VOL. 13 NO. 1,
AUGUST, 2026
E-ISSN 3027-0995
P-ISSN 3026-8265

African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Biotechnology and Agricultural Research (JBAR)

Climate Change Adaptation Strategies among Smallholder Farmers in Nasarawa State, Nigeria

[1]Abdullahi Yusuf Agwai; [2]Ekpo Abraham Salamatu, PhD; & [3]Adamu Suleiman Ogah

[1]Department of Geography Federal University Lafia Nasarawa State. [2]Department of Environmental Management Nasarawa State University keffi. [3]Department of Geography Nasarawa State University Keffi.

Corresponding Author: yusufagwai4@gmail.com
DOI: https://doi.org/10.70382/ajbar.v13i1.033

Abstract

Climate change poses significant challenges to smallholder farmers whose agricultural activities depend largely on climatic conditions. This study examined climate change adaptation strategies among smallholder farmers in Nasarawa State, Nigeria, with emphasis on the strategies adopted and factors influencing their adoption. A descriptive survey design was adopted, and 384 questionnaires were administered to selected smallholder farmers using a multistage sampling technique. A total of 370 questionnaires were retrieved, representing a 96.4% response rate. Data were analyzed using frequencies and percentages, while information from key informant interviews was used to complement the quantitative findings. The major finding revealed that crop diversification and livelihood diversification were the most commonly adopted adaptation strategies, each reported by 14% of respondents, while irrigation/water harvesting and soil and water conservation recorded only 5% each. The study also found that farming experience and farm size were the leading factors influencing adaptation. The study recommends that smallholder farmers should broaden their adoption of climate change adaptation strategies, while the Nasarawa State Government and relevant agricultural agencies should provide extension training, improved farm inputs, irrigation facilities and affordable climate-smart technologies to enhance farmers' adaptive capacity.

Keywords: Adaptation Strategies, Agricultural, Climate change, Nasarawa State, and Smallholder farmers.

Introduction

Climate change is increasingly affecting agricultural production and the livelihoods of smallholder farmers across different regions of the world. In India, for example, changing

temperature and rainfall patterns have increased climate-related risks to agricultural production, particularly among smallholder farming households whose livelihoods depend heavily on natural resources and rain-fed agriculture. Studies have shown that farmers respond to these risks through changes in cropping patterns, adoption of improved varieties, irrigation, diversification of livelihoods and other farm-level adaptation measures (Aryal et al., 2020). Such evidence demonstrates that climate change adaptation has become an important component of agricultural livelihood management globally, particularly in developing countries where farmers have limited capacity to absorb climate-related shocks. The challenge is particularly pronounced in Africa, where agriculture remains central to food production, employment and rural livelihoods. African smallholder farmers are highly exposed to increasing temperatures, rainfall variability, droughts, floods and other climate-related hazards. Their vulnerability is further intensified by dependence on rain-fed agriculture, limited access to irrigation, agricultural credit, improved technologies and reliable climate information. Okoronkwo et al. (2024) reported that farming communities in sub-Saharan Africa are increasingly modifying traditional agricultural practices through crop diversification, agroforestry, soil and water conservation, improved planting practices and other adaptation measures. Similarly, Manda et al. (2023) established that farmers' climate adaptation decisions in Africa are influenced by socioeconomic characteristics, access to information, institutional support and availability of productive resources.

In West Africa, climate change poses a major threat to agricultural production because the region's farming systems are predominantly dependent on seasonal rainfall. Increasing rainfall variability, rising temperatures, droughts and flooding have implications for planting dates, crop yields, food availability and rural household incomes. Evidence from West African farming communities indicates that farmers respond to these challenges through adjustments in planting dates, crop diversification, improved crop varieties, soil and water conservation, irrigation and livelihood diversification. However, the ability of farmers to adopt these strategies is influenced by their access to extension services, credit, climate information, markets and other institutional resources (Manda et al., 2023).

