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Mitigating the risk of climate change in Smallholder Farming: a Case Study of Jos East Local Government Area of Plateau State

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A B S T R A C T :

As a result of climate change and variability, extreme weather occurrences are increasing in frequency across the globe, leading to substantial decreases in agricultural output and food security. The livelihoods of smallholder farmers, especially those struggling to survive by cultivating small arable lands, are especially impacted. Smallholder farmers in Nigeria face increasing risks due to climate change, particularly in semi-arid regions such as Jos East Local Government Area in Plateau State. This study explores the perceptions, adaptation strategies, and barriers faced by farmers in mitigating climate change impacts. Using a mixed-methods approach, data were collected from 384 respondents through structured questionnaires and supported by focused group discussions. The findings reveal a high level of awareness (75.5%) of climate change among farmers, but also highlight significant barriers to adaptation, including financial constraints (70.3%) and limited knowledge of climate-smart practices (41.7%). Cross-tabulation analyses show that education, gender, and marital status significantly influence perceptions and adaptation behaviors. The study concludes by recommending enhanced extension services, financial support, and community-based adaptation initiatives to strengthen resilience.

Keywords: Climate change, Smallholder farmers, Adaptation, Jos East, Nigeria, Agricultural extension, Climate-smart agriculture

1. Introduction

Smallholder farmers mitigate climate change risks by adopting various strategies, such as adjusting feeding practices, improving water management, and diversifying livestock breeds. Community-based approaches, including resource and knowledge sharing, enhance adaptive capacity. However, limitations in access to information, financial resources, and government support can hinder the effectiveness of these measures. Comprehensive policies that integrate local knowledge and provide financial aid, climate-smart technologies, and training in sustainable practices are essential for long-term adaptation and resilience in rural farming (Mujayin et al., 2024). To mitigate climate change risks in smallholder farming, the study highlights the importance of diversifying management strategies, such as early planting, reducing cultivated area, and water harvesting. Implementing sub-surface water retention technology (SWRT) significantly increased maize yields and biomass. Additionally, fostering synergy among food value chain actors, improving access to new technologies, and enhancing market linkages can further empower smallholder farmers to adapt and manage climate risks effectively, ultimately improving their livelihoods and food security (Nkurunziza et al., 2022).

It is essential to provide cushions against risks, such as insurance schemes, weather forecasting, and early warning systems to mitigate the risk of climate change in smallholder farming. Improving the skills and capacity of farmers and value chain actors, along with fostering farm investments like credit facilities and land tenure security, is crucial. Additionally, implementing effective insurance schemes and weather-index insurance systems can significantly benefit smallholder farmers, facilitating the adoption of sustainable agricultural practices (Ahmed, 2023). Mitigating the risk of climate change in smallholder farming involves implementing adaptation and mitigation strategies such as risk management, diversification, and sustainable intensification. These strategies contribute to climate-smart agriculture's three pillars. However, smallholders face significant constraints, including small farm sizes, limited market access, and land tenure insecurity, which hinder the adoption of these measures. To enhance resilience and mitigation efforts, integrated, system-oriented impact assessments are essential, considering the unique challenges faced by smallholder crop-livestock systems. Agroforestry mitigates the risk of climate change in smallholder farming by enhancing resilience and reducing vulnerability through various ecosystem services. Practices such as home gardens, scattered trees on croplands, and improved fallows provide regulating services like windbreaks and erosion control, which protect crops and maintain soil fertility. Additionally, agroforestry improves nutrient cycling and supports biodiversity, helping farmers adapt to climate variability. This integrated approach fosters food security and diversifies income sources, making smallholder systems more resilient to climate change impacts (Smith, 2022).

2. Materials and Methods

The study used farmers as participants and was approved by Institution Based Research Committee, Department of Agricultural and Bio-Environmental Engineering, Plateau State Polytechnic, Barkin Ladi.

