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Building community resilience to climate change through climate-smart agriculture policy intervention in Mubi North, Adamawa State, Nigeria

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Abstract
Climate change poses serious challenges to agrarian communities in northern Nigeria, where smallholder farmers are increasingly confronted with declining rainfall, frequent droughts, and soil degradation, all of which threaten food security and livelihoods. This study examines how climate-smart agriculture (CSA) policy interventions can enhance resilience among farmers in Mubi North, Adamawa State. Guided by resilience theory, the CSA framework, and governance perspectives, a mixed-methods approach was employed, combining household surveys (n = 250), focus group discussions, and key informant interviews. The findings indicate that flooding (M = 4.35) and unpredictable rainfall (M = 4.01) were perceived as the most severe climate-related impacts. Among CSA practices, the use of drought-resistant crops was rated the most effective (M = 3.65), while adoption of irrigation remained relatively low (M = 3.22). CSA practices were strongly associated with reduced crop failure (M = 3.90) and improved food security (M = 3.57), although institutional support received a lower rating, scoring below 3.0. Cross-tabulation analysis showed that CSA adoption was higher among farmers with 21–30 years of experience. However, Chi-square tests indicated no statistically significant relationship between socio-economic variables and CSA adoption (p = 0.999). Binary logistic regression further revealed that access to extension services, availability of credit, and perception of climate change were significant positive predictors of CSA adoption, whereas education level and farm size were not significant. These results suggest that institutional and knowledge-based factors, rather than socio-demographic characteristics, are the primary drivers of CSA uptake. The study concludes that CSA can effectively enhance adaptive capacity and resilience, but its potential is limited by weak institutional support. Strengthening participatory, community-driven CSA policies, alongside improved extension services, credit access, and cooperative support, is recommended to sustainably build resilience among farmers in Mubi North and similar vulnerable agrarian communities.

Keywords: Resilience, climate-smart agriculture, policy, drought, rainfall, flooding

Introduction

Climate change has emerged as one of the most pressing global environmental challenges, attracting growing attention due to its far-reaching impacts on virtually every aspect of the natural and human environment. Haider (2019) [9] notes that profound changes are ongoing on our planet as a result of climate change. Although these effects may have begun many years ago, they have gradually intensified over time, producing widespread environmental consequences that are expected to continue unless deliberate mitigation and adaptation strategies are implemented. Human activities, in particular, have been identified as major contributors to these changes (Mshelia *et al*., 2025) [15].

In Nigeria, climate change poses serious risks to agrarian communities, where smallholder farmers are particularly vulnerable. Agriculture remains central to livelihoods and food security, with approximately 65% of Nigerians relying on farming for subsistence or income, and around 91% of agricultural households engaged primarily in crop production (National Bureau of Statistics [NBS], 2024) [17]. In northern Nigeria—including semi-arid and sub-humid zones such as Adamawa State—shifting rainfall patterns, recurrent droughts, and unpredictable onset and cessation of rains have reduced crop yields, increased the likelihood of crop failure, and undermined rural incomes. More than 84% of households in northern Nigeria rely on climate-sensitive agriculture, making them highly vulnerable to these stresses (Sadiq, 2022) [24].

Smallholder farmers in Adamawa State already report the effects of climate variability, including prolonged dry spells and shortened growing seasons. Vulnerability assessments in comparable LGAs, such as Girei, highlight high exposure to climate hazards, moderate-to-low adaptive capacity, and strong sensitivity of agricultural output to rainfall and temperature fluctuations (Ambrose & Mohammed, 2020) [3]. These changes threaten staple crops such as maize, millet, sorghum, and rice, which many households in Mubi North rely on for both food and income. Although detailed data for Mubi North are limited, state-level studies indicate declining rainfall consistency and a rising frequency of meteorological droughts (Sadiq, 2022) [24].

Climate-smart agriculture (CSA) is increasingly recognized as an effective strategy for addressing these climatic stresses. CSA encompasses agricultural practices that aim to increase productivity, enhance adaptive capacity, and, where possible, reduce greenhouse gas emissions (FAO, ICRISAT & CIAT, 2019). Two CSA strategies particularly relevant in semi-arid zones are the adoption of drought-tolerant crop varieties and improved irrigation techniques. Research in Nigeria has shown that drought-tolerant maize varieties contribute to greater yield stability and reduced crop failure under low-rainfall conditions (Oyetunde-Usman & Shee, 2023) [21]. Similarly, even small-scale irrigation has been found to improve crop yields, household incomes, and food security among smallholders (Ogunwande, 2023) [20].

However, the introduction of CSA practices alone is not sufficient. Successful implementation often depends on participatory, community-based approaches. Involving farmers in decisions related to crop selection, irrigation or water-harvesting systems, and training ensures that interventions are locally relevant, increases adoption rates, and promotes long-term sustainability. Studies in Adamawa State and across northern Nigeria highlight that adaptive capacity is strongly influenced by access to inputs, knowledge, social capital, extension services, institutional support, credit, and infrastructure (Ambrose & Mohammed, 2020) [3].