In Nigeria, climate change has become an important threat to agricultural productivity and rural livelihoods because a large proportion of smallholder farmers depend on rain-fed agriculture. Variations in rainfall, increasing temperatures, droughts and flooding have created uncertainties in agricultural decision-making and increased the vulnerability of farming households. Evidence from Southwest Nigeria shows that smallholder maize farmers adopt multiple adaptation strategies, including crop diversification, changes in planting practices and the use of improved agricultural technologies. Access to climate information, credit, education, farm size, farming experience and membership of farmer associations significantly influenced farmers' adoption of climate change adaptation strategies Adebayo et al (2023). Concerns have been reported in Kebbi State, where agriculture is an important livelihood activity. Solaja et al. (2024), in their study of smallholder rice farmers, found that farmers employed various adaptation measures to cope with climate change, while access to extension services, credit and climate information influenced their adaptation decisions. In Kwara and Nasarawa States, Ayanlade et al. (2023) further established that farmers experienced differentiated vulnerabilities to climate change and adopted different responses according to their socioeconomic circumstances and access to resources. These findings suggest that climate change adaptation among Nigerian farmers is location-specific and that strategies adopted in one agricultural region may not necessarily be equally applicable to another.

Nasarawa State is particularly important for examining climate change adaptation because smallholder agriculture constitutes a major livelihood activity across the state. Farmers depend substantially on climatic conditions for crop production, making them vulnerable to changes in rainfall patterns,

temperature and the occurrence of extreme weather events. Although studies have examined climate vulnerability and adaptation in selected parts of Nasarawa State, there remains limited evidence providing a comprehensive assessment of the range of adaptation strategies employed by smallholder farmers across the state. Much of the existing research has focused on particular crops, selected communities or specific dimensions of vulnerability. Consequently, there is a need for broader empirical evidence on the strategies that smallholder farmers in Nasarawa State employ to cope with the effects of climate change. Therefore, this study examines climate change adaptation strategies among smallholder farmers in Nasarawa State, Nigeria. The study is expected to provide empirical evidence that can assist government agencies, agricultural extension services, development organizations and other stakeholders in designing appropriate interventions to strengthen farmers' adaptive capacity, sustain agricultural production and improve rural livelihood resilience in the face of climate change.

Objectives of the Study

The study seeks to:

- **i.** Identify the major climate change adaptation strategies adopted by smallholder farmers in Nasarawa State, Nigeria.
- **ii.** Examine the factors influencing the adoption of climate change adaptation strategies among smallholder farmers in Nasarawa State, Nigeria.

Climate change adaptation strategies among smallholder farmers

Ogundeji, A. A. (2022) examined climate change adaptation and its implications for smallholder farmers' food security in South Africa. The study found that farmers employed different adaptation measures to reduce the effects of climate-related shocks and that adaptation was important for maintaining household food security. The study demonstrated that farmers' ability to adapt is closely associated with their socioeconomic circumstances and access to resources. However, the study was conducted in South Africa, where agricultural and climatic conditions differ from those of Nigeria, creating a contextual gap for understanding adaptation among Nigerian smallholder farmers.

Yiran, G. A. B., Atubiga, J. A., Kusimi, J. M., Kwang, C., & Owusu, A. B. (2022) examined soil and water management practices used by smallholder farmers in rural Ghana as responses to climate-related stresses. The study found that farmers relied on locally available soil and water management practices to sustain crop production under changing climatic conditions. These practices demonstrated the importance of farmers' indigenous knowledge and locally developed adaptation mechanisms. However, the study concentrated specifically on agro-ecological intensification and soil and water management rather than the broader range of adaptation strategies available to smallholder farmers. It therefore leaves a gap concerning the combined assessment of farm-based and livelihood-based adaptation strategies.

Solaja, S., Kolawole, A., Awe, T. E., Oriade, O. A., Ayojimi, W., Ojo, I., Nayan, G., Adedayo, R., Etta-Oyong, S., Olasehinde, F., Asemokhai, O., & Nsikak, I. (2024) assessed climate change adaptation strategies among smallholder rice farmers in Kebbi State, Nigeria. Based on data from 345 farmers, the study used multivariate probit and ordered probit models to examine both adaptation choices and adoption intensity. The findings showed that marital status, literacy, farm size, farming experience, major occupation, extension visits, access to credit and climate information influenced farmers' choice of adaptation strategies. The study further found that literacy, household size, farm size, extension visits and access to climate information were important determinants of adaptation intensity. While this study provides strong recent evidence from northern Nigeria, its focus on rice farmers in Kebbi State means

that its findings cannot automatically be generalized to smallholder farmers cultivating different crops under the ecological and socioeconomic conditions of Nasarawa State.

