



ANALYSIS OF CLIMATE SMART AGRICULTURE (CSA) ADOPTION TOWARDS BUILDING RESILIENCE AMONG CASSAVA FARMERS IN EBONYI STATE, NIGERIA

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ABSTRACT: This study analysed climate-smart agriculture (CSA) adoption and its role in building resilience among cassava farmers in Ebonyi State, Nigeria. A cross-sectional survey design was used, and data were collected through a structured questionnaire using a multi-stage sampling technique. Data were analysed using percentage, mean score, paired sample t-test, and logistic regression. Results showed that 68.3% of respondents were male, 55.0% were aged 31–50 years, 42.5% had secondary education, 50.0% had household sizes of 6–10 persons, and 47.5% had 10–20 years of farming experience. The most adopted CSA practices were improved cassava varieties ($\bar{x} = 4.3$), intercropping ($\bar{x} = 3.9$), and organic manure use ($\bar{x} = 3.6$). These practices enhanced resilience, particularly in adapting farming strategies ($\bar{x} = 4.0$), maintaining yield despite irregular rainfall ($\bar{x} = 3.9$), and ensuring income stability ($\bar{x} = 3.7$). Cassava output significantly increased after CSA adoption, from 10.5 t/ha to 14.8 t/ha (mean difference = 4.3 t/ha; $t = 9.12$; $p < 0.001$). Education, farm size, access to extension, credit, cooperatives, and climate information significantly influenced CSA adoption. The study recommends improving access to education, extension, and climate services to promote CSA adoption and enhance cassava productivity.

Keywords: Climate-smart agriculture, cassava farmers, adoption, climate resilience

INTRODUCTION

Climate change poses a significant threat to agricultural sustainability globally, with disproportionate effects on developing countries like Nigeria, where agriculture is predominantly rain-fed and dominated by smallholder farmers. Cassava, a major staple crop and a vital source of livelihood in Ebonyi State, is increasingly vulnerable to erratic rainfall, rising temperatures, and extreme weather events (Osuji, Igberi, and Ehirim, 2023; Onyeneke, Nwajiuba, and Iruo, 2018). In response, climate-smart agriculture (CSA) has emerged as a transformative approach aimed at increasing productivity, enhancing resilience, and reducing greenhouse gas emissions (Omotoso and Omotayo, 2024). However, adoption of CSA practices among cassava farmers remains inconsistent and poorly understood.

Previous studies have identified socio-economic and institutional factors influencing CSA adoption, such as access to extension services, education, credit, land tenure security, and membership in farmer groups (Okoro, Ibe, and Okeke, 2022; Eze, Ibekwe, and Nwajiuba, 2020; Kangogo, Mutuku, and Mbatha, 2021). For example, Onyeneke, Nwajiuba, and Iruo (2021) found that farmers' perception of climate change, access to information, and institutional support significantly influenced CSA uptake. Likewise, Njoku, Eze, Okonkwo, and Nwankwo (2025) demonstrated that cassava value chain actors with greater socio-economic resilience were more likely to adopt adaptive strategies. Despite growing attention to CSA, limited empirical evidence exists on its determinants and outcomes within cassava-based systems in Ebonyi State.

Emerging studies from South-East Nigeria suggest that although awareness of CSA practices, such as mulching, crop rotation, use of organic fertilisers, and drought-tolerant varieties, is growing, adoption is still constrained by economic and infrastructural barriers (Nwankwo, Ofoegbu, and Onyekwere, 2022; Njoku *et al.*, 2024). Moreover, institutional factors such as extension services, market access, and supportive policies play a critical role in

farmers' decision-making (Adebayo, Adeola, and Oluwatayo, 2022; Akter, Fatema, and Beyene, 2022). The availability or absence of these supports may either enhance or impede the adoption and sustained use of CSA, thereby affecting farm productivity and resilience to climate shocks.

Beyond improving yields, CSA adoption has been linked to enhanced climate resilience by strengthening farmers' capacity to anticipate, absorb, and adapt to climate-related stressors (Aidoo, Mensah, and Osei-Owusu, 2022; *Njoku et al.*, 2024). Studies by *Njoku et al.* (2025) and Izuogu, Okafor, and Emefiele (2025) highlight that CSA adoption contributes to multidimensional resilience—economic, institutional, and environmental. Furthermore, *Njoku et al.* (2025) found that CSA mitigated yield losses and promoted long-term sustainability in cassava production. However, empirical studies that quantitatively connect CSA adoption to cassava output and resilience outcomes in Ebonyi State remain scarce.