While policy frameworks at national and state levels have begun integrating climate adaptation into agricultural planning, gaps remain. The CSA profile for Adamawa State identifies key interventions, including scaling up drought-resistant seed systems, improving water management, and strengthening institutional coordination (FAO, ICRISAT & CIAT, 2019). Yet policy implementation is often fragmented, resources are insufficient, smallholders frequently lack access to affordable credit and quality inputs, extension services remain limited, and community engagement is often inadequate (Oyetunde-Usman & Shee, 2023; Ideki, Nwaerema & Abali, 2024) [11, 21].

Mubi North, as a major agricultural hub, faces additional challenges including soil degradation, declining crop yields, limited irrigation, poor access to improved seeds and extension services, and insecurity linked to resource conflicts and counter-insurgency operations (Lawan *et al*., 2023) [12]. Despite the existence of Nigeria's National Adaptation Plan Framework and Climate Change Act, policy implementation at the local level remains inconsistent, leaving communities vulnerable to climate shocks and underscoring the need for CSA interventions tailored to local needs.

Against this backdrop, the present study investigates how CSA policy interventions can strengthen the adaptive capacity of smallholder farmers in Mubi North, Adamawa State. Specifically, it examines household vulnerability and resilience dynamics, evaluates the effectiveness of existing CSA practices, and explores the policy environment influencing their adoption and scalability. By engaging local stakeholders, the study aims to co-develop context-specific policy recommendations and propose a framework for monitoring the impact of CSA on agricultural productivity, income diversification, and resilience outcomes over time.

Conceptual and Theoretical Framework

Conceptual Framework Promoting Climate-Smart Agriculture

The conceptual framework demonstrates how climate-smart agriculture (CSA) policy interventions can encourage the uptake of CSA practices, thereby enhancing the adaptive capacity and resilience of farming households in Mubi North. Climate-related stressors, including flooding, drought, and irregular rainfall, place significant pressure on rural livelihoods, highlighting the need for policy-supported adaptation measures (Adger, 2000) [1]. CSA policy inputs such as extension services, access to credit, farmer cooperatives, and awareness programs act as enabling factors that facilitate the adoption of practices like drought-resistant crops, improved irrigation, soil conservation, and agroforestry (Pretty, 2008) [22].

The implementation of these practices helps strengthen household adaptive capacity by expanding knowledge, improving access to resources, and encouraging the adoption of innovative farming approaches, as illustrated in Figure 1. Increased adaptive capacity, in turn, leads to improved livelihood outcomes, including reduced crop failure, enhanced food security, higher household incomes, and more effective coping mechanisms. Together, these outcomes contribute to broader community resilience, supporting the development of sustainable and climate-resilient agricultural systems in Mubi North.

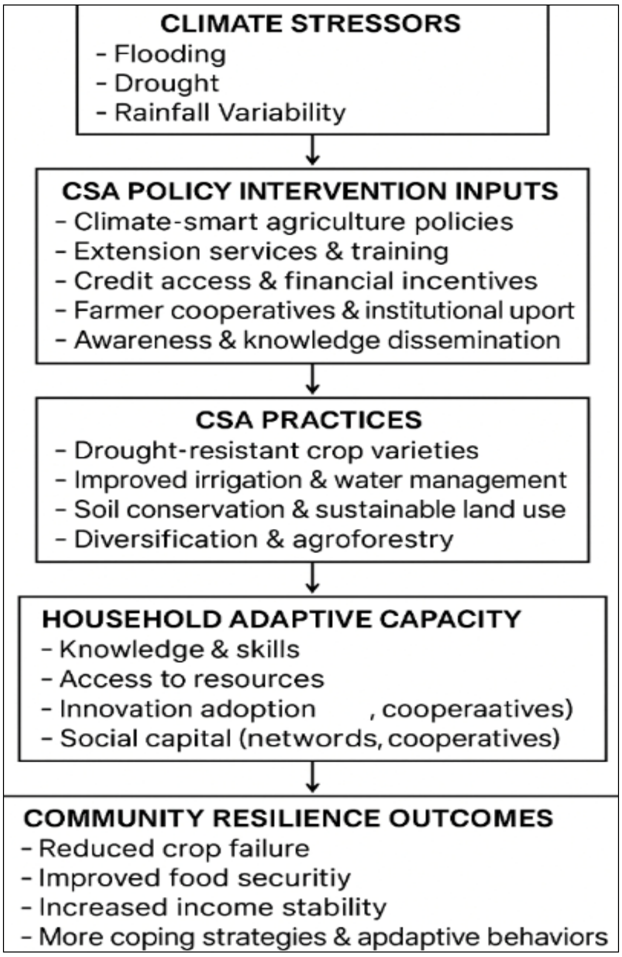


Fig 1: Conceptual Framework Promoting Climate-Smart Agriculture

Theoretical Framework

This study is grounded in an integrated theoretical framework that combines Resilience Theory, the Climate-Smart Agriculture (CSA) framework, and Policy Intervention and Governance Theory to examine how community resilience to climate change can be enhanced through policy-supported CSA interventions in Mubi North, Adamawa State, Nigeria.