Factors influencing the adoption of climate change adaptation strategies

Finizola e Silva, M., Van Schoubroeck, S., Cools, J., & Van Passel, S. (2024) examined the drivers and barriers to climate-smart agriculture adoption among smallholder farmers in Africa. The review identified more than 50 climate-smart agricultural practices and over 40 factors affecting their adoption. These factors were grouped into personal, farm-related, financial, environmental and informational categories. The study concluded that adoption is influenced by a combination of farmers' characteristics, farm conditions, financial capacity, environmental circumstances and access to information. This finding is particularly relevant to the present study because it demonstrates that adaptation decisions should be examined from a multidimensional perspective rather than being attributed to a single socioeconomic factor. However, as a continental systematic review, it does not provide location-specific evidence for Nasarawa State.

Lamichhane, P., Hadjikakou, M., Miller, K. K., & Bryan, B. A. (2022) examined climate change adaptation in smallholder agriculture and identified adoption patterns, barriers and determinants across smallholder farming systems. Their findings emphasize that adaptation is influenced by farmers' available resources and the institutional and socioeconomic environment within which agricultural decisions are made. The study is useful in demonstrating that exposure to climate change alone does not necessarily result in adaptation; farmers must also possess the capacity and resources required to implement appropriate responses. However, the study was not specifically focused on Nigeria and therefore requires contextual examination within Nigerian smallholder farming systems.

Danso-Abbeam, G., Ojo, T. O., Baiyegunhi, L. J. S., & Ogundeji, A. A. (2021) provide further evidence that economic capacity influences adaptation. Their study in Southwest Nigeria showed that participation in non-farm employment significantly increased the number of adaptation practices adopted by smallholder farmers. This finding implies that farmers with alternative income sources may have greater financial capacity to purchase improved seeds, modify farm operations and implement other adaptation measures. However, the study did not examine the influence of other potentially important factors across different agricultural communities in Nasarawa State.

Theoretical Framework: Theory of Planned Behavior (TPB)

This study is anchored on the Theory of Planned Behavior (TPB) developed by Ajzen (1991). The theory explains how individuals' behavioral decisions are influenced by their attitudes, subjective norms and perceived behavioral control. It is appropriate for this study because climate change adaptation among smallholder farmers involves decisions about whether to adopt particular agricultural practices in response to perceived climatic risks. In the context of smallholder farmers in Nasarawa State**,** farmers' attitudes towards climate change adaptation may influence their willingness to adopt practices such as crop diversification, improved seed varieties, adjustment of planting dates, agroforestry, mulching, soil and water conservation, irrigation and livelihood diversification. Farmers who perceive these practices as effective in reducing the adverse effects of climate change and improving agricultural productivity are more likely to adopt them. The subjective norm component of the theory explains the influence of other people and institutions on farmers' adaptation decisions. In Nasarawa State, farmers may be influenced by agricultural extension agents, fellow farmers, farmer associations, traditional/community leaders and family members. Where these social groups encourage climate-resilient farming practices, farmers may be more willing to adopt them. The third component, perceived behavioral control**,** refers

to farmers' perception of their ability to adopt and implement adaptation practices. For smallholder farmers in Nasarawa State, access to credit, farm inputs, extension services, climate information, labor, land, markets and appropriate agricultural technologies may determine whether they consider particular adaptation strategies affordable and practicable.

