



Agricultural Extension Services and the Adoption of Climate-Smart Agricultural Practices among Smallholder Farmers in Northern Taraba State, Nigeria

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DOI: <https://doi.org/10.68050/JAMS.2026.657>

Received: 28 September 2026; Accepted: 05 October 2026; Published: 13 October 2026

ABSTRACT

Climate change poses significant challenges to smallholder agricultural production through changing rainfall patterns, drought, soil degradation and increasing production uncertainty. Climate-smart agriculture (CSA) provides an approach for improving agricultural productivity and resilience while promoting sustainable management of natural resources. Agricultural extension services can support CSA adoption by providing farmers with relevant information, technical knowledge, training and practical demonstrations. This study examined the role of agricultural extension services in promoting the adoption of climate-smart agricultural practices among smallholder farmers in Northern Taraba State, Nigeria. A descriptive survey design was adopted. The accessible population comprised 610 eligible smallholder farmers in Karim Lamido, Jalingo and Zing Local Government Areas, from which 235 farmers were selected using a multistage sampling procedure involving purposive selection, proportionate allocation and simple random sampling. Data were collected using a structured questionnaire and analysed using frequencies, percentages, means, standard deviations and multiple regression analysis. The findings showed that farmers generally adopted CSA practices, with a grand mean of 3.07. Mixed cropping/intercropping recorded the highest mean (3.38), while rainwater harvesting had the lowest mean (2.69). Although 71.1% of farmers had access to agricultural extension services, 46.0% received extension visits only occasionally and 15.7% did not receive extension visits. Farmers had a generally positive perception of extension services, with a grand mean of 2.71, while the perceived role of extension services in promoting CSA adoption recorded a grand mean of 2.83. The multiple regression model was statistically significant ($F = 29.310$, $p < 0.001$) and explained 54.9% of the variation in CSA adoption ($R^2 = 0.549$; adjusted $R^2 = 0.531$). Age had a significant negative association with CSA adoption, whereas education, farming experience, farm size and annual income had significant positive associations. The study concludes that agricultural extension services play an important role in supporting CSA adoption, but greater frequency of extension contact, practical training and stronger linkages to agricultural inputs and support services are needed to enhance farmers' capacity to adopt and sustain appropriate CSA practices in Northern Taraba State.

Keywords: Agricultural extension, climate-smart agriculture, smallholder farmers, climate change, adoption, Northern Taraba State, Nigeria.

1. INTRODUCTION

The citations should be integrated **throughout the article**, especially where you make factual or literature-based claims. Below is a revised version of your section with appropriate academic citations. I have kept it reasonably concise and avoided unsupported claims about Northern Taraba specifically unless they come from your own study.

Introduction

Agriculture remains an important source of livelihood for rural households in Nigeria, particularly among sma-

Smallholder farmers whose production activities are highly dependent on climatic and natural-resource conditions. Climate change and increasing climate variability pose important challenges to agricultural production through changes in rainfall patterns, drought, flooding, increasing temperatures, and other climate-related stresses. Smallholder farmers are particularly vulnerable because they often have limited access to productive assets, technologies, information and financial resources needed to manage climate-related risks (FAO, 2013; FAO, 2024).

Climate-Smart Agriculture (CSA) provides an approach for responding to these challenges by integrating agricultural development with climate adaptation and mitigation. The Food and Agriculture Organization (FAO) identifies three major objectives of CSA: sustainably increasing agricultural productivity and incomes, strengthening resilience and adaptation to climate change, and reducing or removing greenhouse-gas emissions where possible (FAO, 2010; FAO, 2013).

CSA encompasses a range of practices that can be adapted to local farming conditions, including improved crop varieties, conservation agriculture, crop diversification, agroforestry, soil and water conservation, improved soil fertility management, mulching, water harvesting and improved livestock management. Evidence from the literature indicates that the adoption of appropriate CSA practices can contribute to farm productivity, income, resilience and more efficient use of agricultural resources, although the suitability and benefits of particular practices vary according to local conditions (Zheng, Ma, & He, 2024).