Integrated Theoretical Framework

The framework draws on three complementary perspectives (see Figure 2). Resilience Theory (Folke, 2006; Walker *et al*., 2004) [7, 25] serves as the foundation, conceptualizing resilience as the capacity of households and communities to absorb climate-related shocks, adapt to changing conditions, and transform their livelihood strategies while maintaining essential functions.

The CSA Framework, as defined by FAO (2013) and further elaborated by Lipper *et al*. (2014) [13], provides a practical lens by identifying specific agricultural practices such as drought-resistant crops, improved irrigation, and soil and water conservation that enhance adaptive capacity and promote sustainable productivity under variable climate conditions.

Policy Intervention and Governance Theory (Biermann *et al*., 2012), combined with Rogers' (2003) [4, 23] diffusion of innovations perspective, highlights the institutional and socio-economic factors that influence the adoption of CSA innovations at the community level. This includes the critical roles of extension services, access to credit, farmer cooperatives, and knowledge dissemination in enabling or constraining adoption.

By integrating these perspectives, the framework illustrates that effective policy support encourages the uptake of CSA practices, which in turn strengthens household adaptive capacity and contributes to broader community resilience. This combined theoretical approach offers a holistic understanding of how policy-driven CSA interventions can transform vulnerable farming communities into climate-resilient systems.

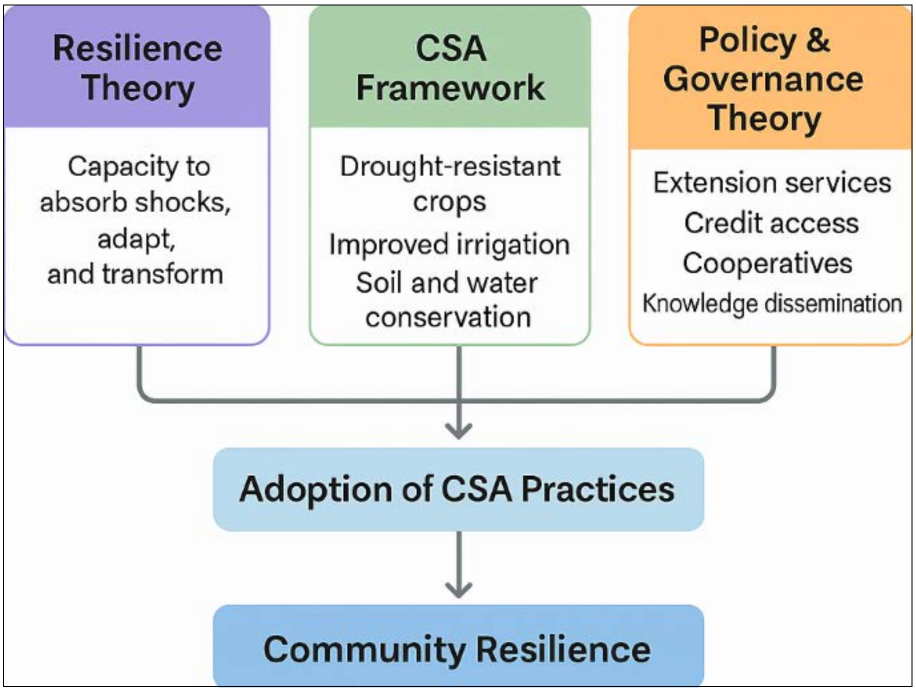


Fig 2: Integrated Theoretical Framework

Synthesis of the Framework

Collectively, these theories show that climate-smart agriculture (CSA) policy interventions operate as a dynamic, multi-level process. They are shaped by the adaptive capacity of communities (Resilience Theory), the technical and agronomic principles of CSA (FAO framework), and the institutional structures that support the uptake of innovations (Governance and Diffusion of Innovations theories). This integrated framework provides a comprehensive lens for analysing how well-designed, effectively governed policy actions can strengthen climate resilience in Mubi North and similar vulnerable farming communities.

Application of the Theoretical Framework in This Study

The integrated framework guides how this study conceptualizes, measures, and interprets variables related to climate change adaptation and community resilience in Mubi North. Resilience Theory informs the outcome indicators measured in this study, including reduced crop failure, improved food security, greater income stability, and enhanced coping capacity. These variables directly reflect the theory's focus on the ability of households and communities to absorb shocks, adapt to stressors, and maintain essential functions.

