EFFECT OF CLIMATE-SMART AGRICULTURE ON THE FOOD SECURITY STATUS OF CASSAVA FARMING HOUSEHOLDS IN KOGI STATE, NIGERIA

ABSTRACT

This study assessed the effects of climate-smart agriculture (CSA) on the food security status of cassava farming households in Kogi State, Nigeria. A multi-stage sampling technique was used to select 120 respondents for the study. Descriptive statistics, multivariate and probit regression models were used to analyze the data. Findings showed that 67.50% were male with a mean age of 46 years. About 60 % were married, with an average household size of 7. The mean farming experience is 11 years. Organic manuring, early planting, mixed cropping, minimum tillage and crop rotation were the major climate-smart agricultural practices adopted by the farmers. Multivariate regression analysis showed that household size, contact with extension service, education and membership of farmers' association were the significant factors influencing the utilization of CSA practices. The result further showed that 42.50%, 27.50%, 22.50% and 7.50% of the households were marginally, low, very low and highly food secure, respectively. Estimates of the Probit regression on the effect of CSA practices adoption on farming households' food security revealed that sex, household size, farm size andnumber of CSAs utilized significantly influenced households` food security. It is recommended that effective scaling of CSA is vital for the rural farming household's food security status.

Keywords: Climate-smart agriculture, Food security, Cassava, Multivariate Regression

Introduction

Climate change presents a significant challenge to agricultural production worldwide. However, its effects are particularly severe in developing regions such as sub-Saharan Africa (SSA), where agriculture largely depends on rainfall (Zizingaet al., 2022; Mirón et al., 2023). The impacts of climate change are evident in the form of prolonged dry periods, meteorological droughts, flooding, erratic rainfall patterns, shifts in cropping calendars, and rising atmospheric temperatures (Franklin et al., 2021). To effectively mitigate these impacts and build resilience in the agricultural sector, it is essential to integrate local knowledge from smallholder farmers with scientific insights through collaborative knowledge co-production (Ayorinde et al., 2022). African smallholder farmers have long employed traditional farming techniques such as intercropping to enhance soil fertility and maximize income. Recently, these practices have been reframed as Climate-Smart Agriculture (CSA) strategies (Ogunyiolaet al., 2021). Encouraging the adoption of CSA is crucial for enhancing smallholder farmers' ability to adapt to climate change, mitigate its negative effects, and contribute to achieving the United Nations Sustainable Development Goals (Ma &Rahut, 2024).

CSA approaches incorporate location-specific indigenous innovations, technologies, and services, emphasizing their contextual nature. In Africa, particularly Nigeria, CSA implementation is still evolving. The prevailing technocratic approach to scaling up CSA strategies may not yield the expected outcomes in addressing climate change. However, adopting CSA practices, technologies, and services has the potential to boost agricultural productivity, optimize resource utilization, improve farmers' income and profitability, strengthen resilience, ensure food security, and enhance carbon sequestration both above and below ground. A systematic approach to adaptation, mitigation, and food security is essential to help farmers effectively respond to climate change (Saleemet al., 2024). Smallholder farmers frequently encounter multiple climate-related risks such as floods, unpredictable rainfall, dry spells, and droughts, all of which significantly impact agricultural productivity. To cope with these challenges, they adopt one or more agricultural strategies (Belachew et al., 2020). CSA encompasses innovative farming techniques and technologies, including agroforestry systems and drought-resistant crop varieties, to address three major challenges of the 21st century: climate change adaptation, mitigation, and food security (Ayorinde et al., 2022).