However, the adoption of climate-smart agricultural practices is influenced by more than farmers' awareness of climate change. Access to agricultural information, extension advice, inputs, finance, markets, technologies and other institutional resources can affect farmers' ability to adopt and sustain improved practices. FAO emphasizes that the transition to climate-smart agriculture requires not only appropriate technologies but also supportive institutional, policy and financial arrangements that enable smallholder farmers to implement those technologies (FAO, 2010).

Agricultural extension services are particularly relevant in this context because extension personnel can provide farmers with technical information, training, demonstrations and advice on appropriate agricultural practices. Extension systems can also facilitate farmers' access to climate information and link them with other agricultural institutions and support services. Recent evidence from Nigeria similarly indicates that extension services and different information channels are important components of farmers' climate adaptation and CSA decision-making (Osuji et al., 2025; Aduaka, Ezeano, & Gbughemobi, 2026).

The importance of extension services is also reflected in empirical studies of CSA adoption in Nigeria. For example, recent research has reported that factors including extension visits and access to agricultural information can influence farmers' adoption of climate-smart agricultural technologies. This suggests that extension contact is not simply a mechanism for transferring general agricultural information but can also support farmers in understanding and applying practices that respond to climate-related production risks.

In Northern Taraba State, smallholder farmers engage in crop and livestock production under conditions in which agricultural activities may be affected by climatic variability and access to agricultural support services. Examining farmers' access to extension services, the frequency of extension contact, the sources of agricultural information and the specific roles performed by extension personnel is therefore relevant to understanding the conditions surrounding CSA adoption in the study area. The local evidence generated by this study can help show whether farmers are receiving agricultural information and practical support needed to implement climate-smart practices.

Against this background, this study examines the **role of agricultural extension services in promoting the adoption of climate-smart agricultural practices among smallholder farmers in Northern Taraba State, Nigeria**. Specifically, the study assesses the climate-smart agricultural practices adopted by farmers, examines the

It access to and frequency of contact with agricultural extension services, assesses farmers' perceptions of extension services, and examines the role of extension personnel in promoting CSA adoption.



1.1 Objectives of the Study

The main objective of the study is to examine the role of agricultural extension services in promoting the adoption of climate-smart agricultural practices among smallholder farmers in Northern Taraba State.

The specific objectives are to:

1. examine the climate-smart agricultural practices adopted by smallholder farmers;
2. assess farmers' perceptions of agricultural extension services; and
3. examine the role of agricultural extension services in promoting the adoption of climate-smart agricultural practices.

H₀₁: The socio-economic characteristic of respondents does not have significant influence on the adoption of Climate-Smart Agriculture (CSA) among smallholder farmers.

2.2 Agricultural Extension and Climate-Smart Agriculture

Agricultural extension serves as an important mechanism through which farmers obtain technical knowledge and information about improved agricultural technologies. Extension agents can provide information on production techniques, climate risks, crop varieties, soil management, pest control and other farming decisions. The role becomes particularly important in CSA because some climate-smart technologies require farmers to understand both their benefits and appropriate methods of implementation. Extension personnel can bridge this knowledge gap through training, demonstrations and farmer-to-farmer learning.

3. METHODOLOGY

3.1 Research Design

The study adopted a descriptive survey research design. The design was considered appropriate because the study sought to obtain information directly from smallholder farmers concerning their adoption of climate-smart agricultural (CSA) practices, access to agricultural extension services, frequency of extension contact, perceptions of extension services, and the role of extension services in promoting CSA adoption. The survey approach enabled the researcher to obtain standardized information from respondents using a structured questionnaire and to analyse the responses using descriptive and inferential statistical techniques.