This study, therefore, examined the factors influencing climate-smart agriculture adoption and cassava farmers' resilience in Ebonyi State, Nigeria. Specifically, it (i) identified the socio-economic and institutional factors influencing CSA adoption; (ii) assessed the level of adoption of specific CSA practices; (iii) determined the effect of CSA adoption on farmers' resilience; and (iv) examined the relationship between CSA adoption and cassava output. It tested the null hypothesis that socio-economic and institutional factors do not significantly influence CSA adoption, against the alternative hypothesis that they do.

METHODOLOGY

The study was conducted in Ebonyi State, Nigeria, located between latitudes 6.26490°N and longitudes 8.01370°E. The state has an estimated population of 3,398,177 people (National Population Commission [NPC], 2020) and lies within the humid tropical zone of south-eastern Nigeria. It experiences two distinct seasons: a rainy season (March to October) and a dry season (November to February). During the dry season, temperatures range between 20°C and 38°C, while the rainy season experiences cooler temperatures between 16°C and 28°C. The harmattan period typically occurs from December to January, bringing dry and dusty winds. The mean annual temperature is about 28°C, with relative humidity ranging from 50% to 80% depending on the season. The region receives between 2,000 mm and 2,500 mm of rainfall annually, which supports year-round crop production (*Ezeano, Ezeano, and Emeh, 2021; Nwaiwu et al., 2022*). The state's economy is predominantly agrarian, and cassava is one of the most widely cultivated crops, serving as a major source of food and income for rural households.

A cross-sectional survey design was adopted for the study. A multi-stage random sampling technique was employed to select respondents. At the first stage, two agricultural zones were purposively selected from the state's existing zones because they are the major cassava-producing areas and were more relevant for assessing climate-smart agriculture (CSA) adoption and resilience. In the second stage, two Agricultural Development Programme (ADP) blocks were randomly chosen from each selected zone. The third stage involved the selection of three ADP circles from each block making it 12 circles. Finally, 75% of registered cassava farmers within each selected circle were proportionally sampled, resulting in a total sample size of 120 respondents.

Primary data were collected using a structured questionnaire. Trained enumerators administered the questionnaires through face-to-face interviews to ensure clarity, completeness, and reliability of the responses. To achieve the stated objectives, various statistical tools were employed. Descriptive statistics, including frequencies and percentages, were used to summarise the socio-economic characteristics of the respondents. This analysis addressed objective (i). The level of adoption of specific CSA practices was measured using a 5-point Likert-type scale. Mean scores were computed from the ratings to determine the extent of adoption, thereby achieving objective (ii). Farmers' perceived resilience to climate change was also assessed using a 5-point Likert scale across selected resilience indicators, which addressed objective (iii). In addition, a paired sample t-test was applied to compare cassava yields before and after CSA adoption to determine the effect of CSA practices on output, also related to objective (iii).

To address the hypothesis, regression models were applied. A binary logistic regression model was used to identify the socio-economic and institutional factors influencing CSA adoption. In this model, the dependent variable was adoption status (1 = adopter, 0 = non-adopter). The explanatory variables were age (years), educational level (years of schooling), farm size (hectares), access to extension services (yes = 1, no = 0), access to credit (yes = 1, no = 0), membership in cooperative societies (yes = 1, no = 0), and access to climate information (yes = 1, no = 0).

Furthermore, a multiple linear regression model was specified to examine the relationship between CSA adoption level and cassava output. The dependent variable was cassava output, measured in kilograms per hectare. The main explanatory variable was the level of CSA adoption, expressed as a composite score derived from the adoption of specific practices. Other socio-economic and institutional factors were included as control variables. The model is specified as:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + \varepsilon$$

Where:

- Y = cassava output (kg/ha)
- $X_1 \dots X_n$ = socio-economic and institutional predictors, including CSA adoption level
- β_0 = intercept
- β_n = regression coefficients showing the contribution of each predictor
- ε = error term

RESULTS AND DISCUSSION

Socio-economic Characteristics of Respondents

The result indicated that 68.3% of cassava farmers were male and 55% were between the ages of 31 and 50 years. This indicates that cassava farming in Ebonyi State is mostly practised by adult men who are in their productive years. These men are likely to be strong, active, and open to new farming practices. The high male participation may be attributed to cultural roles that give men greater access to land and decision-making power. Most of the farmers (42.5%) had attained secondary education, suggesting that they possess the ability to read, understand, and apply information disseminated by extension agents. This increases their potential to adopt climate-smart agricultural (CSA) practices. These findings are consistent with previous studies by Onyeneke *et al.* (2018) and Osuji *et al.* (2023), who reported that education and age significantly influence CSA adoption.

