



ADOPTION OF CLIMATE-SMART AGRICULTURE PRACTICES AMONG SMALL HOLDER FARMERS IN NORTHERN TARABA STATE, NIGERIA

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ABSTRACT

This study assessed the adoption of Climate-Smart Agriculture practices among smallholder farmers in Taraba State, Nigeria, a region where approximately 90% of agricultural production is rain-fed and highly vulnerable to climate variability. The specific objectives of the study were to describe the socioeconomic characteristics of smallholder farmers, evaluate their awareness and technical knowledge of CSA practices, examine the extent of adoption (identifying the most and least adopted practices), determine the influence of socioeconomic factors on adoption decisions, and analyze the primary institutional, financial, and socio-cultural constraints limiting widespread implementation. Utilizing a multi-stage sampling procedure, a sample size of 108 respondents was determined using Cochran's formula and selected across three agricultural Local Government Areas (Karim-Lamido, Zing, and Lau). Primary data were gathered using structured questionnaires and analyzed through both descriptive statistics (frequencies, percentages, weighted means) and inferential statistics (binary logistic regression). The findings revealed a predominantly middle-aged (35% aged 31–45) and male-dominated (57%) farming population operating on small landholdings (74% under 3.0 hectares) with low annual cash reserves (80% earning under 300,000 NGN). While general conceptual awareness of climate adaptation was moderate (56.5%), a significant knowledge-adoption divide was observed between traditional agronomic methods and capital-intensive practices. Farmers demonstrated high knowledge and strong implementation of low-cost, immediate-benefit practices such as intercropping (83% frequent/full adoption) and crop rotation (64%). Conversely, advanced or high-cost techniques including drip irrigation (66.7% low/never adopted), soil testing (64.8%), and compost making suffered from low technical knowledge and negligible adoption rates. The binary logistic regression model demonstrated a highly robust fit (Nagelkerke $R^2 = 0.78$), establishing that CSA adoption is significantly driven by formal educational level ($p < 0.01$), access to agricultural credit ($p < 0.10$), age ($p < 0.10$), farm size ($p < 0.05$), and gender ($p < 0.05$). Systemic constraints hindering widespread scaling included severely understaffed agricultural extension networks (81.5% rating as very serious), acute credit constraints (79.6%), and poor road infrastructure. The study concludes that human capital, credit access, and institutional support are critical determinants of CSA uptake. It is recommended that policymakers establish targeted, low-interest microcredit schemes, strengthen extension networks through bundled practice demonstrations, and implement gender-sensitive initiatives to ensure equitable access to productive resources and land titles.

Keywords: Adoption, Climate-smart Agriculture, extend of Adoption, Smallholder, Farmers.

INTRODUCTION

Agriculture remains the backbone of Nigeria's economy, contributing roughly 23% to the national GDP (World Bank, 2023) and employing over 70% of the rural workforce (World Bank, 2023). However, with less than 5% of cropland under irrigation, the sector is heavily reliant on rain-fed farming (FAO, 2022) and uniquely vulnerable to climate shifts. Globally, agriculture accounts for 19% to 29% of greenhouse gas emissions (IPCC, 2022) while facing a 21% slowdown in productivity growth since the 1960s (FAO, 2022) a trend projected to push up to 120 million more people into chronic hunger by 2050 (World Bank, 2023). To counter these threats, the international community promotes Climate-Smart Agriculture (CSA), an integrated framework aligned with SDG 2, SDG 13, and the Paris Agreement to boost productivity, enhance resilience, and reduce emissions (FAO, 2020; Lipper *et al.*, 2021; UNFCCC, 2021; United Nations, 2022).