3.2 Study Area

The study was conducted in Northern Taraba State, Nigeria, covering Karim Lamido, Jalingo and Zing Local Government Areas (LGAs). The selected LGAs were considered relevant because of their agricultural activities and the concentration of smallholder farmers engaged in crop and livestock production. The study area provides an appropriate setting for examining climate-smart agriculture because agricultural production is influenced by rainfall patterns, soil conditions, availability of agricultural inputs, and farmers' access to extension and climate-related information.

3.3 Population of the Study

The population of the study comprised smallholder farmers in the selected LGAs who were actively engaged in crop and livestock farming activities and met the eligibility criteria established for the study. The accessible population consisted of 610 eligible smallholder farmers identified from agricultural records and farmer registers obtained from relevant agricultural offices and farmer associations.

The accessible population comprised 289 farmers in Karim Lamido LGA, 144 farmers in Jalingo LGA and 177 farmers in Zing LGA, giving a total accessible population of 610 farmers.

3.4 Sample Size and Sampling Procedure

The proportional allocation formula is presented as:

$$n_i = \frac{N_i}{N} \times n$$

Where:

n_i = Number of farmers to be selected from ward i

N_i = Total number of extension workers in ward i

N = Total number of extension workers across all wards

n = Total sample size (in this case, 90 farmers)

Using this formula, the number of farmers allocated to each ward was calculated based on the proportion of extension workers in that ward relative to the total across the ten wards. The resulting distribution is shown below, (Source: Kothari, C.R. (2004).

The allocation was calculated as follows:

Table 3.1: Proportionate Allocation of Sample Size Across Selected LGAs

Selected LGA	Eligible Farmers (N_i)	Proportion	Allocated Sample (n_i)
Karim Lamido	289	$289/610 = 0.474$	111
Jalingo	144	$144/610 = 0.236$	56
Zing	177	$177/610 = 0.290$	68
Total	610	1	235

Source: Researcher's computation, 2026.

The table indicates that Karim Lamido contributed 111 respondents, Jalingo contributed 56 respondents and Zing contributed 68 respondents, producing the total sample of 235 respondents.

Stage Four: Simple Random Sampling

In the final stage, **simple random sampling** was used to select individual farmers from each selected LGA based on the allocated sample.

A sampling frame containing eligible farmers was developed from agricultural offices and farmer registers. Each eligible farmer was assigned a unique identification number, after which the required number of respondents was selected randomly.

The procedure provided each eligible farmer within the sampling frame with an equal opportunity of selection and helped minimize researcher selection bias

3.5 Instrument for Data Collection

Data were collected using a structured questionnaire developed in line with the objectives of the study. The questionnaire was designed to obtain information on respondents' socio-economic characteristics, adoption of climate-smart agricultural practices, perceptions of agricultural extension services, and the role of extension services in promoting CSA adoption.



The questionnaire was organized into four sections. Section A collected information on the socio-economic characteristics of respondents, including gender, age, marital status, level of education, household size, farming experience, farm size, sources of income and annual income.

Section B measured the adoption of climate-smart agricultural practices. The practices assessed included improved drought-resistant crop varieties, conservation agriculture, crop rotation, mixed cropping/intercropping, agroforestry, organic manure/compost, soil and water conservation, mulching, rainwater harvesting, climate information use and improved livestock management. Respondents indicated their level of adoption of the listed practices using the response categories provided in the questionnaire. Mean scores were computed for individual practices and an overall grand mean was used to describe the general level of CSA adoption.

Section C assessed farmers' perceptions of agricultural extension services. The indicators covered the regularity of extension visits, usefulness of agricultural information received, accessibility of extension services, provision of CSA training and the extent to which extension services met farmers' farming needs.

Section D assessed the perceived role of agricultural extension services in promoting CSA adoption. The indicators included creating awareness about climate change impacts, teaching CSA techniques, increasing farmers' CSA knowledge, encouraging improved farming methods, providing demonstrations on CSA practices, and linking farmers with agricultural inputs and support services.