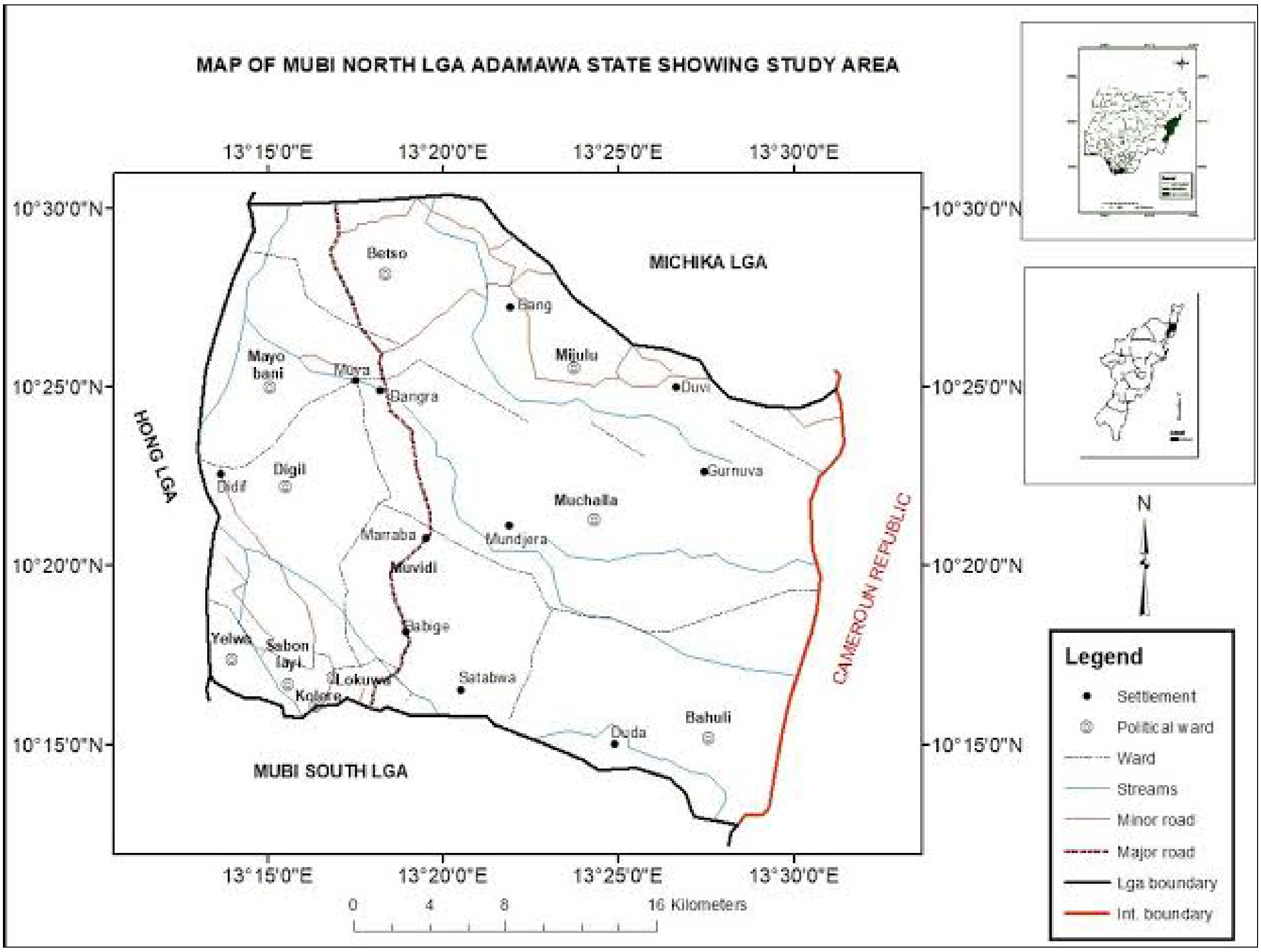
The Climate-Smart Agriculture (CSA) Framework is applied to identify and evaluate the specific CSA practices adopted by farmers, such as drought-resistant crops, improved irrigation, soil conservation, and crop diversification. This framework helps explain how these practices contribute to resilience by boosting productivity and adaptive capacity. It also guides the analysis of mean scores, showing how farmers perceive the usefulness and level of adoption of CSA interventions.

Policy Intervention and Governance Theory is used to examine the socio-economic and institutional factors that influence CSA adoption, including access to credit, extension services, cooperative membership, education, farm size, and farming experience (Nelson *et al*., 2007) [19]. These variables form the basis of Chi-square and logistic regression analyses. Rogers' Diffusion of Innovations perspective further helps interpret why adoption levels may vary across different farmer groups and locations.

By integrating these perspectives, the framework informs the selection of independent, dependent, and outcome variables, supports the interpretation of statistical results (including insignificant Chi-square relationships), and clarifies why certain factors drive CSA adoption. More broadly, it illustrates the pathways through which CSA policy interventions enhance household adaptive capacity and, ultimately, community resilience. This approach ensures that empirical findings are firmly connected to overarching concepts of adaptation, innovation adoption, and resilience-building in climate-vulnerable agricultural communities.

Study Area

Mubi North Local Government Area (LGA) is situated in the northeastern part of Adamawa State, Nigeria, sharing a border with the Republic of Cameroon. Geographically, it lies approximately between 10°15′ and 10°30′ N latitude and 13°10′ and 13°30′ E longitude. The LGA spans an area of about 1,250 km² and has an estimated population of around 200,000 people, most of whom are smallholder farming households (National Population Commission, 2023[18] projection). The climate in Mubi North is typically tropical continental, characterized by two main seasons: a rainy season from May to October and a dry season from November to April. Average annual rainfall ranges between 800 mm and 1,000 mm, generally following a unimodal pattern. However, rainfall has become increasingly variable, with more frequent occurrences of delayed onset and early cessation in recent decades (Sadiq, 2022) [24]. Temperatures average between 24°C and 32°C annually, with March and April often experiencing extremes above 40°C. These climatic conditions, combined with the predominance of rain-fed agriculture, make Mubi North particularly vulnerable to climate-related stresses.