The study area is situated in the northern region of Plateau State, Nigeria. It lies within latitude 9° 55' N and longitude 9° 06' E, with an area of 1,020 km^2 and a population of 85,602 at the 2006 census. The area is characterized by a tropical climate with distinct wet and dry seasons. The annual rainfall ranges between 320 mm to 400 mm, with the rainy season typically lasting from May to October. The terrain of Jos East is well-suited for smallholder agriculture, with fertile land available for cultivation of crops such as maize, yam, potatoes, cassava, and vegetables. Additionally, livestock farming is prevalent, with pastoralists also utilizing the land for grazing. The LGA is traversed by several rivers and streams, providing a valuable water source for both crop irrigation and livestock farming, though water availability is often seasonal. (Zitta and Madaki, 2020).

A mixed-methods approach design was adopted, combining both qualitative and quantitative methods to gain a comprehensive understanding of the risks posed by climate change to smallholder farming in the study area. A multi-stage sampling technique was used to allow the selection of participants who are specifically relevant to the research objectives, while ensuring a broad representation of the smallholder farming community within the study area. Two stages were involved in the selection process. The first step involved the purposive selection of communities based on factors such as proximity to agricultural activities, vulnerability to climate change impacts, and the diversity of farming systems. Within each selected community, random sampling was employed to select individual respondents. This ensured that every household involved in farming had an equal chance of being selected, minimizing bias and enhancing the representativeness of the sample. To ensure that the findings are statistically significant and representative, the sample size for surveys (households) was calculated using Cochran's formula for sample size determination for a finite population. Based on the formula, the sample size for the quantitative survey was 384 farmers.

2.1 Data Analysis

Quantitative data was analyzed using SPSS to generate descriptive statistics, frequency tables, and cross-tabulations. It was also used to analyze survey responses to determine the prevalence of challenges such as erratic rainfall, droughts, floods, and temperature fluctuations. Frequencies, percentages, and bar charts were used to represent the challenges. Percentages were used to show the proportion of farmers affected by each challenge. Qualitative insights were obtained from focused group discussions to validate and enrich the findings.

3. Results

3.1 Demographic and Socioeconomic Characteristics of Respondents

Table 1 provides insights to the demographic and socioeconomic characteristics of the farmers who are engaged in farming activities within the study area, illuminating important socioeconomic characteristics essential for the agricultural sector's climate change adaptation. Findings revealed that majority of respondents were male (60%), while females accounted for 40%. This gender imbalance mirrors traditional agricultural roles in many rural areas of Nigeria, where men are often the primary decision-makers in farming activities. However, the significant participation of women underscores the importance of considering gender-specific needs and opportunities when designing interventions for climate change adaptation (FAO, 2011).The age group 30–39 was the most represented (26.0%), indicating an active working-age population. This group's involvement is crucial as they are more likely to adopt innovative farming practices, including those related to climate change adaptation, compared to older or younger populations (Smit & Wandel, 2006).

Most respondents were married (70.3%) and had a household size of 4–6 persons (52.1%). Larger households provide more labor resources, which can facilitate the implementation of new agricultural practices. However, household size can also put pressure on farming systems, especially when resources are limited, which is often the case in smallholder farming systems (Bryan et al., 2009). A significant portion of respondents (36.5%) had at least secondary education. This level of education is vital for understanding and adopting climate-smart agricultural practices (CSAPs). However, the fact that 23.4% had only primary education suggests that additional outreach and training are needed to bridge the knowledge gap (Beddington et al., 2012).Regarding occupation, 65.1% were full-time farmers, while 20.8% were part-time. Most respondents had 11– 20 years of farming experience (39.6%), with farm sizes largely between 4–6 hectares (52.1%). Crop farming was the most common practice (52.1%), and income from farming was predominantly between ₦100,000 – ₦300,000 annually (39.1%).

