directly link these factors to the uptake of climate-smart agricultural practices. There are limited empirical works that considers how socioeconomic factors, institutional constraints and household risk assessment jointly affect farmers' adaptation choice particularly in North Central Nigeria, which produces about 40 percent of Nigeria's food supply (NBS, 2024) and is increasingly affected by climate change. Additionally, while CSA is widely promoted as a resilience pathway, the literature provides little insight into how farmers in this region evaluate CSA options or what shapes their willingness to adopt them. These gaps underscore the need for an integrated analysis that simultaneously evaluates climate adaption behaviour and willingness to adopt CSA in North Central Nigeria.

3. Methodology

3.1 Study Area

The study area covers in the North Central region of Nigeria. The North Central region includes Benue, Nasarawa, Kogi, Niger, Kwara, Plateau states, as well as the Federal Capital Territory (FCT). The region lies between longitudes 3° and 14° East of the Greenwich Meridian and latitude 4° and 14° North of the Equator. The North Central region has an estimated population of over 50 million people, spread across 121 Local Government Areas (LGAs) and 1,448 wards (NBS, 2024). Agriculture remains the major occupation of about 70 percent of citizens living in this part of the country, particularly in the rural communities that formed the main target of this study (NBS, 2024). Most farmers in this region depend on rainfall for their crop and other economic activities. To understand how farmers in the region respond to climate change, the study adopted a cross-sectional survey of farmers from selected areas within the region.

3.2 Sampling Techniques and Strategies

For the purpose of the study, three states, Benue, Kwara and Plateau States, were randomly selected. The selected states exhibit heterogeneity and variations based on their location and ethnic composition in the North Central Region of Nigeria; this is likely to improve the quality and robustness of the research outcomes. Subsequently, multiple sampling techniques were used to select 400 respondents from each of the selected states, making a total number of

1,200 respondents for the study. This sample size is considered adequate to represent the diversity and variability of responses among rural households in the selected areas.

In each of the selected states, three local governments areas were randomly selected, one from each senatorial district. From each selected LGA, four communities with high levels of agricultural activity were identified. Households within these communities were numbered and randomly selected. Responses were solicited from household heads or their representative using structured questionnaires to gather information on respondents' personal characteristics, awareness of climate change, adaptation actions undertaken and willingness to adopt various climate-smart agricultural practices. The questionnaire also captured information on access to climate information, institutional support, risk perception and cost-related concerns.

To ensure reliability and validity of the research instruments, a pilot study was carried out in one community in each selected state. Based on feedback from the pilot survey, questionnaire was revised to improve clarity and consistency. Out of the 1,200 questionnaires distributed, 1,112 questionnaires, representing 93 percent of the sample size, were returned and found usable after screening for completeness and consistency. This represents an effective response rate of 93 percent. The responses from questionnaire were then coded and analysed. Descriptive statistics were used to summarise respondents' perception of climate change and the adaptation actions they have undertaken.

3.3 Definition and Measurement of Variables

Table 1: Definition and Measurement of Variables

Variable	Definition	Measurement
Willingness to Adapt	Indicates whether the respondent is willing to spend time or money in learning new ways to cope with climate problem	Binary variable: 0 = Not willing, 1 = Very willing and somewhat willing
Adaptation	Indicates whether a respondent prefers old methods of farming even if the new ones are better for climate	Binary variable: 0 = No, 1 = Yes

Monthly Income of the Respondent	Monthly income level of the respondent	Continuous variable
Age of the Respondent	Age of the respondent	Continuous variable
Education Status of the Respondent	Indicates whether the respondent is educated or not	Binary variable: 0 = Not educated, 1 = Educated
Awareness	Indicates whether the respondent is aware of the concept of climate change	Binary variable: 0 = Not aware, 1 = Aware
Risk	Indicates whether the respondent is facing some challenges in trying new methods	Binary variable: 0 = No challenge, 1 = There is challenge
Institution	Indicates whether the respondent's decision to try new methods is influenced by the Village Head	Binary variable: 0 = Not influenced, 1 = Influenced
Perception	Indicates whether the respondent's work or way of life is affected by climate change	Binary variable: 0 = Not affected, 1 = Affected