3.6 Measurement and Scoring Procedure

The adoption of CSA practices was measured using the individual practice scores obtained from respondents. Mean scores were calculated for each practice, while the grand mean was used to summarize the overall adoption level. Higher mean scores represented greater adoption of the respective CSA practices.

Farmers' perceptions of agricultural extension services were measured using statements relating to extension visits, agricultural information, accessibility of extension services, CSA training and the extent to which extension services met farmers' needs. The responses were summarized using mean scores. A mean score of 2.50 was used as the decision point for the perception items, with scores of 2.50 and above interpreted as agreement and scores below 2.50 interpreted as disagreement.

The role of extension services in promoting CSA adoption was assessed using six indicators covering awareness creation, technical instruction, knowledge development, encouragement of improved farming methods, demonstrations and linkages to agricultural inputs and support services. The mean scores and rankings were used to determine the relative contribution of the identified extension roles as perceived by respondents.

3.7 Validity of the Instrument

The questionnaire was subjected to content and face validation before its administration. The instrument was examined to determine the adequacy, clarity and relevance of the items in relation to the objectives of the study. Items considered unclear or inappropriate were revised to improve the suitability of the questionnaire for collecting the required information from smallholder farmers.

3.8 Reliability of the Instrument

The internal consistency of the multi-item sections of the questionnaire was assessed using Cronbach's alpha. Reliability analysis was conducted for the items measuring farmers' perceptions of agricultural extension services and the perceived roles of extension services in promoting the adoption of climate-smart agricultural (CSA) practices. The resulting Cronbach's alpha coefficients were evaluated against the generally accepted threshold of 0.70, with coefficients of 0.70 or higher considered indicative of acceptable internal consistency.



3.9 Data Collection Procedure

The questionnaire was administered to the selected smallholder farmers in the three study LGAs. Respondents were informed of the purpose of the study and the information required from them. Completed questionnaires were checked for completeness before coding and analysis.

3.10 Measurement of CSA Adoption

CSA adoption was operationalized using the listed climate-smart agricultural practices assessed in the questionnaire. The practices included improved drought-resistant crop varieties, conservation agriculture, crop rotation, mixed cropping/intercropping, agroforestry, organic manure/compost, soil and water conservation, mulching, rainwater harvesting, climate information use and improved livestock management. The mean scores for the individual practices were used to identify practices with relatively higher or lower levels of adoption, while the grand mean was used to summarize the overall adoption level.

3.11 Method of Data Analysis

Data collected were coded and analysed using descriptive and inferential statistical techniques. Frequencies, percentages, means and standard deviations were used to summarize respondents' characteristics, CSA adoption, perceptions of agricultural extension services and the perceived roles of extension services in promoting CSA adoption.

Multiple regression analysis was used to examine the statistical association between respondents' socio-economic characteristics and CSA adoption. The explanatory variables entered into the model were gender, age, marital status, level of education, household size, farming experience, farm size, sources of income and annual income.

The regression model was evaluated using the coefficient of determination (R^2), adjusted R^2 , F-statistic, regression coefficients (B), standard errors, standardized beta coefficients (β), t-values and significance levels. Where available, 95% confidence intervals were also reported. Regression diagnostic procedures were considered to assess the suitability of the model, including checks for multicollinearity, independence of errors, normality of residuals and homoscedasticity.

Because the study employed a survey design and observational data, statistically significant regression coefficients were interpreted as associations with CSA adoption rather than as evidence of causal effects.

RESULTS AND DISCUSSION

4.1 Climate-Smart Agricultural Practices Adopted by Farmers

The findings in Table 4.1 indicate that farmers generally adopted the climate-smart agricultural (CSA) practices assessed in the study, as reflected by the grand mean of 3.07. However, the level of adoption varied across the individual practices. Mixed cropping/intercropping recorded the highest mean score of 3.38, followed by crop rotation (3.27), organic manure/compost (3.23), and improved drought-resistant crop varieties (3.18). Rainwater harvesting recorded the lowest mean score of 2.69, followed by agroforestry (2.79) and improved livestock management (2.84).