Map of Mubi-North Lga

Soils in Mubi North are mainly sandy loams and ferruginous tropical types, which are moderately fertile but highly susceptible to erosion and degradation when intensively farmed. The natural vegetation is characteristic of the Sudan Savannah, dominated by grasses, shrubs, and scattered trees such as neem (*Azadirachta indica*), baobab (*Adansonia digitata*), and various acacia species (*Acacia spp.*).

Farming is the primary economic activity, with major crops including maize, sorghum, millet, rice, cowpea, and groundnut. Vegetable gardening is practiced along river valleys, while livestock rearing including cattle, goats, sheep, and poultry is also widespread. Agriculture is predominantly rain-fed, with only limited small-scale irrigation during the dry season. Increasingly, communities face climate-related challenges such as droughts, flash floods, and soil degradation, which pose significant risks to food security and livelihoods. Mubi North was selected as the study area due to its high vulnerability to climate variability, heavy reliance on subsistence agriculture, and the presence of ongoing but underutilized policy interventions aimed at promoting climate-smart agriculture (CSA).

Methodology

Research Design

This study adopts a mixed-methods research design, integrating quantitative household surveys with qualitative participatory approaches. This combination allows for a comprehensive analysis, linking farmers' perceptions with empirical data to provide a robust understanding of climate-smart agriculture (CSA) adoption and resilience in Mubi North.

Population and Sampling

The target population consists of smallholder farming households in Mubi North. A multi-stage sampling approach will be applied (Agresti, 2013) [2]:

1. **Stage 1:** Community Selection: Five farming communities will be purposively chosen to reflect variations in agro-ecological conditions and farming practices.

2. **Stage 2:** Household Selection: Within each selected community, households will be randomly sampled. Using Yamane's formula for finite populations, with a 95% confidence level and a 5% margin of error, a total of 250 households will be surveyed.

3. **Stage 3:** Key Informants and Focus Groups: Qualitative insights will be gathered through 10 key informant interviews (KIIs) with agricultural extension workers, traditional leaders, and representatives of farmer cooperatives, as well as 5 focus group discussions (FGDs) one in each community.

Data Collection Instruments

1. **Household survey questionnaire:** Captures demographic characteristics, farm attributes, adoption of CSA practices (e.g., drought-resistant crops, irrigation use), and perceptions of climate risks, crop yields, and household income.

2. **FGDs and KIIs:** Explore community-level experiences with CSA, challenges to adoption, and the role of policy support.
3. **Field observations:** Document infrastructure for irrigation, crop performance, and adaptation practices.

Data Analysis

Quantitative Analysis

Survey data will be coded and analyzed using SPSS (version 26) or Stata (version 17). Analytical procedures include:

1. **Descriptive statistics:** Means, frequencies, and percentages will summarize respondents' socio-economic characteristics, CSA adoption rates, and perceptions (Greene, 2018[8]; Menard, 2010).

2. **Chi-square tests:** Examine associations between socio-economic variables such as education, access to credit and CSA adoption.

3. **Binary logistic regression:** Identify the determinants of adoption for CSA practices such as drought-resistant crops and irrigation.
   3.1 Dependent variable: Adoption of CSA practice (1 = Yes, 0 = No)
   3.2 Independent variables: Age, gender, education, household size, farm size, access to extension services, credit availability, and perception of climate change.
   3.3 The logistic regression model is expressed as:

$$\text{Logit}(Pi) = \text{In}\left(\frac{Pi}{1-n}\right) = \beta o + \beta 1\ x + \beta 2\ \text{X}\ x2i + \cdots + \beta p\ xki + \varepsilon i$$

Where Pi = the probability that household *i* adopts CSA practices

- $\frac{Pi}{1-n}$ = odds of adopting CSA
- In (.) = natural logarithm
- βo = intercept (constant term)
- $\beta 1, \beta 2, \ldots.\beta k$ = regression coefficients
- $X_{1i}, X_{2i,\ldots\ldots}, Xki$ = *explanatory variables(e.g. education, farm size, land tenure, extension access)*
- $\mathcal{E}i$ = *error term…………………(*Wooldridge *et al*., 2010)

Result and Discussion

Socio-demographic variables

The demographic profile of respondents, summarized in Table 1, indicates that males comprised the majority (64.8%), while females accounted for 35.2% of the sample. Most respondents were aged between 31 and 50 years, with the largest subgroup being 41–50 years (27.9%). In terms of education, the highest proportion of respondents had completed secondary education (43.5%), followed by those with tertiary education (34.2%).

A significant majority of households depended primarily on farming as their main livelihood (74.0%), with most cultivating relatively small plots of land ranging from 1 to 5 hectares (62.4%). Overall, the socio-demographic profile reflects a predominantly farming population with moderate levels of formal education and strong engagement in agricultural activities, providing a representative sample for examining climate-smart agriculture adoption and resilience.