Table 1: Demographic and Socioeconomic Characteristics of Respondents

Variable	Frequency	Percentage
Gender		
Male	230	60
Female	154	40
Other	10	2.6
Prefer not to say	14	3.6
Age		
≤20	30	7.8
20-29	80	20.8
30-39	100	26.0
40-49	90	23.4
50-59	54	14.1
60 and above	30	7.8
Marital status		
Single	60	15.6
Married	270	70.3
Divorced	20	5.2
Widowed	24	6.3

Other	10	2.6
Household size		
1-3	70	18.2
4-6	200	52.1
7-9	88	22.9
10 and above	26	6.8
Educational level		
No formal education	40	10.4
Primary education	90	23.4
Secondary education	140	36.5
Tertiary education	96	25.0
Other	18	4.7
Occupation		
Full-time Farmer	250	65.1
Part-time Farmer	80	20.8
Trader	30	7.8
Civil servant	14	3.6
Other	10	2.6
Years in Farming		
Less than 5 years	60	15.6
5 – 10 years	90	23.4
11 – 20 years	152	39.6
More than 20 years	82	21.4
Size of Farmland		
Less than 1 hectare	60	15.6
1 – 3 hectares	160	41.7
4 – 6 hectares	110	28.6
More than 6 hectares	54	14.1
Type of Farmland		
Crop farming	200	52.1
Livestock farming	40	10.4
Mixed farming	130	33.9
Other	14	3.6
Annual income from Farming		
Less than ₦100, 000	100	26.0
₦100, 000 - ₦300, 000	150	39.1
₦300, 000 - ₦500, 000	84	21.9
Above ₦500, 000	28	7.3
Prefer not to say	22	5.7
Access to extension services		
Yes	220	57.3
No	164	42.7
Climate Change Training		
Yes	110	28.6
No	274	71.4

Source: Field survey, 2024.

3.2 Perception and Attitudes toward Climate Change

The result reveals that while perception of climate change and its associated risks is high among smallholder farmers in the study area, actual adaptation is constrained by knowledge gaps and financial limitations. The majority of respondents demonstrated a high level of awareness regarding the existence and effects of climate change on smallholder farming. Specifically, 75.5% of the respondents either agreed or strongly agreed that climate change is currently affecting farming activities in Jos East Local Government Area. Moreover, 80.7% believed that the impact of climate change has made farming more difficult in recent years, while 78.1% were of the view that farming will continue to be negatively affected if no measures are taken. These findings align with studies by Fadina and Barjolle (2018) and Mertz et al., (2009), who reported that smallholder farmers in sub-Saharan Africa are increasingly becoming aware of the adverse effects of climate variability.

Additionally, while 59.9% of respondents acknowledged being aware of how climate change affects their crops and livestock, only 49.5% expressed confidence in their ability to adapt their farming practices in response. This gap between awareness and confidence to act suggests that while knowledge may be increasing, practical empowerment and resource availability might be lacking.

3.3 Adaptation to Climate Change

When asked about specific adaptation practices and as shown in Table 2, 41.7% of respondents agreed they had sufficient knowledge about climate-smart agricultural practices. Furthermore, 57.3% stated they regularly adjust their farming practices to account for changing weather conditions,

indicating a fair level of proactive behavior among the farming population. However, only 36.5% reported using drought-resistant crop varieties - a key strategy for climate resilience in agriculture (FAO, 2016).

Table 2: Climate Change Adaptation Practices

Statement	Agree (%)
Knowledge about climate-smart practices	41.7
Adjusting practices due to weather changes	57.3
Use of drought-resistant seeds	36.5
Willingness to adopt new technologies	54.7
Financial challenges hinder adaptation	70.3

Source: Field survey, 2024

Willingness to adopt new technologies was high, with 54.7% expressing readiness to embrace innovations aimed at reducing climate-related risks. This points to a positive attitude among respondents, which could be leveraged through targeted extension services and training programs. However, financial constraints remain a significant barrier, with 70.3% citing financial challenges as a major limitation to adaptation. This reinforces the findings of Below et al. (2012), who argue that socio-economic factors, especially access to credit, significantly influence farmers' adaptive capacity.