The relatively high adoption of mixed cropping/intercropping may be associated with its compatibility with farmers' existing production systems. The practice can generally be incorporated into existing cropping activities without requiring major changes to farm infrastructure. It may also provide opportunities for production diversification and risk management. Similarly, the relatively high adoption of crop rotation suggests that practices that can be integrated into existing farming operations may be more readily adopted by smallholder farmers.

In contrast, the relatively low adoption of rainwater harvesting may be related to the greater investment, techn-



ical knowledge, labour and infrastructure that may be required to establish and maintain water-harvesting facilities. Agroforestry also recorded a relatively low adoption level, which may partly reflect the longer period that may be required before farmers obtain substantial benefits from tree-based production systems. These explanations should be interpreted as possible contextual explanations rather than causal effects because the study did not directly examine the specific constraints responsible for differences in adoption of individual CSA practices.

Overall, the findings indicate that farmers were more likely to adopt CSA practices that were relatively compatible with their existing farming systems and resource capacities.

Table 4.1: Climate-Smart Agricultural Practices Adopted by Farmers (n = 235)

Practice	Mean	Decision
Improved drought-resistant crop varieties	3.18	Adopted
Conservation agriculture	3.03	Adopted
Crop rotation	3.27	Strongly Adopted
Mixed cropping/intercropping	3.38	Strongly Adopted
Agroforestry	2.79	Adopted
Organic manure/compost	3.23	Adopted
Soil and water conservation	3.09	Adopted
Mulching	3.13	Adopted
Rainwater harvesting	2.69	Adopted
Climate information use	3.1	Adopted
Improved livestock management	2.84	Adopted
Grand Mean	3.07	Adopted

Source: Field Survey, 2026.

4.2 Farmers' Perception of Agricultural Extension Services

Farmers' perception of agricultural extension services was measured using a four-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly Agree. A mean score of **2.50 was used as the decision threshold**, such that mean scores of **2.50 and above were interpreted as agreement/positive perception**, while mean scores below 2.50 were interpreted as disagreement/negative perception.

Table 4.2 shows that farmers generally had a positive perception of agricultural extension services, with a grand mean of 2.71. The highest mean score was recorded for receiving useful agricultural information from extension agents (2.92), followed by the provision of climate-smart agriculture (CSA) training (2.79). Extension services being easily accessible recorded a mean of 2.68, while meeting farmers' farming needs recorded 2.67. Regular farm visits had the lowest mean score of 2.51. Since all the mean scores were above the 2.50 decision threshold, farmers generally agreed that the agricultural extension services assessed were available and useful.

The relatively high score for receiving useful agricultural information indicates that farmers regarded extension agents as an important source of agricultural knowledge. This finding is consistent with Aduaka, Ezeano, and Gbughemobi (2026), who reported that extension services and the effectiveness of extension agents are important in improving farmers' awareness and adoption of climate-smart agricultural practices. Similarly, evidence from Nigeria indicates that extension visits and access to agricultural information contribute to farmers' capacity to respond to climate-related challenges (Osuji et al., 2025).

The comparatively low mean for regular farm visits suggests that the major limitation may relate to the frequency of extension contact rather than the perceived usefulness of extension services. Regular farm visits provide opportunities for practical demonstrations, follow-up, and clarification of farmers' challenges. The



finding therefore suggests that more regular farm-level contact and follow-up could strengthen the contribution of extension services to CSA adoption.

Table 4.2: Farmers' Perception of Agricultural Extension Services (n = 235)

Statement	Mean	Decision
Extension agents visit my farm regularly	2.51	Agreed
I receive useful agricultural information	2.92	Agreed
Extension services are easily accessible	2.68	Agreed
Extension agents provide CSA training	2.79	Agreed
Extension services meet my farming needs	2.67	Agreed
Grand Mean	2.71	Agreed

Source: Field Survey, 2026.