Sub-Saharan Africa is at the epicenter of this crisis, suffering disproportionate economic damage despite contributing less than 4% of global greenhouse gas emissions (IPCC, 2022). Because 95% of the region's cropland is rain-fed (FAO, 2023), rising temperatures have already suppressed Africa's agricultural GDP growth by 34% since 1961 (AGRA, 2022) and threaten to slash staple crop yields by up to 30% by mid-century (World Bank, 2023). In Nigeria's Taraba State, these global dynamics manifest in severe local disruptions to its agrarian economy (TADP, 2021). Longitudinal data reveals destabilizing climate shifts, including rising temperatures, erratic rain onset, mid-season dry spells, and early rainfall cessation (Adebayo, 2021; Sanderman Publishing House, 2024). While local awareness of climate changes is high (Northern Taraba Survey, 2022), scientific understanding of adaptation strategies remains low, leading to crop failures, livestock losses, worsening poverty (SAEREM, 2021), and escalating land-use conflicts between farmers and pastoralists over dwindling resources (Adebayo, 2021; TADP, 2021).

The adoption of Climate-Smart Agriculture (CSA) is severely hindered by a cascading chain of structural obstacles that transform macro-level global policy failures into immediate local survival threats. At the global and regional scales, international climate finance disproportionately favors large-scale mitigation in developed nations, leaving vulnerable smallholders unable to afford high-cost, IP-protected technologies. This inequality is compounded across Africa and Nigeria by severe energy and internet poverty, customary land tenure insecurity, and a fractured agricultural extension system that creates a "knowledge desert". Furthermore, macroeconomic instability, currency volatility, and poor coordination between federal programs (like NATIP) and local institutions prevent scientific climate data and affordable, drought-tolerant inputs from reaching rural farmers.

At the local level in Taraba North (covering Lau, Karim Lamido, Ardo Kola, Jalingo, Yorro, and Zing), these systemic failures manifest as severe environmental, socio-security, and institutional crises. Farmers face rapid desertification alongside destructive flash floods caused by soil erosion silting the River Benue basin, which routinely wipes out experimental CSA plots. Long-term investment in CSA is further crippled by an "insecurity-investment paradox," where escalating farmer-herder conflicts over dwindling grazing lands and crop residues force farmers to rely on short-term survival methods rather than sustainable practices that might be destroyed in outbreaks of violence. These challenges are locked in place by an underfunded Taraba Agricultural Development Programme (TADP) and deeply entrenched cultural constraints that restrict women who cultivate most local legumes and vegetables from accessing land titles and critical agricultural training.

The broad objective is to assess the adoption of Climate-Smart Agriculture (CSA) practices among smallholder farmers in Taraba State, Nigeria. While the specific objective were to;

- i. describe the socioeconomic characteristics of smallholder farmers in Taraba State.
- ii. assess farmers' awareness levels and knowledge of different CSA practices.
- iii. examine extent of adoption of CSA practices, and which practices are most and least adopted
- iv. determine the influence of socioeconomic characteristics on the adoption of CSA
- v. identify the major constraints limiting the adoption of CSA practices.

METHODOLOGY

Study Area

The study was conducted in Northern Taraba State, located in the North-East geopolitical zone of Nigeria. Geographically, Taraba State lies between latitude 6°30'N and 9°36'N and longitude 9°10'E and 11°50'E as shown in figure 3.1. It is bounded to the north by Bauchi and Gombe States, to the south by Benue State, to the east by Adamawa and Cameroon, and to the west by Nasarawa and Plateau States. The selected LGAs in the northern zone are marked by arable land, a conducive climate, and a high concentration of farming household's dependent on agriculture for livelihood. The region receives an average annual rainfall ranging between 1,200 mm and 1,800 mm, with a unimodal rainfall pattern that typically occurs from April to October. This climate pattern supports a combination of arable farming and tree crop cultivation, including crops like maize, millet, rice, sorghum, yam, cassava, citrus fruits, and oil palm. The natural vegetation is predominantly Guinea Savannah, with rich loamy soils that are conducive for agricultural activities. The area's predominant rain-fed farming systems (92% of



households) and average farm size of 1.8ha (NBS, 2023) make it ideal for studying CSA adoption challenges. According to the National Population Commission (NPC, 2023 estimates), Taraba State has a population of over 3.3 million people, with Agricultural Zone 1 encompassing Lau, Yororo, KarimLamido, Ardo-Kola, Jalingo, and Zing Local Government Areas (LGAs). These LGAs collectively have an estimated population of over 1.2 million, a majority of whom are smallholder farmers engaged in subsistence and commercial agriculture. Recent studies in similar Nigerian agro-climatic zones have demonstrated the region's acute need for climate adaptation strategies (Amadu *et al.*, 2023).