CSA is designed to "sustainably increase agricultural productivity and incomes, enhance resilience in food and agricultural systems against climate change, and minimize or eliminate greenhouse gas emissions while ensuring national food security" (Mohummed & Ullah, 2024). Despite the growing body of research on CSA, findings on its effectiveness remain inconsistent. While some studies report its success across different agro-ecological zones and socio-economic conditions, others indicate limited impact, and some findings present mixed results…. For instance, Oyawoleet al. (2020) examined the impact of CSA adoption on food security among farm households in northern Nigeria and found that adoption levels were generally low. This highlights the need for continued empirical research on the effects of CSA practices on crop yields, household income, farmers' welfare, and overall food security. In response to this research gap, this study was conducted to assess the impact of CSA practices on household food security status among cassava farmers in Kogi State, Nigeria. The findings from this study will contribute to the existing body of knowledge on agricultural adaptation to climate change while offering valuable insights for policymakers in mainstreaming CSA in Nigeria's agricultural sector. The study specifically aimed to:identify the climate-smart agricultural practices; investigate factors influencing farmers' decision to utilize CSA practices; assess the food security status of cassava farming households; and determine the effect of CSA usage on the food security status of cassava farming households in the study area.

Methodology

The research was conducted in Kogi State, Nigeria, which comprises 21 Local Government Areas. Geographically, the state lies between latitudes 6°30'N and 8°05'N and longitudes 5°51'E and 8°00'E. The predominant ethnic groups in the region are the Igala, Ebira, and Yoruba (Okun), with agriculture being the main economic activity. The primary crops cultivated include cocoyam, maize, yam, and cassava. Additionally, most farming households engage in some form of livestock rearing. Men in the region are involved in crafts such as basket weaving and wood carving, while women primarily focus on processing farm produce. The state's economy and social structure are largely centered on agriculture. This study relied on primary data collected through a structured questionnaire administered to 120 cassava farmers in Kogi State. Both descriptive and inferential statistical methods were employed for data analysis.

A multi-stage sampling procedure was used to select the study respondents. In the first stage, two Local Government Areas (LGAs) were randomly selected from each of the four agro-ecological zones of the state using a Simple Random Sampling (SRS) technique. The second stage involved randomly selecting two cassava farming communities from each of the chosen LGAs, also using SRS. In the third stage, eight respondents were randomly selected from each identified community using the same SRS technique. This resulted in a total sample size of 128 respondents, of which 120 questionnaires were completed and returned for analysis.

Primary data was gathered using a structured questionnaire administered to cassava farmers. A total of 128 questionnaires were distributed to the sampled respondents, with 120 completed and returned. The data collection process was carried out by the researcher with the assistance of trained research assistants.

The collected data were analyzed using descriptive statistics, multivariate analysis, and an Ordered Probit regression model.

Results and Discussion

Socio-economic characteristics of the farmers

The distribution of the respondents according to their socioeconomic characteristics is presented in Table 1.

Table 1: Socio-economic characteristics of the respondents

Variables	Frequency	Percentage	Mean
Age			
≤ 20	1	0.83	
21-30	22	18.33	
31-40	15	12.50	
41-50	35	29.17	46 years
51-60	32	26.67	
>60	15	12.50	
Gender			
Male	81	67.50	Male
Female	39	32.50	
Marital status			
Single	48	40.00	
Married	72	60.00	Married
Household size (Persons)			
1-5	38	31.67	
6-10	71	59.17	7 persons
>10	11	9.17	
Educational level			
No formal education	1	0.83	
Primary school education	14	11.67	
Secondary school	46	38.33	
Tertiary school education	59	49.17	Tertiary education
Farm size (Hectares)			
1-2	114	95.00	1.44 hectares
>2	6	5.00	
Farm experience (years)			
1-10	74	61.67	
11-20	24	20.00	11 years
21-30	14	11.67	
>30	8	6.67	
Annual income (Naira)			
≤ 100,000	18	15.00	
100,001-200,000	30	25.00	
200,001-300,000	8	6.67	
300,001-400,000	15	12.50	
400,001-500,000	21	17.50	₦406,916.7
>500,000	28	23.33	
Extension contacts			
Had contact	26	21.67	
Had no contact	94	78.33	Had no contact
Membership of Association			
Member	55	54.17	
Non-member	65	45.83	Non-member