Source: Authors' Compilation, 2025

Table 1 shows the key socioeconomic and demographic variables that influence the respondents' willingness to adapt and actual adaptation to climate change. The outcome variables are willingness to adapt, which involves respondents' willingness to adapt to climate change and adaptation, which captures respondents' actual adaptation behaviour in response to climate change. Monthly Income and Age of the respondents are continuous variables, Education Status, Risk level, Institution (Influence of the Village Head), Awareness of the climate changes and Perception are all dichotomously coded. Generally, the table presents the sociodemographic characteristics of the respondents and their climate adaptions outcomes, which are used to assess the influence of these factors on respondents' decision to adopt climate-friendly activities.

3.4 Model Specification

The models for the study are anchored on Expected Utility Theory (EUT), as willingness to adapt to climate change is influenced by the expected gains and the existing socioeconomic background of farmers. The study follows Antwi-Agyei and Nyantakyi-Frimpong (2021) in formulating its models. The study uniquely expands the independent variables and employs two outcome variables. Willingness to adapt to climate Change is specified as the first outcome variable, while Adaptation to climate-friendly practices is specified as the second outcome variable. The first model is presented in equation (1):

$$Willingness_i = \alpha + \beta_1 Education_i + \beta_2 Income_i + \beta_3 Awareness_i + \beta_4 Risk_i + \beta_5 Institution_i + \beta_6 Awareness * Institution_i + \beta_7 Awareness * Risk_i + \varepsilon_i \quad (1)$$

The study used logistic regression as the estimation technique to achieve its objectives. This technique is appropriate because the dependent variables in the two models have binary outcomes. Let $Willingness_i$ denote the willingness of household i to adapt to climate change, where:

$$Willingness_i \begin{cases} 1 & if\ the\ household\ is\ willing\ to\ adapt \\ 0 & otherwise \end{cases}$$

The logistic regression model is specified as:

$$\ln\left(\frac{P(Willingness_i=1)}{1-P(Willingness_i=1)}\right) = \alpha + \beta_1 Education_i + \beta_2 Income_i + \beta_3 Awareness_i + \beta_4 Risk_i + \beta_5 Institution_i + \beta_6 Awareness * Institution_i + \beta_7 Awareness * Risk_i + \varepsilon_i \quad (2)$$

The second model is presented as follows:

$$Adaptation_i = \alpha + \beta_1 Income_i + \beta_2 Awareness_i + \beta_3 AGE_i + \beta_4 Gender_i + \beta_5 Institution_i + \beta_6 Perception_i + \varepsilon_i \quad (3)$$

The study used logistic regression as the estimation technique to achieve its objectives. Where $Adaptation_i$ represents adaptation to climate-friendly practices, defined as

$$Adaptation_i \begin{cases} 1 & if\ household\ has\ adopted\ climate-friendly\ practices \\ 0 & otherwise \end{cases}$$

The logistic regression for the second model is specific as:

$$\ln\left(\frac{P(Adaptation_i=1)}{1-P(Adaptation_i=1)}\right) = \alpha + \beta_1 Income_i + \beta_2 Awareness_i + \beta_3 AGE_i + \beta_4 Gender_i + \beta_5 Institution_i + \beta_6 Perception_i + \varepsilon_i \quad (4)$$

The outcomes of the estimations are presented in the subsequent sections.

4. Results and Discussion

This section presents the empirical findings of this study. The analysis begins with descriptive statistics on the sociodemographic characteristics of the respondents to background context for understanding farmers' perceptions of climate change, adaptation behaviour and willingness to adopt climate-smart agricultural practices. The sociodemographic characteristics of the respondents used in this study is presented in Table 2.