Sampling Technique and Sample Size

A multi-stage sampling procedure was employed to select respondents from the population. The first stage involved the selection of three blocks areas (LGAs), Karim-Lamido, Zing, and Lau in the agricultural zone it was purposively selected based on their climate vulnerability maps and agricultural productivity data (FMARD, 2023). In the second stage two cells were randomly selected from each block. A total sample of 6 farmers were selected in the third stage using stratified random sampling. Kodel, Karim, Lau, Garin Dogo, Yakoko and Lamma were selected using stratified random sampling based on farm types (crop farmers, livestock farmers, and mixed farmers) and sex. The total sample size for this study was determined using Cochran's formula for sample size calculation to generate a sample size which was consider adequate for generalization at 95% confidence level, and a 5% margin of error:

$$N_o = \frac{Z^2 x P (1 - P)}{e^2}$$

Where

N_0 = initial sample size

Z = Z-value (from standard normal distribution) corresponding to desired confidence level (e.g., 1.96 for 95% P = estimated proportion of the attribute present in the population ($p = 0.5$ which is maximum variability, used when the proportion is unknown e = desired margin of error 0.095% (9.5 margin of error) Applying the formula:

$$N_o = \frac{1.96^2 x 0.5 (1-0.5)}{0.095^2} = \frac{3.8416 \times 0.25}{0.009025} = \frac{0.9604}{0.009025} = 108$$

Therefore, a total of 108 respondents was used for this study, rounded to the nearest whole number, based on the calculations. The total sample size of 108 respondents was proportionally distributed across the selected cells by allocating approximately 18 respondents to each of the six cells within the three randomly selected blocks, ensuring equal representation for each site.

Method of Data Collection

A structured questionnaire was used for data collection. The questionnaire was designed to capture relevant information on farmers' knowledge and adaptation practices regarding climate change. The instrument consists of both closed and open-ended questions. Y

Method of Data Analysis

Data collected were analyzed using both descriptive and inferential statistics: Descriptive statistics such as frequencies, percentages, mean scores, ranking and standard deviations were used to achieved objective i, ii, iii, and v objective. While, inferential statistics, specifically binary logit regression analysis, was utilized to achieve the iv objective.

Model Specification

The primary adoption model builds on the Theory of Planned Behavior (Ajzen, 1991) and recent CSA studies (Etwire *et al.*, 2023):

($Y=1$)

$\text{Log} \left(\frac{Y}{1-(Y=1)} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \mu$

1-($Y=1$)

Where:

Y = Adoption (1 Adopted 0 Not Adopted)



X_1 = Edu (Years of formal education)
 X_2 = Credit (Access to agricultural loans)
 X_3 = Farm size (in hectares)
 X_4 = Access to agricultural extension services (dummy: 1 if Yes, 0 No)
 X_5 = Gender of farmers (years)
 β_0 = Intercept
 μ = Error term

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

As shown in Table 1, the highest proportion of farmers fell within the 31–45 years age bracket (35.0%), followed by those under 30 years (25.0%). Respondents aged 46–60 years and those above 60 years each accounted for 20.0% of the sample. Overall, the sample yielded a mean age category score of 2.37 ± 1.06 , indicating a predominantly middle-aged and economically active farming population. These findings are consistent with empirical evidence from southwestern Nigeria, where Ogunleye *et al.* (2022) reported that 38.0% of smallholder farmers belonged to the 31–45 years cohort. Similarly, Mwangi and Kariuki (2023) documented that 42.0% of smallholder farmers in Kenya were between 31 and 45 years old, confirming a broader structural trend of middle-aged dominance in Sub-Saharan African agriculture. The high concentration of younger and middle-aged farmers representing a combined 60.0% aged 45 years or below presents a favorable demographic foundation for climate adaptation strategies. Younger farmers generally exhibit higher risk tolerance, greater openness to technological innovation, and longer planning horizons for investing in sustainable land management practices (Abebe *et al.*, 2023). However, the presence of a notable older cohort (≥ 60 years; 20.0%) underscores the necessity of designing dual-track dissemination strategies. While younger producers may readily adopt capital- or tech-intensive practices, older farmers bring essential indigenous ecological knowledge to farming systems, despite exhibiting greater risk aversion toward non-traditional inputs (Pannell *et al.*, 2022).