Source: Field survey, 2024

The findings presented in Table 1 indicate that the respondents had an average age of 46 years, suggesting that they were still within the productive age range for farming and capable of adopting improved agricultural technologies, particularly Climate-Smart Agriculture (CSA) practices and other advanced farming methods. This aligns with the studies conducted by Moses, Epko, and Ogah (2024), as well as Onya et al. (2019), which reported a mean age of 43 years among cassava farmers. Additionally, the results showed that a significant proportion (67.50%) of cassava farmers were male. This finding is consistent with the research of Uzokwe&Ofuoku (2022) and Moses, Epko, & Ogah (2024), who observed that cassava and smallholder farming are predominantly practiced by men. Furthermore, 60.00% of the surveyed farmers were married, indicating that a majority had family responsibilities and could rely on family labour for cassava farming. This observation corroborates the study by Uzokwe&Ofuoku (2022), which also identified marriage as a common characteristic among cassava farmers.

The analysis further revealed that the average household size was seven individuals, signifying a relatively large household composition. This finding is consistent with the study by Moses, Epko, & Ogah (2024), which reported an average household size of six persons among cassava farming families. Moreover, nearly all farmers (99.31%) had received some level of formal education, which has significant implications for the adoption of modern agricultural technologies, including CSA practices. This finding is in line with the work of Owolade, Alonge, Agbontale, &Adesanlu (2019), who argued that educated farmers are more likely to embrace innovative cassava farming techniques, ultimately enhancing agricultural productivity. The study also found that the mean farm size was 1.44 hectares, indicating that farmers in the region predominantly operated as smallholders with limited land resources. This finding aligns with previous research by Bello et al. (2022) and Chukwujekwuet al. (2022), which reported an average farm size of approximately two hectares. The average farming experience in the study area was 11 years, suggesting that farmers had accumulated considerable expertise to navigate agricultural challenges. This is consistent with the studies of Moses, Epko, & Ogah (2024), as well as Uzokwe&Ofuoku (2022), which reported an average farming experience of 13 years.

Regarding farm income, the results indicated that annual earnings were relatively low, with an average annual income of ₦406,916.70. This aligns with the findings of Chukwujekwuet al. (2022), who reported that smallholder farmers in Nigeria generally earn poor incomes. Furthermore, only 21.67% of the farmers had contact with extension services, reflecting poor outreach efforts, which could be attributed to insufficient extension personnel or inadequate funding. This lack of extension support could negatively impact the adoption of CSA practices among cassava farmers in the study area. Lastly, the findings revealed that 54.17% of respondents were affiliated with farmers' associations, while 45.83% were not. This suggests that a majority of the farmers were members of at least one agricultural organization.

The Climate-smart Agricultural practices utilized by the Cassava farmers in the study area

The distribution of farmers according to the CSA practices adopted in the study area is present in Table 2.

Table 2: Awareness of Climate-Smart Agricultural practices by the respondents

Climate-Smart Agricultural practices	Frequency (*)	Percentage
Engage in mulching	37	30.83
Control of irrigation water	43	35.83
Changing planting time to meet with rain	104	86.67
Planting of cover crops to maintain soil moisture	42	32.29
Harvest and store rain water to be used on my farm	72	60.00
Minimum tillage	90	75.00
Take crop insurance to protect my farm	65	54.17
Organic manuring	109	90.83
Mixed cropping	97	80.83
Afforestation	55	45.83
Crop rotation	93	77.50

Source: Field Survey, 2024 (*) = Multiple response allowed

The findings presented in Table 2 indicate that the most adopted climate-smart agricultural practices among cassava farmers in the study area included the use of organic manure (90.83%), adjusting planting schedules to align with rainfall patterns (86.67%), mixed cropping (80.83%), crop rotation (77.50%), and minimal tillage (75.0%). These results suggest that the adoption of Climate-Smart Agriculture (CSA) practices varies among smallholder cassava farmers in the region. This observation aligns with the studies of Kanyenjiet al. (2020) and Collins et al. (2022), which reported varying adoption rates of agricultural practices in Kenya. Previous studies, such as Reppinet al. (2020), have highlighted that CSA practices—including the application of animal manure, soil and water conservation techniques, agroforestry, crop diversification, and crop-livestock integration—play a crucial role in enhancing food security and improving community livelihoods. The broader implication of these findings is that such climate-smart strategies enable farmers to mitigate the negative impacts of climate change and enhance farm productivity in the study area (Acevedo et al., 2020; Barasa et al., 2021).