Table 1: Frequencies and Percentages of Respondents' Demographic Characteristics

Variable	Category	Frequency	Percentage (%)
Sex	Male	162	64.8
	Female	88	35.2
Age (years)	20–30	43	15.4
	31–40	69	24.6
	41–50	78	27.9
	51–60	40	14.3
	61 and above	50	17.9
Education level	None	7	2.7
	Primary	31	11.9
	Secondary	113	43.5
	Tertiary	89	34.2
	Qur'anic	20	7.7
Livelihood activity	Farming	185	74.0
	Trading/Civil/Other	-	-
Farm size (ha)	1–5 hectares	156	62.4

Source: Field Survey (2025)

Means and Standard Deviations for Likert-Scale Statements

The mean scores reveal generally strong agreement across several areas of the survey. Respondents demonstrated high awareness of climate change, with items 1 and 3 recording mean scores of 3.98 and 4.24, respectively, indicating a clear perception of increasing climate variability (see Table 2). Adoption of climate-smart agricultural (CSA) practices showed moderate agreement, with mean scores ranging from 3.21 to 3.41, suggesting that while farmers are engaging with CSA practices, there is still room for wider uptake. Socio-economic factors influencing adoption also received moderate to strong agreement, particularly item 15 (M = 3.83, SD = 0.97), reflecting the role of variables such as access to resources and knowledge in shaping CSA uptake.

Perceptions of policy and institutional support, however, were relatively low, with mean scores below 3.0. This indicates a general dissatisfaction among farmers regarding government and NGO support for climate-smart initiatives. Finally, respondents expressed strong agreement on statements related to livelihood resilience, with items 23 and 25 scoring 3.80 and 3.89, respectively. These findings suggest that CSA practices contribute meaningfully to household resilience. To provide a more detailed understanding, the study analysed each Likert-scale statement in relation to the study objectives, examining respondents' views on climate change impacts, CSA adoption, and livelihood and resilience outcomes, as presented in Tables 3 to 5.

Table 2: Means and Standard Deviations for Likert-Scale Statements by Section

Section	Statement No.	Mean	SD
B: Perceptions of Climate Change	1	3.98	0.97
	3	4.24	0.80
	5	3.36	1.18
C: Adoption of CSA Practices	6	3.21	1.24
	9	3.41	1.19
D: Socioeconomic Factors	12	3.66	1.14
	15	3.83	0.97
E: Policy and Institutional Support	16	2.84	1.33
	19	2.78	1.16
F: Livelihood Resilience	23	3.80	1.07
	25	3.89	1.00

Source: Field Survey (2025)

Climate Change Impacts

Farmers rated flooding at M = 4.35 and unpredictable rainfall at M = 4.01 as the most severe climate change impacts, indicating strong recognition of hydrological and rainfall-related disruptions. Moderate concern was expressed regarding increased drought frequency of 3.77 and reduced crop yields, while soil degradation received the lowest mean score of 3.23 as shown in Table 3. These results suggest that climate change is experienced most intensely through extreme weather events that directly hinder farming operations.

Table 3: Mean Scores and Ranking of Farmers' Perceptions of Climate Change Impacts

Statement	Mean	Rank
Flooding has negatively affected farming	4.35	1
Rainfall patterns have become unpredictable	4.01	2
Droughts are becoming more frequent	3.77	3
Climate change has reduced crop yields	3.64	4
Soil degradation has worsened	3.23	5

Source: Field Survey (2025)

Adoption of CSA Practices

Drought-resistant crop varieties emerged as the highest ranked CSA practice having M = 3.65, reflecting farmers' confidence in their ability to improve yields under climate stress. Food security benefits of CSA also received positive mean scores of 3.57 while the view on irrigation as a coping with rainfall variability strategy recorded mean value of 3.17. However, individual farmers' cultivation of drought resistant crops varies ranked lowest with 3.14 as shown in Table 4, suggesting that infrastructural, financial, or technical barriers may be limiting farmers' adoption of improved irrigation methods despite recognizing their usefulness.

Table 4: Mean Scores and Ranking of Adoption and Benefits of CSA Practices (Section C)

Statement	Mean	Rank
Drought-resistant crops help increase yields	3.65	1
CSA practices have improved food security	3.57	2
I have adopted improved irrigation practices	3.22	3
Irrigation helps me cope with rainfall variability	3.17	4
I cultivate drought-resistant crop varieties	3.14	5

Source: Field Survey (2025)

Livelihood and Resilience Outcomes

Table 5 shows perceived livelihood outcome was the strongest ability of CSA to reduce crop failure risk with mean = 3.90. This indicates that farmers view CSA primarily as a risk-reduction strategy. However, the high mean score for CSA is good but poorly understood with mean = 3.87 show that awareness and technical understanding remain limited. Moderate ratings for income improvement and resilience which is mean 3.47 suggest that benefits are emerging but not yet fully realized. Coping strategies received the lowest ranking of 3.11, highlighting gaps in adaptive capacity.