3.4 Cross-tabulation Analysis

Cross-tabulation analysis was used to examine the relationship between two categorical variables simultaneously. This approach is particularly valuable in climate-adaptation research, where understanding how socio-economic and demographic factors influence farmers' perceptions and practices can inform targeted intervention strategies (Bryan et al., 2013; Deressa et al., 2009). In this study, three key cross-tabulations were performed: Education Level vs Knowledge of Climate-Smart Agricultural Practices (Table 3) - to assess whether formal schooling enhances awareness of adaptation options, Gender vs Perception that Climate Change Will Continue to Affect Farming (Table 4) - to explore potential gender differences in risk perception and information access (FAO, 2013) and Marital Status vs Financial Challenges in Adapting to Climate Change (Table 5) - to investigate how household obligations intersect with resource constraints (Maddison, 2007).

3.4.1. Education Level vs Knowledge of Climate-Smart

Agricultural Practices Table 3 provides the results of Education Level vs Knowledge of Climate-Smart Agricultural Practices to assess whether formal schooling enhances awareness of adaptation options.

Table 3: Education Level vs Knowledge of Climate-Smart Agricultural Practices

Education Level	Agree/Strongly agree	Disagree/Neutral	Total
No formal education	10 (25%)	30 (75%)	40
Primary education	30 (33%)	60 (66.7%)	90
Secondary education	60 (42.9%)	80 (57%)	140
Tertiary education	50 (52.1%)	46 (47.9%)	96
Other	10 (55.6%)	8 (44.4)	18
Total	160 (41.7)	224 (58.3)	384

Source: Field survey, 2024

The cross-tabulation as represented in Table 3 shows that respondents with higher formal education levels report greater knowledge of climate-smart agricultural practices: tertiary- educated farmers (52%) versus only 25% of those with no formal education. This aligns with Deressa et al., (2009), who found that education significantly enhances both awareness and uptake of adaptation measures. This is corroborated by Ayinla et al., (2024) who stated that farmers having moderately higher levels of education, particularly post-primary (secondary) education are inclined to have increased farm income as it attributes to their proper understanding of climate change and its potential consequences. Bryan et al., (2013) similarly demonstrate that secondary and tertiary education increases the likelihood of farmers seeking out and understanding climate information. The relatively high awareness does not translate into practice due to institutional and economic constraints. This calls for a multi-stakeholder approach that integrates farmer training, credit access, and community engagement in policy formulation.

3.4.2 Gender vs Perception that Climate Change Will Continue to Affect Farming

Table 4 presents the results of Gender vs Perception that Climate Change Will Continue to Affect Farming, to explore potential gender differences in risk perception and information access. Table 4: Gender vs Perception that Climate Change Will Continue to Affect Farming

Gender	Agree/Strongly Agree	Disagree/Neutral	Total
Male	140 (77.8%)	40 (22.2%)	180
Female	130 (72.2%)	50 (27.8%)	180
Other	6 (60.0%)	4 (40.0%)	10
Prefer not to say	10 (71.4%)	4 (28.6%)	14
Total	286 (74.5%)	98 (25.5%)	384

Source: Field survey, 2024

Both male and female farmers exhibit high levels of concern - with 77.8% of men and 72.2% of women agreeing that climate change will continue to impact farming. Brody (2008) note that while women often report greater perceived vulnerability, men's higher access to extension services may drive their stronger agreement. The slight gender gap here may reflect women's more limited access to climate information (FAO, 2013). Respondents in the

"Other" and "Prefer not to say" categories, though small in number, also show substantial concern, indicating that awareness transcends traditional gender binaries.

3.4.3 Marital Status vs Financial Challenges in Adapting to Climate Change

Table 5 presents the results of Marital Status vs Financial Challenges in Adapting to Climate Change, to investigate how household obligations intersect with resource constraints.