Factors influencing the usage of Climate-smart Agricultural

Table 3: Factors influencing the usage of Climate-smart Agricultural

Variables	**Changing planting date**		**Minimum tillage**		**Organic manure**		**Mixed farming**		**Crop rotation**	
	Coef.	**Std. err**	**Coef.**	**Std. err**	**Coef.**	**Std. err**	**Coef.**	**Std. err**	**Coef.**	**Std. err**
Age	0.000078	0.002899	-0.0022778	0.0035753	0.00329	0.0025	-0.00430	0.00316	0.001749	0.003587
Sex	0.019488	0.749967	-0.0233834	0.092493	-0.0344	0.0648	0.10824	0.08192	0.108595	0.092811
Household size	-0.023551	0.013842	-0.0324434	0.0170717	-0.02580**	0.0119	-0.02930	0.01512	0.000624	0.017130
Years spent schooling	-0.001002	0.005684	-0.018299**	0.0070112	0.003161	0.0049	0.001638	0.00621	-0.00758	0.007035
Farm size	0.0277938	0.537724	0.1062024	0.663172	-0.00027	0.0464	0.021723	0.05873	0.059190	0.066545
Extension contact	0.0225447	0.79974	-0.228481**	0.986315	0.030771	0.69111	-0.17539	0.08736	-0.182778	0.098970
Association	-0.010575	0.734214	0.1758923	0.0905502	-0.06658	0.06344	0.061566	0.08020	0.010576	0.090861
Awareness of CSA	-0.063267	0.895462	-0.0085634	0.1104368	-0.07995	0.07738	-0.07389	0.09781	-0.12406	0.110816

Number of CSA utilized	0.763526***	0.275775	0.1048371***	0.340112	0.018853	0.02383	0.10395***	0.03012	0.047377	0.034128
Constant	0.4979958**	0.22273	0.407388	0.274698	0.84692***	0.19248	0.4149644	0.24330	0.369480	0.275643

Source: field Survey, 2024 *, ** and *** represents statistical significance at 10%, 5%, and 1% level.

The factors influencing farmers' decisions to adopt individual or combined climate-smart agricultural (CSA) practices were analyzed. Various determinants influenced the adoption of these practices (Table 3). The results indicate that the household head’s level of formal education played a role in the use of minimum tillage. Specifically, farmers with fewer years of formal education were more likely to implement minimum tillage compared to those with higher educational attainment. This contradicts the findings of Baba & Abdulai (2023), who reported that education influenced the use of minimum tillage, such as soil fertility conservation and water retention, making them more inclined to adopt the practice. Furthermore, there was a significant negative relationship between farmers’ contact with extension agents and the adoption of minimum tillage. Extension services enhance smallholder farmers’ understanding and application of agricultural technologies. Research indicates that farmers who frequently interact with extension agents are more likely to adopt CSA practices, including minimum tillage, due to increased awareness of its benefits (Jabbar et al.,2024). Moreover, the adoption of minimum tillage was positively associated with the number of CSA practices adopted. This suggests that engaging with multiple CSA practices increases the likelihood of adopting minimum tillage. These findings align with previous studies that highlight the role of CSA practice diversity in influencing adoption decisions.