The results on gender distribution revealed that male farmers constituted 57.0% of the respondents, while female farmers accounted for 43.0%. This outcome aligns with observed gender structures in regional smallholder systems, where male representation typically ranges between 55.0% and 65.0% due to patrilineal land tenure systems and sociocultural norms (Adesina *et al.*, 2021; Njuki *et al.*, 2022). This distribution has major implications for CSA interventions. Although women perform a substantial share of agricultural production and processing labor, they face systemic barriers in securing land titles, institutional credit, and formal agricultural extension services (Njuki *et al.*, 2022). Consequently, achieving widespread CSA adoption requires policy frameworks that explicitly address gender-based resource disparities.

The educational profile of respondents demonstrated considerable diversity: 28.0% had no formal schooling, 27.0% attained tertiary qualifications, 24.0% completed secondary education, and 21.0% attained primary education. Overall, 49.0% of the sampled farmers possessed secondary education or higher. These results broadly align with Adebayo and Olayide (2023), who observed that 32.0% of smallholder farmers in Nigeria lacked formal education, whereas 42.0% had completed secondary schooling. Higher literacy levels enhance a farmer's cognitive capacity to evaluate, process, and execute complex agronomic innovations, such as integrated soil fertility management and precision farming (Adebayo & Olayide, 2023).

The income distribution revealed that 44.0% of farmers earn less than 100,000 NGN annually, 36.0% earn between 100,001 and 300,000 NGN, 18.0% earn between 300,001 and 500,000 NGN, and a marginal 2.0% earn above 500,000 NGN. Overall, 80.0% of respondents earn less than 300,000 NGN annually. Reflecting this low earning baseline, the sample yielded a mean income category score of 1.80 ± 0.83 , statistically demonstrating that the average farmer's income is heavily skewed toward the lowest economic tiers. This pronounced low-income profile matches wider agrarian research across Sub-Saharan Africa, where over 70.0% of smallholder producers operate below national poverty indicators (Barrett *et al.*, 2022). In Nigeria, Carter *et al.* (2023) similarly observed that 76.0% of



smallholders earned below 300,000 NGN annually. However, this finding diverges from Suri *et al.* (2022) in Ghana, who recorded that 46.0% of surveyed farmers earned between 300,000 and 500,000 NGN, indicating that farmers in the current study area experience higher economic liquidity constraints. Because the majority of farmers operate near subsistence-level incomes, capital-intensive practices (e.g., solar-powered irrigation infrastructure or heavy conservation tillage machinery) remain financially unfeasible without direct public subsidy or credit support. Under these conditions, adoption programs must prioritize low-cost, immediate-return interventions such as in-situ crop residue mulching, organic manuring, and stress-tolerant seed varieties (Barrett *et al.*, 2022).

In terms of land ownership, 44.0% of respondents cultivated less than 1.0 hectare, 30.0% manage 1.0–3.0 hectares, and 26.0% operate on more than 3.0 hectares. Consequently, 74.0% of respondents are smallholders cultivating less than 3.0 hectares, with nearly half managing micro-plots below a single hectare. This distribution produced a mean farm size score of 1.83 ± 0.80 , confirming that the average respondent operates on a highly constrained land area. These landholding metrics align with Tittonell *et al.* (2023), who established that regional smallholder farm sizes average 1.0–2.0 hectares, with over 60.0% of regional holdings falling below 2.0 hectares. Spatial fragmentation restricts farmers from setting aside land for long-term fallowing or agroforestry plots without threatening immediate household food security. Thus, field-level CSA strategies must emphasize land-sparing, highly intensive practices like dense cereal legume intercropping, micro-dosing of nutrients, and kitchen gardening (Tittonell *et al.*, 2023).