The TPB therefore provides a useful framework for understanding why some smallholder farmers in Nasarawa State adopt particular climate change adaptation strategies while others do not. The theory suggests that farmers' attitudes, social influences and perceived capacity**,** together with the resources available to them, shape their intention and eventual adoption of adaptation practices. Consequently, the theory supports the study's examination of both the adaptation strategies adopted by smallholder farmers and the factors influencing their adoption**.**

Methodology

The study adopted a descriptive survey design and was conducted among smallholder farmers in Nasarawa State, Nigeria. The study population comprised smallholder farming households across the state, from which a manageable sample of 384 respondents was determined using the Krejcie and Morgan (1970) sample-size determination table**.** A multistage sampling technique was used to select farming communities and respondents across the state. Primary data were collected using a structured questionnaire, complemented by key informant interviews with agricultural extension agents and farmer/community leaders, while relevant secondary information was obtained from scholarly publications and official documents. Data were analyzed using frequencies and percentages, while qualitative information from key informants was transcribed and used to complement the quantitative findings.

Data Presentation and Analysis

Data collected from the 370 validly retrieved questionnaires out of 384 distributed were coded, tabulated and analyzed using descriptive statistics. Frequencies and percentages were used to identify and describe the major climate change adaptation strategies adopted by smallholder farmers in Nasarawa State and the factors influencing their adoption. The analysis was based on 370 valid responses (n = 370)**,** representing a 96% response rate, while the 14 questionnaires not returned were excluded from the analysis. The results were presented in frequency and percentage tables and interpreted in relation to the study objectives. Information obtained from key informant interviews with agricultural extension personnel and farmer/community leaders was transcribed and descriptively interpreted to complement the quantitative findings.

Table 1: Climate Change Adaptation Strategies Adopted by Smallholder Farmers in Nasarawa State

S/N	Adaptation strategy	Frequency	Percentage (%)
1	Crop diversification	53	14 (%)
2	Improved/drought-tolerant varieties	20	6 (%)
3	Changing planting dates	48	13 (%)
4	Agroforestry	49	13 (%)
5	Mulching	34	9 (%)
6	Organic manure application	30	8 (%)
7	Soil and water conservation	19	5 (%)

S/N	Adaptation strategy	Frequency	Percentage (%)
8	Irrigation/water harvesting	18	5 (%)
9	Crop rotation	46	13 (%)
10	Livelihood diversification	53	14 (%)
	Total	**370**	**100 (%)**

Table 1 presents the climate change adaptation strategies adopted by smallholder farmers in Nasarawa State. The results indicate that crop diversification and livelihood diversification were the most commonly reported strategies, each accounting for 53 respondents (14%). This suggests that farmers mainly respond to climate-related uncertainties by cultivating different crops and diversifying their sources of livelihood, thereby reducing dependence on a single crop or income source. Agroforestry and changing planting dates were each reported by 49 and 48 respondents, representing 13% each. Similarly, crop rotation was adopted by 46 respondents (13%). These findings indicate that a considerable proportion of farmers adjust their farming practices and production calendars in response to changing climatic conditions. Other strategies included mulching, adopted by 34 respondents (9%), and organic manure application, adopted by 30 respondents (8%). These practices suggest farmers' efforts to maintain soil fertility and conserve soil moisture under changing climatic conditions. The least reported strategies were irrigation/water harvesting, adopted by 18 respondents (5%), and soil and water conservation, adopted by 19 respondents (5%). The use of improved/drought-tolerant varieties was reported by 20 respondents (6%). The relatively low adoption of these strategies may be associated with limited access to irrigation facilities, improved planting materials, financial resources, technical knowledge and extension support. The findings show that smallholder farmers in Nasarawa State rely more on crop-based and livelihood-based strategies that are relatively accessible, particularly crop diversification, livelihood diversification, agroforestry, adjustment of planting dates and crop rotation. Conversely, strategies that may require greater financial investment, infrastructure or technical support, such as irrigation, water harvesting and improved drought-tolerant varieties, recorded lower levels of adoption. This highlights the need for strengthened extension services, improved access to climate information, affordable farm inputs, irrigation facilities and financial support to enhance farmers' adaptive capacity.

The extension agent explained that farmers in the area are increasingly changing their farming practices because rainfall is becoming less predictable. According to the officer, many farmers now cultivate different crops on their farms and adjust their planting dates when the onset of rainfall changes. The officer also noted that crop rotation, agroforestry and the use of organic manure are increasingly encouraged because they can improve soil fertility and help farmers cope with changing climatic conditions. However, adoption of improved drought-tolerant varieties and irrigation remains relatively low because many farmers have limited financial resources and inadequate access to improved inputs and irrigation facilities *(KII/Male/47/EA/Aug/2026)*.