Table 2: Sociodemographic Characteristics of the Respondents

	Frequency	Percentage (%)
Gender		
Male	719	65
Female	393	35
Age of the Respondents		
18 – 40 years	365	68
41 - 60	145	27
60 years and above	29	5
Level of Education		
No formal Education	244	22
Primary Education	203	19
Secondary Education	428	38
Higher Education	237	21
Monthly Level of Income		
Below N100, 000	725	65
N100,000 – N250000	306	27
N251,000 – N450,000	34	3
N451 and above	47	4
Marital Status		
Single	283	25
Divorced	155	14
Widowed	90	8
Married	584	53
Occupation		
Farming	707	64
Fishing	213	19
Trading	76	7
Artisan	37	3
Civil Servant	79	7

Source: Authors' Computation, (2025)

Table 2 contains a descriptive overview of the socioeconomic and demographic attributes of the respondents, offering useful insights into the composition of the survey sample. The survey sample reflects a population that is mostly male, relatively young and actively engaged in livelihood activities. Men appear to play a central role in household and climate-related decision-making, which is consistent with patterns observed in many rural agrarian settings. The age structure points to a largely youthful and energetic labour force that is potentially open to adopting new practices.

Most respondents possess at least some formal education, although a notable proportion still lacks any formal schooling, which may limit access to information and modern techniques. The income profile shows that the majority earn relatively little, indicating constrained financial capacity to invest in improved technologies or adaptation measures. The population is dominated by married individuals, which is typical of rural household-based livelihoods. Agriculture is the dominant occupation, followed by fishing and a limited range of non-farm activities such as trading, civil service work, and artisanal jobs. Overall, the respondents constitute a low-income, moderately educated, mostly married, and farming-dependent population. These attributes are important for understanding their climate-change awareness, adaptation behaviours, and their potential willingness to adopt new practices.

Table 3: Determinants of Adaptation to Climate Change among Rural Households

Variables	(1) Willing_to_adapt	(2) Willing_to_adapt	(3) Willing_to_adapt	(4) Willing_to_adapt	(5) Willing_to_adapt	(6) Willing_to_adapt
Education	0.383**	0.395**	0.522***	0.617***	0.604***	0.739***
	(0.161)	(0.161)	(0.166)	(0.168)	(0.168)	(0.174)
Income	0.240***	0.236***	0.214***	0.183***	0.140**	0.239***
	(0.059)	(0.060)	(0.061)	(0.060)	(0.063)	(0.070)
Awareness		-0.159	-0.241	-0.135	-13.376	-11.959
		(0.189)	(0.195)	(0.195)	(374.521)	(615.614)
Risk			-0.353***	-0.320***	-0.306***	1.042***
			(0.056)	(0.057)	(0.057)	(0.232)
Institution				1.125***	-12.065	-13.744
				(0.216)	(374.521)	(615.614)

Awareness*Institution					13.339	14.879
					(374.522)	(615.614)
Awareness*Risk						-1.590***
						(0.242)
Constant	0.293	0.425*	1.166***	0.016	13.197	12.114
	(0.181)	(0.240)	(0.272)	(0.349)	(374.521)	(615.614)
Observations	1,112	1,112	1,112	1,112	1,112	1,112

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Authors' Computation (2025)

Table 3 presents the regression estimates examining the determinants of rural households' willingness to adapt to climate change across six model specifications. The models progressively incorporate cognitive, institutional, and interaction variables to assess the consistency and robustness of the determinants. The regression results indicate that only a few variables consistently and significantly influence rural households' willingness to adapt to climate change. Education emerges as a strong and reliable predictor across all model specifications, demonstrating that more educated households are consistently more willing to adopt adaptation strategies in the selected North Central state. Income is also statistically significant in every model, indicating that households with greater financial resources are more capable and more inclined to engage in adaptation.

Risk perception becomes significant in several model specifications. It exhibits a negative relationship with willingness to adapt in models without interaction terms, indicating that households with weaker or distorted perceptions of climate risks are less likely to adopt adaptation measures. When interaction terms are introduced, the effect of risk perception shifts to a positive and significant influence, suggesting that the role of risk perception depends on the broader cognitive context. The interaction between awareness and risk perception is also statistically significant in the final model. Its negative coefficient suggests that when both awareness and perceived risk are high, households may experience heightened concern or information overload, which reduces adaptive willingness. In summary, the statistically significant determinants of willingness to adapt are education, income, risk perception, and the awareness–risk perception interaction. These factors play the most reliable roles in shaping adaptation decisions among rural households.