Household size was found to have a negative influence on the adoption of organic manure, suggesting that smaller households were more likely to incorporate organic manure into their farming practices. Household size serves as a critical factor in agricultural decision-making, as it indicates the availability of labour for implementing new farming techniques. This finding contrasts with the study by Njoku et al. (2024), which reported that the adoption of organic manure tends to increase with larger household sizes. Additionally, contact with extension services had a significant negative effect on the adoption of mixed farming. Extension services are essential in equipping smallholder farmers with the knowledge and skills needed to implement advanced agricultural technologies. However, the findings suggest that the limited availability of extension personnel may hinder the effective dissemination of technical knowledge on mixed farming. This contradicts the conclusions of Mogaka and Murithi (2021), who found that farmers' engagement with extension services enhances the adoption of climate-smart agricultural (CSA) practices. Furthermore, the number of CSA practices adopted had a positive effect on the uptake of mixed farming. This indicates that farmers who engage with multiple CSA techniques are more likely to incorporate mixed farming into their agricultural activities. The positive correlation aligns with previous studies, which found that cassava farmers frequently employ multiple cropping systems, implying that smallholder farmers tend to integrate various CSA practices into their farming strategies (Waaswaet al., 2022; Vatvaet al., 2023).

Food security status of the respondents

The result of the food security status of households in the study area is presented in Table 4.

Table 4: Food Security Status of Households

Food security category	**Frequency**	**Percentage**
Highly food secure	9	7.50
Marginally Food secure	51	42.50
Low food secure	33	27.50
Very Low food secure	27	22.50
Total	120	100

Source: Field Survey, 2024

Table 4 shows the result of the food security using the USDA food security assessment approach. The result revealed that a large proportion of the households were marginally food secure (42.50%), while 27.50% and 22.50% were low food secure and very low food secure, respectively. Only 7.50% were highly food secure. The result implies that more than half of the cassava farming households experience one form of food insecurity or the other, making it a matter of critical concern. According to Akukwe (2020), most of the respondents in the agrarian community of South-East Nigeria were food insecure (53.5%), while 46.5% were food secure.

Table 5 presents the findings of the ordered probit regression, analyzing the impact of climate-smart agricultural (CSA) practices on the food security status of cassava farming households. The Chi-square statistic (61.27) was highly significant at the 1% level ($p<0.01$), indicating that the independent variables meaningfully influenced food security outcomes. The model’s R^2 value of 20.45% suggests that the included variables accounted for 20.45% of the variation in the probability of food security among cassava farming households. The results indicate that gender ($p<0.05$) had a negative coefficient, whereas household size ($p<0.05$), farm size ($p<0.05$), and the number of CSA practices adopted ($p<0.01$) had positive coefficients. The negative relationship between gender and food security suggests that female-headed households are more likely to experience food insecurity than male-headed households. This finding aligns with Nnaji, Nazmum, and Alan (2022), who highlighted that limited access to land and other productive resources among female-headed households negatively impacts their food security.

Table 5: Effect of CSA practices adoption on Cassava farming households` Food Security Status in the study area

	Food security			
Variables	**Coefficient**	**Std. error**	**Z**	**P>/z/**
Age	0.0124	0.0101443	1.22	0.222
Sex	-0.6569621	0.2572643	-2.55	0.011**
Household size	0.1092416	0.0495384	2.21	0.027**
Years spent schooling	-0.0195468	0.0226429	-0.86	0.388
Farm size	0.3884572	0.187156	2.08	0.038**
Farming experience	-0.0199916	0.0112072	-1.78	-0.074
Extension contact	0.3811826	0.2755423	1.38	0.167
Awareness of CSA	0.3327511	0.3015334	1.10	0.270
Number of CSA utilized	0.2455158	0.0905688	2.71	0.007***
/cut 1/	-0.4186698	0.7906208		
/cut 2/	1.64613	0.7971871		
/cut 3/	2.685814	0.8160163		
Diagnostic test				
Number of obs	120			
LR chi2 (9)	61.27			
Prob > chi2	0.0000			
Pseudo R2	0.2045			

Sources: Estimates from the analysis of the data from the field survey. *, ** and *** represent statistical significance at 10%, 5% and 1% level respectively.