Table 5: Mean Scores and Ranking of Livelihood and Resilience Outcomes (Section F)

Statement	Mean	Rank
CSA reduces the risk of crop failure	3.90	1
CSA is good but not well understood by farmers	3.87	2
My household is more resilient to climate shocks	3.47	3
My farm income has improved due to CSA	3.37	4
I now have more coping strategies than before	3.11	5

Source: Field Survey (2025)

The analysis reveals that climate stress is most strongly perceived through flooding and rainfall variability**,** which aligns with increasing climate instability in many farming regions**.** CSA adoption is also driven mainly by trust in drought-resistant crops, while irrigation remains underutilized similarly CSA improves resilience and reduces crop losses**,** but farmers do not have adequate knowledge and institutional support, limiting the full potential of CSA.

Cross-Tabulation Table

The cross-tabulation in Table 6 shows the distribution of respondents' agreement with CSA adoption across different categories of farming experience. Farmers with 21 - 30 years of experience recorded the highest proportion of high agreement (n = 62), followed by those with 11 - 20 years (n = 54). Respondents with 1 - 10 years of experience reported considerably lower levels of high agreement (n = 27). Additionally, farmers with more than 50 years of experience had the lowest endorsement of CSA adoption (n = 4), although this group also had the smallest representation. Overall, the table suggests that agreement with CSA adoption tends to increase with farming experience up to about 30 years, after which it gradually declines.

Table 6: Cross-Tabulation of Farming Experience and Level of Agreement with CSA Adoption

Farming Experience (years)	High Agreement (SA + A)	Low Agreement (N + D + SD)
1 - 10	27	12
11 - 20	54	19
21 - 30	62	12
31 - 40	32	8
41 - 50	12	5
51+	4	3

Source: Field Survey (2025)

Chi-Square Test of Association between Socio-Economic Factors and CSA Adoption

The Chi-square results in Table 7 indicate no statistically significant association between any of the examined socio-economic variables (education, farm size, farming experience, access to credit, and cooperative membership) and the adoption of two climate-smart agriculture (CSA) practices (irrigation and drought-resistant crop varieties). All p-values are greater than .05 (p = .999)**,** and the Chi-square statistics are extremely small, suggesting that the observed distributions of CSA adoption across categories of each socio-economic variable are almost identical. This means the results collectively suggest that socio-economic characteristics alone may not be the primary drivers of CSA adoption in the study area. Instead, adoption may be influenced by other factors such as awareness and knowledge of CSA practices, availability of inputs, extension services, risk perception, or environmental conditions. This finding highlights the need for policies that go beyond socio-economic profile targeting and focus more on institutional support, incentives, training**,** and access to CSA technologies**.**

Table 7: Chi-Square Test of Association between Socio-Economic Factors and CSA Adoption

Predictor Variable	CSA Practice	χ^2	df	P	Significance
Education	Irrigation	0.08	4	.999	Not significant
Education	Drought-Resistant Crops	0.03	4	.999	Not significant
Farm Size	Irrigation	0.04	4	.999	Not significant
Farm Size	Drought-Resistant Crops	0.02	4	.999	Not significant
Farming Experience	Irrigation	0.10	5	.999	Not significant
Farming Experience	Drought-Resistant Crops	0.03	5	.999	Not significant
Access to Credit	Irrigation	0.05	4	.999	Not significant
Access to Credit	Drought-Resistant Crops	0.01	4	.999	Not significant
Cooperative Membership	Irrigation	0.01	4	.999	Not significant
Cooperative Membership	Drought-Resistant Crops	0.04	4	.999	Not significant

Source: Field Survey (2025)

Adoption of Climate-Smart Agriculture Practices

The logistic regression model in Table 8 shows that several socio-economic and institutional factors significantly predict the likelihood of adopting climate-smart agriculture (CSA) practices.

Overall, the model demonstrates strong explanatory power, accounting for approximately 41% of the variance in CSA adoption (Nagelkerke R^2 = .41), and exhibits an adequate fit based on the non-significant Hosmer–Lemeshow test (p = .47).

Table 8: Logistic Regression Predicting Adoption of Climate-Smart Agriculture Practices

Predictor Variable	Odds Ratio (OR)	Std. Error	z	P
Education (Tertiary vs. None)	2.05	0.42	3.12	.002
Farm Size (≥6 ha vs. <1 ha)	1.78	0.39	2.65	.008
Farming Experience (21–30 yrs vs. 1–10 yrs)	1.46	0.31	2.11	.035
Access to Credit (Yes vs. No)	2.72	0.51	4.21	<.001
Cooperative Membership (Yes vs. No)	2.34	0.47	3.89	<.001
Extension Services (Yes vs. No)	1.91	0.36	3.14	.002

Model Fit Indices

Nagelkerke R^2 = .41

Hosmer–Lemeshow $\chi^2(8)$ = …, p = .47

Overall Classification Accuracy = 74%

OR > 1 indicates increased likelihood of CSA adoption;

CSA = Climate-Smart Agriculture.

Strongest Predictors of CSA Adoption

The study found that several factors significantly influence the adoption of climate-smart agriculture (CSA) practices among farmers in Mubi North.

a. Key Drivers of Adoption

1. **Access to credit (OR = 2.72, p < .001):** Farmers with access to credit are nearly three times more likely to adopt CSA practices compared to those without, highlighting that financial resources are a major enabling factor for innovation.