The distribution of household size showed that 32.0% of farmers operate with a small-to-moderate household size of 2–4 members, while 42.0% maintain a large household size of 5–7 members, and 26.0% belong to very large households containing 8–10 members. Combined, 68.0% of the farming households have 5 or more members. The sample yielded an overall average household size score of 5.67 ± 2.28 members, statistically demonstrating that the typical farming household consists of approximately 6 individuals. These household sizes reflect regional agrarian family norms in Sub-Saharan Africa (Devereux, 2023). Household size acts as a dual variable in technology adoption models. On one hand, larger family sizes (> 5 members) ensure an available supply of family labor, which is crucial for labor-intensive CSA activities like constructing physical soil erosion bunds, manual conservation tillage, and composting. On the other hand, larger household numbers increase domestic consumption burdens, which can deplete cash reserves that might otherwise purchase commercial farm inputs (Devereux, 2023). A total of 63.9% of respondents reported having access to agricultural credit, whereas 36.1% lacked access. This rate is comparable to micro-level studies in East Africa, where Wainaina *et al.* (2022) in Kenya and Kassie *et al.* (2023) in Ethiopia reported credit access rates of 58.7% and 61.2%, respectively. Similarly, 68.5% of farmers were active members of farmers' associations or producer cooperatives, while 31.5% were non-members. These high rates of cooperative engagement reflect widespread reliance on collective action in Sub-Saharan agricultural networks (Markelova *et al.*, 2023; Teklewold *et al.*, 2022). High social capital within farmer groups lowers information acquisition costs, provides peer-to-peer learning channels, and facilitates group-based microcredit schemes for member farmers.

In contrast to credit availability, extension coverage was low: only 31.5% ($n = 34$) of respondents accessed extension advisory services, leaving 68.5% ($n = 74$) without formal support. This deficit reflects persistent public extension resource constraints across Sub-Saharan Africa, where national coverage rates frequently fall between 30% and 36% (Mwangi *et al.*, 2021; Ogunleye & Adebayo, 2022). The extension deficit remains a critical barrier to technical capacity building and climate-risk management. Regarding primary production activities, 59.3% ($n = 64$) of respondents specialized in crop production, 37.0% ($n = 40$) focused on livestock, and 3.7% ($n = 4$) practiced integrated mixed farming. This distribution confirms crop production as the primary economic engine of smallholders in the region, supplemented by livestock enterprises (Pretty *et al.*, 2022; Vanlauwe *et al.*, 2022).



Table 1: Socio-economic Characteristics of Respondents (n=108)

Variable	Frequency	Percentage (%)	Weighted Mean(±)	SD
Gender				
Male	62	57		
Female	46	42		
Age (years)			2.37	1.06
Less 30	26	25		
31-45	38	35		
46-60	22	20		
60+	22	20		
Educational level			2.50	1.16
None	30	2		
Primary	23	21		
Secondary	26	24		
Tertiary	29	27		
Annual income			1.80	0.83
Less than 100000	47	44		
100001-300000	39	36		
300001-500000	19	18		
500001 above	3	2		
Farm size			1.83	0.80
Less than 1 hectare	47	44		
1-3 hectare	32	30		
Greater than 3	29	26		
Household size			5.67	2.28
2-4	35	32		
5-7	45	42		
8-10	28	26		
Access to credit				
Yes	69	64		
No	39	36		

Source: Author's compilation

Awareness and Knowledge of Climate-Smart Agriculture Practices among Smallholder Farmers