Household size exhibited a positive and statistically significant relationship ($p<0.05$) with food security status. This supports the findings of Herrera et al. (2021), who reported that larger households benefit from increased labour availability, which enhances agricultural productivity and food security. Similarly, farm size was positively associated with food security ($p<0.05$), corroborating the study by Yahaya and Danmaigoro (2020), which found that larger farm sizes contribute to improved food security among farming households in Zuru Agricultural Zone, Kebbi State. Furthermore, the number of CSA practices adopted by cassava farmers had a positive and highly significant ($p<0.01$) impact on food security. This suggests that increasing the use of CSA techniques enhances the likelihood of food security among farming households, providing valuable insights into strategies for improving food security in Nigeria.

Table 6: Effect of CSA practices adoption on Cassava farming households` food security - Marginal Effect of Food Security

	Highly Food secure		**Marginal Food secure**		**Low Food secure**		**Very Low Food secure**	
Variables	$\frac{\partial y}{\partial x}$	P>/z/	$\frac{\partial y}{\partial x}$	P>/z/	$\frac{\partial y}{\partial x}$	P>/z/	$\frac{\partial y}{\partial x}$	P>/z/
Age	-0.006	0.267	-0.004	0.227	0.002	0.242	0.00271	0.224
Sex	0.0292	0.061	0.223	0.011	-0.095	0.012	-0.162	0.023
Household size	-0.006	0.089	-0.038	0.033	0.019	0.053	0.024	0.031
Year of Formal education	0.001	0.402	0.007	0.392	-0.003	0.398	-0.004	0.390
Farm size	0.021	0.105	0.134	0.044	-0.069	0.064	-0.084	0.042
Farming experience	0.001	0.144	0.007	0.080	-0.003	0.102	-0.004	0.079
Extension contact	-0.017	0.167	-0.134	0.172	0.058	0.114	0.093	0.213

Awareness of CSA	-0.015	0.273	-0.117	0.274	0.053	0.226	0.078	0.307
Number of CSA utilized.	-0.013	0.060	-0.084	0.010	0.044	0.024	0.054	0.009

Source: Field survey, 2024

The marginal effects analysis indicated that the sex of the household head had a positive influence on Marginal Food Secure and Very Low Food Secure, but a negative impact on Low Food Secure. This finding aligns with Boscowet al. (2025), who highlighted the role of gender in determining the adoption of climate-smart agricultural (CSA) practices and, by extension, food security status. Additionally, household size positively influenced Marginal Food Secure and Very Low Food Secure. However, this study's findings contrast with those of Ali et al. (2022) and Musafiri et al. (2022). They argued that as households adopt more CSA practices, more resources are allocated to agricultural activities, leaving fewer resources for food expenditures. Furthermore, farm size had a positive effect on Marginal Food Secure but a negative influence on Very Low Food Secure. The positive relationship aligns with Li et al. (2024), who reported that an increase in farm size enhances production levels, thereby improving food security status. The analysis also showed that the number of CSA practices adopted positively influenced Marginal Food Secure, Low Food Secure, and Very Low Food Secure. This supports previous research indicating that an increase in CSA practices helps mitigate climate change effects, enhances agricultural productivity, and ultimately improves food security (Girma et al.,2023; Ma & Rahut,2024). Additionally, these findings are in line with studies suggesting that greater adoption of CSA practices leads to higher yields, which positively impacts household food security and dietary diversity (Omotosho & Omotayo, 2024; Vatsa et al., 2023; Akter et al., 2022).

Conclusion and Recommendations

This study investigated the effect of climate-smart agricultural (CSA) practices on food security among cassava farming households in Kogi State, Nigeria. It provides valuable insights into how CSA practices influence household food security in the region. The findings indicate that the most adopted CSA practices among cassava farmers include the application of organic manure, changing planting to align with rainfall patterns, mixed cropping, minimal tillage, and crop rotation. Key factors influencing the decision to adopt CSA practices in the study area include the number of CSA techniques utilized, years of formal education, and household size. Additionally, factors such as gender, household size, farm size, and the number of CSA practices adopted significantly impacted the food security status of farming households. Based on these findings, the study recommends that governments and development partners establish inclusive financial policies and institutional frameworks—developed in collaboration with smallholder farmers—to facilitate the widespread adoption of CSA practices in Kogi State, Nigeria.

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