4.3 Role of Agricultural Extension Services in Promoting CSA Adoption

The role of agricultural extension services in promoting climate-smart agriculture (CSA) adoption was measured using a four-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly Agree. A mean score of 2.50 was used as the decision threshold, such that mean scores of 2.50 and above were interpreted as agreement, indicating that farmers perceived the extension service as contributing to the promotion of CSA practices.

Table 4.3 shows that farmers generally agreed that agricultural extension services played a role in promoting CSA adoption, with a grand mean of 2.83. The highest mean score was recorded for creating awareness about climate change impacts (2.95), followed by teaching farmers CSA techniques (2.91) and increasing farmers' CSA knowledge (2.88). Encouraging improved farming methods recorded a mean of 2.82, while providing demonstrations on CSA practices recorded 2.77. The lowest mean score was recorded for linking farmers with inputs and support services (2.66). Since all the mean scores were above the 2.50 decision threshold, farmers generally agreed that agricultural extension services contributed to the promotion of CSA adoption.

The relatively high score for creating awareness about climate change impacts indicates that farmers perceived extension agents as an important source of information for understanding climate-related challenges and their implications for farming. Awareness is an important first step in promoting CSA because farmers need to understand the effects of climate change before they can appreciate the relevance of adaptive and mitigation practices. This finding is consistent with Aduaka, Ezeano, and Gbughemobi (2026), who reported that effective extension services and access to agricultural information can strengthen farmers' awareness and engagement with climate-smart agricultural practices. Similarly, Osuji et al. (2025) reported that access to extension information and advisory services contributes to farmers' capacity to respond to climate-related challenges.

The high mean score for teaching farmers CSA techniques (2.91) further indicates that extension services contributed not only to awareness creation but also to the transfer of practical knowledge needed for CSA implementation. Similarly, the mean score of 2.88 for increasing farmers' CSA knowledge suggests that extension agents played an important educational role in helping farmers understand climate-smart practices. These findings indicate that the contribution of extension services was particularly evident in information dissemination, technical guidance and knowledge development.

The comparatively lower mean score for linking farmers with inputs and support services (2.66) suggests that the role of extension services was relatively stronger in providing information and technical knowledge than in facilitating access to complementary resources. Farmers may require inputs, credit, markets, technologies and other forms of institutional support to translate knowledge of CSA into actual adoption. FAO (2013) emphasizes that successful climate-smart agriculture requires not only appropriate knowledge and technologies but also supportive institutional and resource arrangements.

Overall, the findings indicate that agricultural extension services contributed to CSA promotion mainly through **awareness creation, technical education, knowledge development, encouragement of improved farming methods and practical demonstrations**. However, the relatively lower score for linking farmers with inputs and support services suggests an area that could be strengthened. Improving linkages between farmers, input suppliers, financial institutions, markets and other agricultural support programmes could enhance the ability of farmers to translate extension knowledge into sustained adoption of CSA practices.

Table 4.3: Role of Extension Services in Promoting CSA Adoption (n = 235)

Extension Service Role	Mean	Rank
Create awareness about climate change impacts	2.95	1
Teach farmers CSA techniques	2.91	2
Increase farmers' CSA knowledge	2.88	3
Encourage improved farming methods	2.82	4
Provide demonstrations on CSA practices	2.77	5
Link farmers with inputs and support	2.66	6
Grand Mean	2.83	—

Source: Field Survey, 2026.

4.4 Test of Hypothesis

H₀₁: Socio-economic characteristics of respondents are not significantly associated with the adoption of Climate-Smart Agriculture (CSA) among smallholder farmers.