The community leader reported that farmers have noticed changes in the timing and distribution of rainfall, which affect their normal farming calendars. The leader explained that farmers increasingly plant different crops and engage in alternative livelihood activities to reduce the effects of poor harvests. According to the leader, some farmers have also adopted agroforestry, mulching and crop rotation, while irrigation and water harvesting are less common because of the cost of facilities and limited access to reliable water sources. The leader emphasized that greater access to farm inputs, extension services and financial support would encourage more farmers to adopt additional climate change adaptation practices *(KII/Male/57/CL/Aug/2026)*.

The interview responses support the questionnaire findings, particularly the relatively high adoption of crop diversification, livelihood diversification, agroforestry, changing planting dates and crop rotation. The interviews also help explain the relatively low adoption of irrigation/water harvesting and improved drought-tolerant varieties, mainly in terms of financial constraints, limited access to inputs and inadequate irrigation facilities.

These findings are consistent with Ogundeji (2022)**,** who reported that smallholder farmers in South Africa employed various adaptation measures to cope with climate-related shocks and improve household food security. Similarly, Solaja et al. (2024) found that smallholder rice farmers in Kebbi State, Nigeria, adopted different climate change adaptation strategies, with socioeconomic and institutional factors influencing their choices. The present finding on the importance of changing farming practices also agrees with Yahaya et al. (2024)**,** who reported that smallholder farmers in Ghana adopted various strategies in response to climate-related risks and that their adaptation decisions were influenced by climate-risk perceptions and farmers' adaptive capacity.

Thus, the findings of this study generally agree with previous empirical evidence that smallholder farmers tend to prioritize adaptation strategies that are accessible, affordable and compatible with existing farming systems**,** while adoption of practices requiring substantial financial and infrastructural resources remains comparatively limited.

Table 2: Factors Influencing the Adoption of Climate Change Adaptation Strategies

S/N	Factor	Frequency	Percentage (%)
1	Access to extension services	44	12 (%)
2	Access to climate information	22	6 (%)
3	Availability of credit/financial resources	26	7 (%)
4	Availability of farm inputs	42	11 (%)
5	Education/level of awareness	40	10 (%)
6	Farming experience	50	14 (%)
7	Farm size	50	14 (%)
8	Access to irrigation facilities	26	7 (%)
9	Market access	48	13 (%)
10	Perception of climate change	22	6 (%)
	Total	**370**	**100**

Table 2 presents the factors influencing the adoption of climate change adaptation strategies among smallholder farmers in Nasarawa State. The findings show that farming experience and farm size were the most frequently identified factors, with 50 respondents (14%) each. This suggests that experienced farmers may possess greater practical knowledge of changing climatic conditions and farming practices, while farmers with larger farms may have greater flexibility and resources to implement different adaptation measures. Market access was identified by 48 respondents (13%)**,** followed by access to extension services, reported by 44 respondents (12%)**.** This indicates that farmers' ability to access agricultural markets and obtain technical guidance can influence their adoption of adaptation practices. Extension services can expose farmers to improved farming techniques, while market access may provide income and incentives needed to invest in adaptation measures. The availability of farm inputs was reported by 42 respondents (11%)**,** while education/level of awareness was identified by 40 respondents (10%). These findings suggest that farmers' knowledge of climate-related risks and their

ability to obtain appropriate inputs are important in determining their capacity to adapt. Farmers who have access to improved seeds, fertilizers and other inputs may be better positioned to implement appropriate adaptation practices. Availability of credit/financial resources and access to irrigation facilities were each reported by 26 respondents (7%)**.** This indicates that financial and infrastructural resources also contribute to farmers' adaptation decisions, although they were less frequently identified than farming experience, farm size, market access and extension services. Access to climate information and perception of climate change were the least reported factors, each accounting for 22 respondents (6%)**.** This may suggest that although farmers are exposed to climate variability, awareness or perception alone may not be sufficient to encourage adoption when other resources and institutional support are limited.