2. **Cooperative membership (OR = 2.34, p < .001):** Being part of a farmer cooperative more than doubles the likelihood of CSA adoption, emphasizing the role of social networks, knowledge sharing, and collective action.

3. **Education (OR = 2.05, *p* = .002):** Farmers with tertiary education are about twice as likely to adopt CSA practices, reflecting how knowledge and the ability to understand new technologies facilitate innovation uptake.

b. Moderate but Influential Predictors

1. **Farm size (OR = 1.78, *p* = .008):** Larger farms are more likely to adopt CSA, suggesting that greater land or resource availability supports investment in practices like irrigation and soil conservation.

2. **Extension services (OR = 1.91, *p* = .002):** Access to technical guidance and farmer training significantly increases adoption, showing the importance of institutional support in facilitating practical implementation.

c. Additional Predictors

1. **Farming experience (OR = 1.46, *p* = .035): Experienced farmers are modestly more likely to adopt CSA, likely due to accumulated knowledge and longer exposure to climate risks.**

Therefore, while farmers in the study area are clearly aware of climate change impacts particularly flooding and rainfall variability the decision to adopt CSA practices is shaped more by financial, social, and institutional factors than by basic socio-demographic characteristics alone. Although Chi-square tests did not reveal simple associations, logistic regression highlighted strong predictors such as credit access, cooperative membership, farm size, education, and extension support.

Among CSA interventions, drought-resistant crops were the most trusted and widely adopted, whereas irrigation remains underutilized. CSA adoption contributes positively to household resilience and reduces crop failure. However, the full potential of CSA is constrained by limited knowledge, weak institutional support, and gaps in extension services.

To enhance adoption, the study recommends strengthening knowledge systems, improving access to credit, expanding cooperative networks, and increasing extension services, thereby supporting more widespread and effective use of CSA practices in Mubi North.

Policy Recommendations

1. **Expand CSA Extension Services:** Government should scale up climate-smart agriculture (CSA) extension programs to strengthen farmer training, provide hands-on demonstrations, and improve access to timely climate information.

2. **Enhance Rural Education:** Educational initiatives targeting rural communities should be improved to increase farmers' understanding of climate risks and promote the adoption of modern adaptation technologies.

3. **Secure Land Tenure:** Strengthening formal land rights can encourage farmers to make long-term investments in soil conservation and adopt CSA practices more confidently.

4. **Integrate CSA Frameworks:** Policymakers should establish a coherent CSA framework that aligns extension services, education, and land-tenure reforms to ensure more effective and coordinated implementation.

5. **Support Community Structures:** Farmer cooperatives and local resilience networks should be reinforced to enhance knowledge sharing, mobilize resources, and promote collective adaptation strategies.

6. **Embed CSA in Rural Development:** CSA should be mainstreamed into rural development planning through measures such as improved access to credit, subsidized inputs, small-scale irrigation, and better storage facilities to reduce post-harvest losses.

Policy Support by Education Level (Tertiary vs. Non-Tertiary)

The Mann-Whitney U test was used to examine whether farmers' education levels influenced their perceptions of policy support for CSA. Results showed no significant differences between tertiary and non-tertiary educated farmers across all five policy indicators (all p-values > .05). This suggests that both education groups hold similar views ranging from agreement to neutrality on community initiatives, local leadership, government policies, NGO support, and collaboration with policymakers.

The lack of significant differences can be explained by the community-wide nature of policy delivery in Mubi North. CSA-related interventions, extension services, and government programs are typically implemented at the local level rather than individually, so farmers encounter the same strengths and limitations regardless of educational background. Additionally, many policies are still perceived as under-implemented or largely theoretical, resulting in uniform, moderate, or skeptical perceptions across the farming population.

In essence, the findings reflect that in rural settings like Mubi North, collective policy exposure and structural constraints outweigh individual education differences in shaping perceptions of CSA support. This underscores the need for improved policy outreach, practical implementation, and community engagement to enhance the effectiveness of CSA initiatives.

Mann-Whitney U Test Results for Policy Support (Statements 16 - 20) by Education Level (Tertiary vs Non-Tertiary)

Statement	Group	N	Mean Rank	Sum of Ranks	Median	U	Z	P
16. Community initiatives promote CSA adoption	Tertiary	89	118.4	10,536	3.0	6,428	–1.12	.263
	Non-Tertiary	161	128.2	20,656	3.0			
17. Local leaders & cooperatives mobilize CSA	Tertiary	89	133.1	11,838	4.0	6,402	–1.15	.249
	Non-Tertiary	161	123.1	19,354	4.0			
18. Government supports improved irrigation	Tertiary	89	130.4	11,606	4.0	6,631	–0.89	.374
	Non-Tertiary	161	124.3	19,586	4.0			
19. Government/NGOs support drought-resistant crops	Tertiary	89	127.6	11,358	3.0	6,879	–0.52	.602
	Non-Tertiary	161	125.7	19,834	3.0			
20. Collaboration between farmers and policymakers	Tertiary	89	129.9	11,571	3.0	6,666	–0.82	.412
	Non-Tertiary	161	124.6	19,623	3.0			

Source: Field Survey (2025)

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