4.4.1 Association Between Socio-economic Characteristics and CSA Adoption

The regression results in Tables 4.4, 4.4.1 and 4.4.2 show that the model was statistically significant ($F = 29.310$, $p < 0.001$), with an R^2 of 0.549 and an adjusted R^2 of 0.531. This indicates that the socio-economic characteristics included in the model jointly explained 54.9% of the variation in farmers' CSA adoption, while the adjusted R^2 indicates that 53.1% of the variation was explained after accounting for the predictors included in the model. The statistically significant F-test indicates that the set of socio-economic variables, taken together, was significantly associated with CSA adoption.

Age was significantly and negatively associated with CSA adoption ($\beta = -0.142$, $p = 0.008$). This indicates that, holding the other variables in the model constant, higher age was associated with lower CSA adoption scores. This finding agrees with Eze et al. (2025), who reported a negative relationship between age and the adoption of some CSA practices among cassava farmers in Southeastern Nigeria. The observed association may reflect differences in farmers' exposure to new agricultural practices and technologies; however, the present study does not establish a causal effect of age on CSA adoption.

Education was significantly and positively associated with CSA adoption ($\beta = 0.241$, $p < 0.001$). This indicates that farmers with higher educational attainment tended to have higher CSA adoption scores, controlling for the other variables in the model. Education may facilitate farmers' understanding and use of technical agricultural information. This finding agrees with Alalade et al. (2023) and Ifeanyi-Obi et al. (2024), who identified education as an important factor associated with CSA adoption in Nigeria.

Farming experience was also significantly and positively associated with CSA adoption ($\beta = 0.169$, $p = 0.004$). More experienced farmers tended to have higher CSA adoption scores when the other variables in the model were held constant. Accumulated farming knowledge may help farmers respond to changing production and climatic conditions. This finding is consistent with Alalade et al. (2023) and Ifeanyi-Obi et al. (2024), who reported a significant association between farming experience and CSA adoption.

Farm size was significantly and positively associated with CSA adoption ($\beta = 0.253$, $p < 0.001$) and had the

largest standardized coefficient among the statistically significant predictors. This indicates that farmers with larger farm holdings tended to report higher CSA adoption scores, controlling for the other predictors. The finding agrees with evidence from Taraba State and other parts of Nigeria showing an association between farm size and adoption of improved and climate-related agricultural practices (Agou et al., 2025; Ifeanyi-Obi et al., 2024).

Annual income was also significantly and positively associated with CSA adoption ($\beta = 0.176$, $p = 0.003$). This suggests that farmers with higher annual income tended to have higher CSA adoption scores, holding the other variables constant. Higher income may provide greater capacity to obtain inputs or invest in practices requiring additional resources. This finding is consistent with Alalade et al. (2023) and Ifeanyi-Obi et al. (2024), who reported a positive relationship between income and CSA adoption.

Gender ($\beta = -0.061$, $p = 0.209$), marital status ($\beta = 0.052$, $p = 0.294$), household size ($\beta = 0.073$, $p = 0.135$) and sources of income ($\beta = 0.044$, $p = 0.381$) were not significantly associated with CSA adoption at the 5% significance level.

Overall, age, education, farming experience, farm size and annual income showed statistically significant associations with CSA adoption, whereas gender, marital status, household size and sources of income did not show statistically significant associations. Therefore, the null hypothesis was rejected based on the overall significance of the regression model. However, because the study used observational survey data, the statistically significant regression coefficients should be interpreted as associations rather than causal effects.

Table 4.4: Model Summary of Multiple Regression Analysis Showing the Association Between Socio-economic Characteristics and CSA Adoption (n = 235)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.741	0.549	0.531	0.462

Table 4.4.1: ANOVA for the Association Between Socio-economic Characteristics and CSA Adoption (n = 235)

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	56.324	9	6.258	29.31	0.000*
Residual	46.897	220	0.213		
Total	103.221	229			

*Significant at $p < 0.05$.