Table 5: Marital Status vs Financial Challenges in Adapting to Climate Change

Marital Status	Agree/Strongly Agree	Disagree/Neutral	Total
Single	40 (66.7%)	20 (33.3%)	60
Married	200 (74.1%)	70 (25.9%)	270
Divorced	12 (60.0%)	8 (40.0%)	20
Widowed	15 (62.5%)	9 (37.5%)	24
Other	3 (30.0%)	7 (70.0%)	10
Total	270 (70.3%)	114 (29.7%)	384

Source: Field survey, 2024

Married farmers report slightly higher financial constraints (74.1%) than singles (66.7%). This is consistent with Maddison (2007), who argues that household obligations (e.g., dependents) can intensify perceived financial barriers to adaptation. This is consistent with the findings of Ayinla et al., (2024) who reported that being a male and married farmer induces a higher farm income, while an increase in the age of the farmers and the family size also leads to an increase in farm income. Deressa et al. (2009) also found that larger household units - often correlated with marital status - face greater input costs, reducing capacity to invest in drought-resistant seeds or new technologies.

4. Discussion

Understanding the demographic and socioeconomic profiles of smallholder farmers is essential for assessing their capacity to adapt to climate change and for formulating effective agricultural policies. The majority of farmers in the study area fall within the active age bracket of 31–50 years, indicating a workforce capable of engaging in labor-intensive agricultural activities and adapting to new farming practices. This age distribution aligns with findings from Bunkure, where 79.3% of farmers were within the 31–50 years age range (Haliru et al., 2021). According to Alao et al. (2014), younger farmers are more likely to be creative, flexible, and open to implementing new technology, all of which can increase farm income and productivity. Agriculture in the area is predominantly male-dominated, with 60% of farmers being male. This finding agrees with Ayanlade et al. (2023) who reported that that gender plays a significant role in the adoption of adaptation practices in the agricultural sector and that males often have more access to resources and decision-making power in farming as the heads of households. This trend is consistent with cultural norms in northern Nigeria, where men are primarily responsible for farming activities (Haliru et al., 2021). To ensure that men and women have equal possibilities to profit from adaptation options in agriculture, more gender-sensitive methods to adaptation planning and implementation are required.

Farmers' coping mechanisms are greatly influenced by their marital status, and married farmers may profit from shared duties, resources, and labor, which can increase farm profitability and productivity. It is reported that Ethiopian farmers' coping strategies, such as moving to another area, are influenced by their marital status. Married persons and heads of households are less likely to flee their homes when harvests fail and there is a shortage of food. This demonstrates the strong sense of duty that married men and women, regardless of gender, have to support their families (Adimassu & Kessler, 2016). Another key factor is the size of one's family. Ahmed and Givens (2025) highlighted that people with lower incomes are less likely to be able to pay for hired assistance, and closely supervising non-family members may raise ethical concerns. According to Atinkut and Mebrat (2016), larger families are more likely to adapt to climate change and lessen its negative effects. Education is a vital human resource that is essential to raising farm income. Education status has significant influence on farmers' adaptation strategies to both deal with climate variability and to ensure household income (Arin and Knight, 2023).Higher productivity and revenue are the results of educated farmers' increased use of modern farming methods, usage of better inputs, and access to market trends. Climate information and environmental education are some of the potentially strategies that are crucial in the battle against the adverse consequences of climate change and the creation of new adaptations to those effects. According to Maddison (2006), in order for farmers to make the right adaptation choices, they must be cognizant of the changes in the climate characteristics they are experiencing, like temperature and precipitation.