Farming experience, farm size, market access and extension services strongly influence farmers' ability to adopt climate change adaptation practices. Experienced farmers are more familiar with changes in rainfall and farming conditions and can adjust their practices accordingly. The officer further noted that farmers with larger farms have greater opportunities to diversify crops and adopt different practices. However, inadequate access to improved farm inputs, credit, irrigation facilities and timely climate information limits the adoption of some adaptation strategies *(KII/Female/43/EA/Aug/2026)*.

Farmers' experience, access to markets and availability of farm inputs significantly affect their decisions to adopt adaptation practices. According to the leader, farmers who can easily sell their produce and obtain farm inputs are more willing and able to try new farming practices. The leader also noted that limited access to credit, irrigation facilities and reliable climate information discourages some farmers from adopting more resource-intensive adaptation measures *(KII/Male/39/Farmer/Aug/2026)*.

The interview responses support the questionnaire findings, particularly the importance of farming experience, farm size, market access, extension services and availability of farm inputs**.** The interviews further indicate that inadequate access to credit, irrigation, farm inputs and climate information constrains farmers' ability to adopt a wider range of climate change adaptation strategies.

The findings are consistent with Solaja et al. (2024)**,** who found that factors such as farm size, farming experience, extension visits, access to credit and climate information influenced climate change adaptation among smallholder rice farmers in Kebbi State, Nigeria. The present finding further supports their conclusion that adaptation is influenced by a combination of farm-level and institutional factors. The importance of extension services and farm inputs in the present study also agrees with Yahaya et al. (2024)**,** who reported that extension visits, income, farming experience, climate-change awareness and adaptive capacity influenced adaptation strategies among smallholder farmers in Ghana. Similarly, Finizola e Silva et al. (2024) identified personal, farm-related, financial, environmental and informational factors as important drivers or barriers to climate-smart agriculture adoption among African smallholder farmers.

The finding that farming experience and farm size were among the strongest reported factors is also supported by Danso-Abbeam et al. (2021)**,** whose study in Southwest Nigeria demonstrated that farmers' economic circumstances and livelihood opportunities influenced their capacity to adopt multiple climate change adaptation practices. Lamichhane et al. (2022) likewise emphasized that economic, technological and informational resources can either facilitate or constrain adaptation among smallholder farmers.

The findings also support the Theory of Planned Behavior (Ajzen, 1991)**,** which provides the theoretical foundation for this study. In particular, the results relate strongly to the theory's concept of perceived behavioral control**.** Factors such as farm size, farming experience, access to extension services, farm inputs, credit, irrigation and markets determine the extent to which farmers perceive themselves as

capable of implementing climate change adaptation practices. Thus, even where farmers recognize the need to adapt, limited resources or institutional support may restrict their ability to do so. The findings therefore suggest that farmers' adoption decisions are shaped not only by their awareness or perception of climate change but also by their practical capacity and access to resources required to implement adaptation strategies. This reinforces the relevance of the Theory of Planned Behavior to explaining climate change adaptation among smallholder farmers in Nasarawa State.

Findings

i. The first objective examined the climate change adaptation strategies adopted by smallholder farmers in Nasarawa State. The findings revealed that crop diversification and livelihood diversification were the most commonly reported strategies, each accounting for 14% of the respondents. This was followed by agroforestry, changing planting dates and crop rotation, each accounting for approximately 13%. The prominence of these strategies suggests that farmers largely depend on practices that can be incorporated into their existing farming and livelihood systems and do not necessarily require substantial financial investment. Crop diversification helps to spread production risks, while livelihood diversification provides alternative income sources when agricultural activities are affected by climate-related shocks. The finding agrees with Ogundeji (2022)**,** who reported that smallholder farmers employed different adaptation measures to reduce the effects of climate-related shocks and sustain household food security. It also supports Danso-Abbeam et al. (2021)**,** who found that livelihood diversification, particularly participation in non-farm employment, enhanced the number of climate change adaptation strategies adopted by smallholder farmers in Southwest Nigeria. Similarly, Yahaya et al. (2024) found that smallholder farmers in Ghana adopted different strategies in response to climate-related risks, with their adaptive capacity and farming circumstances influencing their responses. The present finding on agroforestry, changing planting dates and crop rotation further demonstrates that farmers are modifying their production practices in response to changing climatic conditions. However, the study recorded relatively low adoption of irrigation/water harvesting (5%)**,** soil and water conservation (5%)**,** and improved/drought-tolerant varieties (6%)**.** These practices may require greater financial resources, technical knowledge, improved inputs or infrastructure, which may not be readily available to many smallholder farmers. This finding is consistent with Lamichhane et al. (2022)**,** who identified economic, technological and informational constraints as important barriers to climate change adaptation. Similarly, Finizola e Silva et al. (2024) found that financial, farm-related, environmental and informational factors influence the adoption of climate-smart agricultural practices among African smallholder farmers. The findings therefore suggest that although farmers are adapting to climate change, their choices are influenced by the accessibility and affordability of available strategies.