Table 4: Determinants of Adaptation to Climate Change among Rural Households

Variables	(1) Adaptation	(2) Adaptation	(3) Adaptation	(4) Adaptation	(5) Adaptation	(6) Adaptation
Education	0.210	0.211	0.188	0.212	0.225	0.383**
	(0.148)	(0.148)	(0.150)	(0.151)	(0.152)	(0.158)
Income	0.004	0.011	0.013	-0.004	-0.007	-0.057
	(0.045)	(0.046)	(0.046)	(0.046)	(0.047)	(0.048)
Age		-0.249***	-0.264***	-0.263***	-0.256***	-0.339***
		(0.067)	(0.068)	(0.069)	(0.069)	(0.072)
Gender			-0.147	-0.198	-0.197	-0.392***
			(0.131)	(0.132)	(0.132)	(0.137)
Awareness				-0.546***	-0.540***	-0.626***
				(0.160)	(0.160)	(0.165)
Institution					0.159	0.181
					(0.209)	(0.209)
Constant	-0.389**	0.224	0.370	0.866***	0.697*	1.783***
	(0.160)	(0.230)	(0.264)	(0.304)	(0.376)	(0.421)
Observations	1,112	1,112	1,112	1,112	1,112	1,112

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1
Source: Authors' Computation (2025)

Table 4 presents the regression estimates of the determinants of climate change adaptation across six model specifications. The results are discussed based on the stability, significance, and direction of the coefficients as additional explanatory variables are introduced into the models. The significant determinants of rural households' climate change adaptation are limited to a few key demographic and cognitive variables. Age is consistently negative and highly significant across all relevant models, indicating that younger household heads are more likely to adopt adaptation strategies than older farmers. Gender becomes significant in the full model, showing that female-headed households are more likely to adapt than their male counterparts once perception and institutional factors are controlled.

Education emerges as significant only in the final model, demonstrating that higher educational attainment increases adaptive behaviour when cognitive and institutional conditions are simultaneously accounted for. Awareness of climate change is strongly significant in all models where it appears, with negative

coefficients, indicating that low level of awareness substantially reduces adaptation likelihood. Risk perception is also highly significant, with a strong negative effect, confirming that households with poor understanding of climate risks are less inclined to adopt adaptation measures. In summary, the statistically significant drivers of adaptation include age, gender, education, awareness, and risk perception. Income and institutional support do not have significant effects on adaptation decisions.

4.1 Discussion of Findings

The results collectively offer a comprehensive understanding of both the determinants of climate change exposure among rural households and the factors shaping their willingness to adapt. Together, these findings illustrate a consistent pattern in which socioeconomic factors, particularly education and income, play a central role in shaping vulnerability and adaptive behaviour. Across both models, education emerges as a significant predictor of climate-related outcomes. The results show that higher education levels were associated with reduced exposure to climate risks, indicating that more educated households are likely to possess better knowledge, planning capacity, and access to protective resources. The findings of this study reinforce the fact that education significantly increases the willingness to adapt. This finding aligns closely with Manh and Ahmad (2021) and Nguyen et al. (2021), who show that farmers' experience and knowledge enhance climate risk interpretation and adaptive decision-making. It also supports Limantol et al. (2016), who find that education strengthens farmers' resilience- building efforts in Ghana. This consistent influence highlights the importance of human capital in facilitating both climate risk awareness and proactive adaptation.

Similarly, household income significantly reduces exposure to climate risks while strongly increasing adaptation willingness. Higher-income households are better equipped to invest in protective technologies, diversify livelihoods and absorb climate-related shocks. This result is consistent with Sallawu et al. (2020) and Lakshmi et al. (2025), who document that income and access to financial resources significantly enhance farmers' adaptive capacity by easing constraints related to inputs and technology adoption. The findings provide mixed evidence regarding climate change awareness. While awareness does not significantly reduce exposure, it shows no direct significant effect on adaptation willingness. However, when combined with risk

perception, a significant negative interaction emerges, indicating that awareness strengthens the behavioural effect of perceived risk. Households who both understand climate change and perceive high levels of risk are more likely to engage in adaptation. This outcome corroborates the finding by Fasina et al. (2021), who argue that climate information alone is insufficient unless farmers personally experience or perceive climate threats as immediate and severe. This suggests that awareness alone is insufficient; households must also interpret climate change as a personal threat before acting.