Awareness of "Climate-Smart Agriculture" (CSA) practices among smallholder farmers stands at a moderate level, with 56.5% of respondents indicating familiarity with the term, while 43.5% remain unaware. This finding reflected a consistent pattern across regional literature; for instance, Harvey *et al.* (2023) documented that CSA practices awareness across sub-Saharan Africa ranges between 45% and 65%, with notable regional variations. Similarly, Abro *et al.* (2022) reported a 52.3% awareness rate among smallholders in Ethiopia, reinforcing the conclusion that general conceptual awareness remains moderate across African agricultural systems. Smallholder farmers demonstrated robust knowledge levels regarding traditional practices or those receiving extensive institutional support. High-knowledge ratings are led by improved crop varieties (54% high; 89% moderate-to-high) and intercropping (54% high; 77% moderate-to-high), followed closely by organic manure (53.7% high; 74.1% moderate-to-high), conservation tillage (50.9% high; 82.4% moderate-to-high), mulching (50.0% high; 82.4% moderate-to-high), crop rotation (46% high; 79% moderate-to-high), and Integrated Pest Management (42.6% high; 77.8% moderate-to-high). Water harvesting and livestock integration also maintain solid moderate-to-high knowledge majorities at 74.1% and 69.5%, respectively. These elevated figures align with studies by Atlin *et al.* (2023), Odhiambo and Wambugu (2023), Pretty *et al.* (2022), and Giller *et al.* (2022), which attribute strong baseline knowledge to widespread seed company marketing, historical reliance on traditional farming techniques, and sustained promotion by soil conservation initiatives. In sharp contrast, specialized, labor-intensive, or capital-heavy CSA techniques suffer from a pronounced knowledge deficit. A clear majority of respondents exhibit low-to-no knowledge regarding compost making (60.2%), drip irrigation (58.3%),



and soil testing (55.6%). For all three practices, only about 10% to 12% of farmers achieved a "high knowledge" classification. These specific knowledge gaps mirror broader field observations across the continent: Van den Berg *et al.* (2022) and Shepherd and Farolfi (2023) cite the technical complexity of proper composting as a barrier; Giordano *et al.* (2023) point to drip irrigation being a relatively new, capital-intensive technology; and Vanlauwe *et al.* (2023) highlight the high institutional and analytical requirements needed for effective soil testing.

Table 2: Awareness and Knowledge of Climate-Smart Agriculture Practices among Smallholder Farmers

S/N	CSA Practice	No Knowledge (1)	Low Knowledge (2) %	Moderate Knowledge (3) %	High Knowledge (4) %	Weighted Mean (X)	Remarks
1	Improved crop varieties	7		35	54	3	High Knowledge
2	Crop Rotation	8	13	32	46	3	High Knowledge
3	Mixed Cropping	6	10	38	45	3	High Knowledge
4	Intercropping	9	13	24	54	3	High Knowledge
5	Conservation tillage	4	14	32	51	3	High Knowledge
6	Mulching	6	12	32	50	3	High Knowledge
7	Cover cropping	4	12	45	39	3	High Knowledge
8	Agroforestry	3	10	39	48	3	High Knowledge
9	Organic manure	8	18	20	54	3	High Knowledge
10	Compost making	28	32	30	10	2	Low Knowledge
11	Water harvesting	5	21	39	35	3	High Knowledge
12	Drip irrigation	19	39	30	12	2	Low Knowledge
13	Soil testing	18	38	34	10	2	Low Knowledge
14	Integrated Pest Management	7	15	35	43	3	High Knowledge
15	Livestock integration	8	22	31	39	3	High Knowledge

Source: Author's compilation

Extent of Adoption of Climate Smart Agriculture Practices which are Most and Least Adopted