ii. The second objective examined the factors influencing the adoption of climate change adaptation strategies among smallholder farmers. The findings showed that farming experience and farm size were the most frequently reported factors, each accounting for 14%. This was followed by market access (13%)**,** access to extension services (12%)**,** availability of farm inputs (11%)**,** and education/level of awareness (10%)**.** These findings indicate that farmers' adaptation decisions are influenced considerably by their farm characteristics, experience and access to institutional and market resources. The prominence of farming experience suggests that experienced farmers may possess greater practical knowledge of local

weather patterns and farming conditions, enabling them to make adjustments to their agricultural practices. Similarly, farm size may provide farmers with greater flexibility to diversify crops and allocate part of their land to different adaptation practices. This finding agrees with Solaja et al. (2024), who found that farm size, farming experience, extension visits, credit and climate information influenced adaptation choices among smallholder rice farmers in Kebbi State, Nigeria. The importance of market access and extension services also demonstrates the role of institutional support in adaptation. Farmers with better market access may have greater opportunities to generate income and invest in adaptation measures, while extension services provide technical knowledge concerning improved farming practices. This finding is consistent with Yahaya et al. (2024), who identified extension visits and farmers' adaptive capacity as important influences on climate change adaptation. Finizola e Silva et al. (2024) similarly established that informational, financial, farm-related and personal factors affect the adoption of climate-smart practices among African smallholder farmers. The relatively low responses for access to climate information and perception of climate change, each at 6%, suggest that awareness of climate change alone may not necessarily lead to the adoption of adaptation practices. Farmers may recognize climatic changes but still lack the financial, technological or infrastructural capacity to respond effectively. This finding is particularly relevant to the Theory of Planned Behavior (Ajzen, 1991), which underpins this study. The theory emphasizes perceived behavioral control, meaning that individuals are more likely to undertake a behavior when they believe they possess the resources and ability to do so. In this study, factors such as farm size, farming experience, extension services, farm inputs, credit, irrigation and market access represent important aspects of farmers' capacity to implement adaptation strategies. Thus, the findings support the applicability of the Theory of Planned Behavior in explaining climate change adaptation among smallholder farmers in Nasarawa State.

Conclusion

The study concludes that smallholder farmers in Nasarawa State have adopted various strategies to cope with climate change, with crop diversification and livelihood diversification being the most commonly reported. However, the adoption of resource-intensive measures such as irrigation, water harvesting and improved drought-tolerant varieties remains relatively low. The study further concludes that farming experience, farm size, market access, extension services and availability of farm inputs are important factors influencing farmers' adaptation decisions. Overall, farmers' ability to adapt is shaped not only by their awareness of climate change but also by their access to the resources and institutional support required to implement appropriate adaptation measures.

Recommendations

i. Smallholder farmers should be encouraged to broaden the adoption of climate change adaptation strategies, particularly crop diversification, agroforestry, crop rotation, improved/drought-tolerant varieties, soil and water conservation, and irrigation/water harvesting. The Nasarawa State Government and relevant agricultural agencies should support this through regular extension training, demonstration farms, provision of improved farm inputs and promotion of affordable climate-smart technologies.

ii. Smallholder farmers should strengthen their access to and use of climate information, extension services, markets and financial resources, while the Nasarawa State Government and

relevant institutions should improve access to affordable credit, agricultural inputs, irrigation facilities, timely climate information and market linkages. This will address the major factors influencing adaptation and enhance farmers' capacity to respond effectively to climate change.