Furthermore, 47.5% of respondents had between 10 and 20 years of farming experience. This indicates that they are not only active but also have a considerable understanding of farming and the observable impacts of climate change, which may enhance their capacity to adapt their practices accordingly. In addition, 50% of the respondents had household sizes ranging from 6 to 10 members. A large household size may imply greater access to family labour, which is useful for carrying out labour-intensive CSA practices such as mulching and composting. This suggests that both farming experience and household size are relevant factors in the adoption of CSA. The implication is that CSA training and support programmes should target farmers who are educated, experienced, and have access to sufficient labour, as they are more likely to adopt and benefit from CSA practices.

Table 1: Socioeconomic Characteristics of respondents

Variable	Category	Frequency	Percentage (%)
Sex	Male	82	68.3
	Female	38	31.7
Age (years)	≤30	18	15.0
	31–50	66	55.0
	>50	36	30.0
Educational Level	No formal education	12	10.0
	Primary	25	20.8
	Secondary	51	42.5
	Tertiary	32	26.7
Household Size	1–5	40	33.3
	6–10	60	50.0
	>10	20	16.7
Years of Farming Experience	<10	28	23.3
	10–20	57	47.5
	>20	35	29.2

Source: Field survey, 2024

Level of Adoption CSA Practices

The results show that improved cassava varieties ($\bar{x} = 4.3$), intercropping ($\bar{x} = 3.9$), and organic manure use ($\bar{x} = 3.6$) were the most adopted climate-smart agricultural (CSA) practices among cassava farmers in the study area. These practices recorded mean scores above 3.5, indicating high to moderately high levels of adoption. Improved cassava varieties were likely preferred because they are more tolerant to climate stress and offer better yield performance. Intercropping was also widely adopted, probably due to its ability to optimise land use and minimise production risks. The fairly high use of organic manure may be attributed to its role in improving soil fertility while reducing reliance on expensive chemical fertilisers.

These findings align with those of Njoku *et al.* (2022) and Izuogu *et al.* (2021), who reported that cassava farmers in southeastern Nigeria are more inclined to adopt cost-effective, easy-to-implement CSA practices that contribute to higher productivity. The implication is that extension programmes should focus on scaling up these practices by improving farmers' access to improved varieties and promoting the use of organic amendments that support sustainable and climate-resilient production.

Table 2: Level of Adoption of Specific CSA Practices

CSA Practice	Mean Score	Std. Dev.	Adoption Level
Improved cassava varieties	4.3	0.8	High
Organic manure use	3.6	1.1	Moderate–High
Intercropping	3.9	0.9	High
Mulching	2.8	1.2	Moderate
Crop rotation	3.5	1.0	Moderate–High
Agroforestry	2.2	1.3	Low–Moderate
Rainwater harvesting	2.6	1.1	Moderate
Soil conservation (ridging/terracing)	3.1	0.9	Moderate

Source: Field survey, 2024

Effect of CSA Adoption on Resilience to Climate Change

Result on effect of CSA adoption on resilience to climate change is presented in Table 3. show that cassava farmers reported a strong capacity to adapt their farming strategies in response to climate changes, with a high mean score of 4.0. They also demonstrated a good ability to maintain yield despite irregular rainfall ($\bar{x} = 3.9$) and income stability over the last three years ($\bar{x} = 3.7$). The ability to recover quickly from climate-related losses had a moderately high mean score of 3.6, while access to early warning or climate information was lower, with a mean score of 3.2. These findings suggest that CSA adoption has improved farmers' resilience in terms of adaptive capacity, yield stability, and income security, though access to timely climate information remains a limitation.

This agrees with Njoku *et al.* (2025), who found that CSA practices contributed significantly to adaptive resilience among cassava farmers in Ebonyi State. Similarly, Njoku *et al.* (2024) observed that farmers with higher levels of CSA adoption exhibited better income stability and were less affected by climate shocks. The implication is that while CSA adoption enhances resilience, there is a need to strengthen farmers' access to timely climate information, which could further improve their capacity to respond proactively to extreme weather events.