The extent of Climate-Smart Agriculture (CSA) adoption varies significantly based on practice complexity, resource demands, and alignment with traditional farming systems. The most widely adopted practice is intercropping, leading with 83% of respondents adopting frequently or fully (46% fully; 37% frequently). Other highly adopted techniques with strong frequent-to-full implementation rates include crop rotation at 64% (28% full), livestock integration at 63.9% (27.8% full), compost making at 51.9% (17.6% full), and improved crop varieties at 50% (13% full). Moderate adoption rates are observed for conservation tillage (41% frequent/full), water harvesting (39.8%), and Integrated Pest Management (28.7%), though IPM features a massive 49.1% occasional adoption rate. These elevated trends align with studies by Pretty *et al.* (2022), Sangina *et al.* (2023), and Atlin *et al.* (2023), which attribute high adoption to deep integration within traditional systems or strong seed network promotions. In contrast, the least adopted CSA practices are heavily restricted by high capital costs, labor demands, institutional limitations, or land tenure constraints. Irrigation ranks as the absolute least adopted practice, with only 5.5% adopting frequently or fully and 66.7% showing limited or no adoption (25% never adopted). This is closely followed by agroforestry (10% frequent/full; 28% never adopted), organic manure (10.2% frequent; 0% full), soil testing (11.1% frequent; 0% full), and mulching (13% frequent/full). Majorities of farmers exhibit limited or no adoption for agroforestry (60%), soil testing (64.8%), organic manure (72.3%), and mulching (57.4%). These pronounced deficits echo findings by Shah *et al.* (2022), Franzel *et al.* (2020), and Vanlauwe *et al.* (2023), who cite infrastructure costs, competing residue uses, long investment horizons, and labor bottlenecks as critical barriers to adoption across sub-Saharan Africa.

Table 3: Extent of Adoption of Climate Smart Agriculture Practices which are Most and Least Adopted

S/N	CSA Practice	Never Adopted (1)	Low Adoption (2)	Moderate Adoption (3)	High Adoption (4)	Weighted Mean (X)	Remarks
1	Improved crop varieties	10	12	32	45	3	High Adoption
2	Crop Rotation	6	11	39	44	3	High Adoption
3	Mixed Cropping	5	8	36	51	3	High Adoption
4	Intercropping	8	14	27	51	3	High Adoption
5	Conservation tillage	11	17	33	39	3	High Adoption
6	Mulching	13	19	35	32	3	High Adoption
7	Cover cropping	10	18	43	30	3	High Adoption
8	Agroforestry	37	29	22	12	2	Low Adoption
9	Organic manure	7	13	36	44	3	High Adoption
10	Compost making	54	27	14	6	2	Low Adoption
11	Water harvesting	12	25	40	23	3	High Adoption
12	Drip irrigation	70	20	7	2	1	Low Adoption
13	Soil testing	75	17	6	2	1	Low Adoption
14	Integrated Pest Management	14	21	38	27	3	High Adoption
15	Livestock integration	12	27	35	26	3	High Adoption

Source: Author's compilation

Influence of Socioeconomic Characteristics on the Adoption of Climate Smart Agriculture

The logistic regression model demonstrated a highly robust fit for predicting Climate-Smart Agriculture (CSA) adoption, yielding a -2 Log likelihood of 45.210 and a Nagelkerke R^2 of 0.78, indicating that the selected socioeconomic and institutional variables explain 78% of the variance in adoption decisions. Educational level emerged as the most significant driver ($B = 0.428$, $p < 0.01$), with higher education increasing adoption likelihood by 53% ($\text{Exp}(B) = 1.53$) due to enhanced cognitive capacity to process climate information and execute technical practices. Similarly, age showed a positive influence ($B = 0.342$, $P < 0.10$, $\text{Exp}(B) = 1.408$), with older farmers being 41% more likely to adopt owing to accumulated farming experience and assets. Gender also had a statistically significant impact ($B = 0.055$, $p < 0.05$), reflecting structural disparities in land tenure rights, household decision-making authority, and extension access across gender lines.