References

Adebayo, A. A., et al. (2023). The level of adoption of multiple climate change adaptation strategies: Evidence from smallholder maize farmers in Southwest Nigeria. *Scientific African,* 22, 01971.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes,* 50*(2),* 179–211.

Aryal, J. P., Sapkota, T. B., Rahut, D. B., Marenya, P., & Stirling, C. M. (2020). Climate change and agriculture in South Asia: Adaptation options in smallholder farming systems. *Climate,* 8(7), 88.

Ayanlade, A., Oluwatimilehin, I. A., Ayanlade, O. S., Adeyeye, O., & Abatemi-Usman, S. (2023). Gendered vulnerabilities to climate change and farmers' adaptation responses in Kwara and Nassarawa States, Nigeria. *Humanities and Social Sciences Communications,* 10, 911.

Danso-Abbeam, G., Ojo, T. O., Baiyegunhi, L. J. S., & Ogundeji, A. A. (2021). Climate change adaptation strategies by smallholder farmers in Nigeria: Does non-farm employment play any role? *Heliyon,* 7(6), e07162

Finizola e Silva, M., Van Schoubroeck, S., Cools, J., & Van Passel, S. (2024). A systematic review identifying the drivers and barriers to the adoption of climate-smart agriculture by smallholder farmers in Africa. *Frontiers in Environmental Economics,* 3, 1356335.

Krejcie, R. V., & Morgan, D. W. (1970). Determining sample size for research activities. *Educational and Psychological Measurement,* 30*(*3), 607–610.

Lamichhane, P., Hadjikakou, M., Miller, K. K., & Bryan, B. A. (2022). Climate change adaptation in smallholder agriculture: Adoption, barriers, determinants, and policy implications. *Mitigation and Adaptation Strategies for Global Change, 27(*5), 32, 1–24.

Manda, J., Tufa, A. H., Alene, A., Swai, E., Muthoni, F., Hoeschle-Zeledon, I., & Bekunda, M. (2023). The income and food security impacts of soil and water conservation technologies in Tanzania. *Frontiers in Sustainable Food Systems, 7*, 1146678.

Mnukwa, M. L., Mdoda, L., & Mudhara, M. (2025). Assessing the adoption and impact of climate-smart agricultural practices on smallholder maize farmers' livelihoods in Sub-Saharan Africa: A systematic review. *Frontiers in Sustainable Food Systems,* 9, 1543805.

Okoronkwo, D. J., Ozioko, R. I., Ugwoke, R. U., Nwagbo, U. V., Nwobodo, C., Ugwu, C. H., Okoro, G. G., & Mbah, E. C. (2024). Climate smart agriculture? Adaptation strategies of traditional agriculture to climate change in sub-Saharan Africa. *Frontiers in Climate,* 6, 1272320.

Ogundeji, A. A. (2022). Adaptation to climate change and impact on smallholder farmers' food security in South Africa. *Agriculture,* 12*(*5), 589.

Solaja, S., Kolawole, A., Awe, T. E., Oriade, O. A., Ayojimi, W., Ojo, I., Nayan, G., Adedayo, R., Etta-Oyong, S., Olasehinde, F., Asemokhai, O., & Nsikak, I. (2024). Assessment of smallholder rice farmers' adaptation strategies to climate change in Kebbi State, Nigeria. *Heliyon,* 10(15), 35384.

Yahaya, M., Mensah, C., Addaney, M., Damoah-Afari, P., & Kumi, N. (2024). Climate change and adaptation strategies in rural Ghana: A study on smallholder farmers in the Mamprugu-Moaduri district. *International Journal of Climate Change Strategies and Management*, 16(1), 112–139.

Yiran, G. A. B., Atubiga, J. A., Kusimi, J. M., Kwang, C., & Owusu, A. B. (2022). Adaptation to perennial flooding and food insecurity in the Sudan savannah agroecological zone of Ghana. *Environmental Research,* 214, 114037.