Farmers' perceptions, attitudes, and awareness of climate change have a big impact on their capacity to handle extreme weather occurrences as well as their farm income. These elements are crucial in determining how farmers react to the difficulties presented by climate change, including their readiness to invest in resilient farming methods, embrace adaptive techniques, and use information and technology that can assist in reducing hazards. Most farmers noticed notable alterations in the weather, including hotter temperatures, erratic precipitation, and longer dry seasons. Many believe that climate change is having a negative impact on agricultural productivity as a result of these observations. This aligns with the findings of Ricart et al. (2023) who posit that increasing climate change awareness is often considered necessary in the first stages of the adaptation process to manage its impacts and reduce overall vulnerability. There is mounting evidence that farmers must first comprehend the effects of extreme weather before they can establish coping mechanisms or adaptation plans for climate change (Boillat & Berkes, 2013). Despite recognizing the impacts of climate change, farmers' attitudes towards adaptation vary. While some are proactive in seeking and implementing adaptive strategies, others remain hesitant due to factors such as financial constraints, lack of access to information, and limited support services. This hesitancy is consistent with observations in sub-

Saharan Africa, where farmers' attitudes towards climate change adaptation are influenced by socioeconomic and institutional factors (Juana et al., 2013). Awareness of climate change among farmers is generally high, primarily due to firsthand experiences of its effects. However, there is a notable gap in understanding the underlying causes and broader implications of climate change. Many farmers attribute climatic changes to natural variability rather than anthropogenic factors. This limited knowledge can hinder the adoption of effective adaptation strategies.

The findings underscore the need for targeted interventions to enhance farmers' knowledge and capacity to adapt to climate change. This includes the provision of accessible information on climate change causes and adaptation strategies, strengthening extension services, and facilitating access to financial resources. By addressing these areas, policymakers and development practitioners can support farmers in building resilience against climate-related challenges.

5.0 Conclusion

This study investigated the demographic and socioeconomic characteristics, perceptions, attitudes, and awareness of climate change among smallholder farmers in Jos East Local Government Area, Plateau State, Nigeria. The findings revealed that while a significant number of farmers are aware of climate change and its adverse effects on agriculture, several barriers hinder effective adaptation. Key barriers identified include financial constraints, limited access to climate information, inadequate extension services, high input costs, labor shortages, pest and disease infestations, and limited access to credit facilities. The study underscores the need for targeted interventions to address these barriers and enhance the adaptive capacity of smallholder farmers. By implementing the recommendations outlined below, stakeholders can support farmers in building resilience against climate-related challenges.

6.0 Recommendations

I. Enhance Access to Financial Resources. Develop and implement financial schemes, such as low-interest loans and grants, tailored to the needs of smallholder farmers to facilitate investment in climate-resilient agricultural practices.
II. Improve Climate Information Dissemination. Establish reliable and timely channels for disseminating climate and weather information, including the use of mobile technology and community-based platforms, to aid farmers in making informed decisions.
III. Strengthen Agricultural Extension Services. Increase the number and capacity of extension officers to provide farmers with up-to-date knowledge and training on climate-smart agricultural practices.
IV. Facilitate Access to Credit Facilities. Simplify the process of obtaining credit by reducing bureaucratic hurdles and providing financial literacy programs to empower farmers to effectively manage and utilize credit for adaptation purposes.
V. Promote Community-Based Adaptation Strategies. Encourage the formation of farmer groups and cooperatives to foster knowledge sharing, collective action, and access to resources, thereby enhancing community resilience to climate change.

7.0 Ethical Consideration

This study was conducted in strict accordance with ethical standards governing research involving human participants. All participants were thoroughly informed about the study's objectives, procedures, potential risks, and benefits. Informed consent was obtained from each participant, with assurances that their participation was entirely voluntary and that they could withdraw at any point without any repercussions. The study adhered to the ethical principles outlined in the Declaration of Helsinki and the Belmont Report, emphasizing respect for persons, beneficence, and justice. The study was approved by Institution Based Research (IBR) Committee, Department of Agricultural and Bio-Environmental Engineering, Plateau State Polytechnic, Barkin Ladi.

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