Conversely, risk perception alone shows consistent significance across both tables. Higher risk perception increases reported exposure to climate shocks, suggesting that households who perceive greater risk may reside in more hazard-prone environments or have more acute sensitivity to climate impacts. Risk perception is found to significantly increases willingness to adapt, indicating that actual or perceived vulnerability is a strong motivator for behavioural change. This finding aligns with Nhemachena et al. (2014) and Nyahunda and Tirivangasi (2019), who show that heightened risk perception among rural communities directly drives adaptation behaviour in Southern Africa.

Institutional support shows no significant influence on exposure but strongly increases adaptation willingness in the baseline model. Although the institutional variable becomes unstable in the interaction models due to large standard errors, its significance in earlier specifications supports its relevance. This result supports Jat et al. (2025) and Bhattattarai et al. (2020), who identify access to extension services, climate information and institutional support as critical enablers of adaptation among rural farmers. This indicates that institutions primarily function as facilitators of adaptation rather than as direct shields against climate exposure.

The interaction between awareness and institutions is not significant, suggesting that institutional mechanisms alone do not amplify the effect of awareness. Instead, institutions likely contribute independently through resource provision, information dissemination, and technical training. This finding is consistent with Cheng et al. (2017), who argue that institutional effectiveness depends more on addressing structural vulnerability than on information provision alone. Taken together, the results reveal a climate resilience pathway shaped by socioeconomic capacity, perceived vulnerability and institutional support.

Households with higher education and income are both less exposed to climate risks and more likely to adopt adaptation behaviours. This integrated outcome reinforces Antwi-Agyei and Nyantakyi-Frimpong (2021), who emphasise that adaption strategies emerge from the interaction of knowledge and enabling institutions. This indicates that climate adaptation is not merely a function of environmental pressures but also of structural inequalities that shape the resources and capabilities households possess. Overall, the evidence highlights that adaptation readiness depends on a combination of capacity (education and income), cognition (awareness and risk) and context (institutional support). Policies aimed at strengthening rural climate resilience must therefore adopt integrated strategies that enhance human capital, reduce poverty, build risk literacy, and expand institutional reach.

5. Conclusion and Policy Recommendations

This study examined the socioeconomic and institutional factors shaping climate change adaptation among rural households in North Central Nigeria. Results consistently indicate that education and income are central predictors across both adaptation behaviour and willingness to adapt. The findings show that climate change adaptation among rural households is shaped by a combination of socioeconomic capacity, cognitive factors and institutional conditions. Education consistently enhances both the ability and willingness to adapt, highlighting the importance of human capital. Income also supports adaptation willingness by easing financial constraints. In north Central Nigeria, where agriculture employs a large number of the population and livelihoods are highly climate-sensitive, low income and subsistence farming conditions significantly limit farmers' capacity to invest in climate adaptation and climate-smart agricultural practices. This implies that adaptation decisions are closely tied to household economic realities rather than awareness alone.

Risk perception plays a key role, as households that recognize climate-related vulnerabilities are more motivated to adopt adaptation strategies. Although awareness alone is not consistently significant, it strengthens adaptation willingness when combined with risk perception. This finding reflects the situation in north central Nigeria where increasing exposure to floods, delayed rainfall and shortened growing seasons translates climate information into action only when farmers directly experience livelihood losses and production risks.

Institutional support shows positive but sometimes unstable effects, indicating that extension services and local organizations can facilitate adaptation, though their influence varies by context.

To strengthen adaptive capacity, policies should invest in improving education, expanding access to financial resources, and enhancing climate communication that provides clear, localized risk information. Policy efforts should prioritize farmer-focused climate education, including extension-led training on climate-smart agriculture and sustainable land-use practices rather than broad climate awareness campaigns. Institutional systems must also be reinforced to support community-based adaptation efforts in North-central region of Nigeria. Such support should aim at strengthening agricultural extension services and integrating CSA support into local governance structures so as to translate adaptation willingness into actual adoption of climate-smart practices.

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