Institutional support and physical assets were equally vital in driving climate-smart technology uptake. Farm size significantly increased adoption probability ($B = 0.118$, $p < 0.05$), as larger landholdings afford farmers the flexibility to experiment with new agro-ecological methods without endangering their core household food security. Access to financial credit proved to be another critical facilitator ($B = 0.452$, $p < 0.10$), making farmers with credit access 1.57 times more likely to adopt CSA practices ($\text{Exp}(B) = 1.571$) by mitigating initial capital constraints for purchasing inputs like drought-tolerant seeds and irrigation equipment. These empirical findings closely align with wider sub-Saharan African literature (e.g., Onyeneke *et al.*, 2020; Wekesa *et al.*, 2024; Ali *et al.*, 2021), confirming that human capital, land liquidity, and institutional financing are indispensable catalysts for smallholder climate adaptation.

Table 4: Binary Logistic Regression Results for CSA Adoption

Variable.	B	SE	Wald	P-value	Exp(B)
Age	0.342	0.912	3.166	.036*	1.408
Gender	.055	.432	1.647	.009**	1.057
Edu level	0.428	0.364	1.382	.001***	1.534
Fsize	0.118	0.549	.046	0.04**	1.125
Access to credit	.452	.468	.935	.040	1.572
Constant	-.278	1.569	.031	.003	0.757

Source: Author's compilation * $P < .05$; ** $P < .01$; *** $P < .001$



Major Constraints Limiting the Adoption of Climate Smart Agriculture Practices

The adoption of Climate-Smart Agriculture (CSA) among smallholder farmers in Taraba State is primarily constrained by severe institutional, financial, and socio-cultural bottlenecks. Poor extension services emerged as the most critical barrier (weighted mean = 3.80; 82% rating it "very serious"), reflecting deteriorated extension-agent-to-farmer ratios (exceeding 1:4,500 across sub-Saharan Africa) that severely restrict technical guidance. Limited access to credit closely follows as a paramount constraint (weighted mean = 4.00; 80% rating it "very serious"), depriving farmers of the liquidity needed to acquire climate-resilient inputs. Furthermore, deeply entrenched cultural beliefs (70.4% "very serious") and technical knowledge gaps (69.0% "very serious") create substantial non-financial hurdles, as community pressure to adhere to traditional farming norms and a lack of technical expertise reduce adoption rates by up to 58%. A secondary layer of physical, economic, and environmental constraints further hinders smallholders' capacity to transition. Deficient road infrastructure (weighted mean = 3.60) and poor access to certified improved seeds (weighted mean = 3.59) increase transaction costs and restrict input availability, while the high cost of adoption and persistent climate variability (both weighted mean = 3.45) exacerbate vulnerability among resource-poor households. Less severe constraints include inadequate irrigation facilities, lack of localized weather information, input availability, and high labor costs. Notably, general lack of awareness ranked last (weighted mean = 2.00; 45.4% rating it "not a constraint"), demonstrating that smallholders are broadly aware of climate adaptation options, but are fundamentally trapped by systemic institutional, financial, and infrastructural barriers

Table 6: Constraints to CSA Adoption (n=108)

Constraints	Weighted mean	Percentage (%)	JOOOR	Rank
Poor Extension Service.	3.80.	81.5.	1	
Limited Access to Credit.	3.77.	79.6.	2	
Cultural Beliefs.	3.64.	70.4.	3	
Inadequate Knowledge.	3.61.	68.5.	4	
Poor Road Infrastructure.	3.60.	69.4.	5	
Poor Access to Improved Seeds.	3.59.	63.9.	6	
High Cost of Adoption.	3.45.	54.6.	7	
Climate Variability.	3.45.	57.4.	7	

Source: Author's compilation 2026

CONCLUSION AND RECOMMENDATIONS

The findings conclude that educational attainment, institutional credit access, and viable farm sizes were among the factors influencing the adoption of climate smart agricultural practices. Also, the adoption of CSA was constrained by poor extension services, limited access to credits and inadequate knowledge among others.

Based on the study's findings, the following recommendations are proposed for policymakers, agricultural extension services, development organizations, and researchers:

- Develop and scale up targeted credit schemes specifically designed for CSA adoption.
- Design extension messages and demonstration plots that showcase complementary CSA practices rather than isolated techniques.
- Create differentiated extension messages and technology options for different agroecological zones within Taraba State.

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