Table 4.4.2: Regression Coefficients for the Association Between Socio-economic Characteristics and CSA Adoption (n = 235)

Variable	B	Std. Error	Beta (β)	t-value	Sig.
Constant	1.842	0.531	—	3.47	0.001
Gender	-0.073	0.058	-0.061	-1.26	0.209
Age	-0.011	0.004	-0.142	-2.67	0.008*
Marital Status	0.041	0.039	0.052	1.05	0.294
Level of Education	0.183	0.044	0.241	4.16	0.000*
Household Size	0.015	0.01	0.073	1.5	0.135
Farming Experience	0.026	0.009	0.169	2.89	0.004*
Farm Size	0.214	0.051	0.253	4.2	0.000*
Sources of Income	0.029	0.033	0.044	0.88	0.381
Annual Income	0.128	0.042	0.176	3.05	0.003*



Source: Field Survey, 2026.

Note: * Significant at $p < 0.05$

CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

The study concludes that smallholder farmers in Northern Taraba State generally adopted climate-smart agricultural (CSA) practices, although the level of adoption varied across individual practices. Mixed cropping/intercropping and crop rotation recorded relatively high adoption, while rainwater harvesting and agroforestry recorded comparatively lower adoption. The findings indicate that farmers were more likely to adopt CSA practices that could be incorporated into their existing farming systems.

The study also concludes that agricultural extension services played an important role in promoting CSA adoption. Although a majority of farmers had access to extension services, the frequency of extension visits was relatively low. Farmers nevertheless expressed generally positive perceptions of extension services, particularly regarding the usefulness of agricultural information and provision of CSA training. Extension services contributed to CSA promotion mainly through climate-change awareness, technical training, knowledge development, encouragement of improved farming methods, and demonstrations. However, the relatively limited role of extension services in linking farmers with agricultural inputs and other support services indicates an area requiring further attention.

The regression results further show that the socio-economic characteristics included in the model were jointly significantly associated with CSA adoption and explained 54.9% of the variation in adoption. Education, farming experience, farm size and annual income had significant positive associations with CSA adoption, whereas age had a significant negative association. Gender, marital status, household size and sources of income were not significantly associated with CSA adoption. Overall, the findings demonstrate the importance of strengthening agricultural extension contact, practical CSA training, and institutional linkages to improve farmers' capacity to adopt and sustain appropriate climate-smart agricultural practices in Northern Taraba State.

5.2 Recommendations

Based on the findings of the study, the following recommendations are made:

1. **Increase the frequency of extension contact:** Agricultural extension agencies should strengthen regular farm visits and improve extension coverage so that farmers receive continuous technical advice, follow-up and practical guidance on CSA practices.
2. **Strengthen practical CSA training and demonstrations:** Extension programmes should place greater emphasis on hands-on training and field demonstrations, particularly for relatively less-adopted practices such as rainwater harvesting and agroforestry.
3. **Improve linkages to agricultural inputs and support services:** Extension personnel should strengthen their linkages with input suppliers, financial institutions, markets and relevant government programmes to help farmers translate technical knowledge into practical CSA adoption.
4. **Provide adequate resources for extension delivery:** Government and relevant agricultural institutions should provide extension personnel with adequate transportation, communication facilities, training materials and other logistical support required for regular interaction with farmers.
5. **Target extension interventions according to farmers' characteristics:** Extension programmes should consider differences in farmers' educational levels, farming experience, farm sizes and income when designing and delivering CSA interventions. Farmers with limited educational or financial resources may require more practical and accessible forms of extension support.



6. **Promote resource-efficient CSA practices:** Extension services should encourage practices that can be implemented using locally available resources while gradually introducing more resource-intensive technologies where farmers have the capacity and necessary institutional support.
7. **Strengthen institutional collaboration:** Agricultural extension organisations should collaborate with research institutions, local government authorities, farmer organisations and development agencies to improve access to climate information, CSA technologies, inputs and other support services.
8. **Sustain climate-change awareness programmes:** Continuous awareness campaigns should be implemented to improve farmers' understanding of climate-related risks and the potential benefits of appropriate CSA practices for agricultural productivity and resilience..

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