Table 3: Effect of CSA Adoption on Resilience to Climate Change

Resilience Indicator	Mean Score	Std. Dev.
Ability to maintain yield despite irregular rainfall	3.9	0.9
Quick recovery from climate-related losses (flood, drought)	3.6	1.1
Access to early warning or climate information	3.2	1.3
Income stability from cassava farming over the last 3 years	3.7	1.0
Capacity to adapt farming strategies in response to climate change	4.0	0.8

Source: Field survey, 2024

Relationship between Level of Adoption and Cassava Output

The result of the relationship between the level of adoption of CSA and cassava output is presented in Table 4. Show that the mean cassava output increased from 10.5 tonnes per hectare before CSA adoption to 14.8 tonnes per hectare after adoption, resulting in a mean difference of 4.3 tonnes. The paired sample t-test revealed that this difference was statistically significant ($t = 9.12$, $p < 0.001$). This indicates that the adoption of climate-smart agricultural (CSA) practices had a positive and significant effect on cassava yield.

This finding is consistent with Njoku *et al.* (2023), who reported higher productivity among CSA adopters in southeastern Nigeria. Similarly, Osuji *et al.* (2023) found that CSA use, particularly improved varieties and intercropping, contributed to increased output. The implication is that CSA technologies are effective in enhancing cassava production, thereby improving food availability and income generation among farming households.

Table 4: Relationship between Level of Adoption and Cassava Output

CSA Adoption Status	Mean Output (tonnes/ha)	Std. Dev.
Before adoption	10.5	2.4
After adoption	14.8	3.1
Mean difference	+4.3	

Source: field survey, 2024

Paired sample t-test result: $t = 9.12$, $df = 119$, $p < 0.001$ (significant)

Socioeconomic Determinants of CSA Adoption

Results on the Socioeconomic Determinants of CSA Adoption presented in Table 5. Showed that education level, farm size, access to extension, access to credit, cooperative membership, and access to climate information significantly influenced CSA adoption, as their p-values were less than 0.05. Among these factors, access to extension services had the strongest effect, with an odds ratio (OR) of 2.812, indicating that farmers who had access to extension were nearly three times more likely to adopt CSA practices than those without such access. Similarly, access to climate information (OR = 2.038) and access to credit (OR = 1.855) also had strong positive influences on adoption. Education level (OR = 1.261), farm size (OR = 1.519), and cooperative membership (OR = 1.689) were also statistically significant, suggesting that better-educated farmers with larger farm sizes and membership in cooperative societies were more inclined to adopt CSA practices. Age was not significant ($p = 0.473$), implying that the likelihood of adoption was not influenced by the farmer's age.

These results support the findings of Njoku *et al.* (2023) and Eze *et al.* (2020), who noted that access to information, credit, and institutional support play critical roles in the adoption of CSA practices. The implication is that strengthening extension services, improving farmers' access to credit facilities, and promoting group participation can significantly enhance the uptake of CSA practices among cassava farmers.

Table 5: Socioeconomic Determinants of CSA Adoption

Predictor Variable	B	S.E.	Wald	Sig. (p)	Exp(B) (Odds Ratio)
Age	-0.015	0.021	0.515	0.473	0.985
Education level	0.232	0.096	5.830	0.016	1.261
Farm size	0.418	0.187	5.001	0.025	1.519
Access to extension	1.034	0.431	5.756	0.016	2.812
Access to credit	0.618	0.303	4.165	0.041	1.855
Cooperative membership	0.524	0.266	3.882	0.049	1.689
Access to climate information	0.712	0.291	5.991	0.014	2.038
Constant	-3.212	1.009	10.148	0.001	-

Note: ** = significant at 5% level; ns = not significant. Source: Field survey, 2024.

CONCLUSION AND RECOMMENDATIONS

The study concludes that cassava farmers in the area are actively engaging with climate-smart agriculture (CSA) practices, with adoption levels ranging from moderate to high. The uptake of practices such as improved cassava varieties, intercropping, and organic manure application has not only enhanced productivity but also strengthened

resilience by improving farmers' capacity to adapt, sustain yields, and recover from climate-related shocks. The findings further revealed that socioeconomic characteristics, particularly education, farm size, access to extension services, access to credit, cooperative membership, and access to climate information, play a critical role in shaping adoption decisions. This underscores the importance of strengthening institutional support systems, improving farmers' knowledge base, and enhancing access to productive resources to foster broader and sustained CSA adoption.

Based on the results from the research, the following are recommended:

1. Strengthen farmers' access to extension services for effective dissemination of CSA knowledge and practices.
2. Improve access to timely and reliable climate information to guide farm-level decisions.
3. Expand credit facilities tailored to smallholder farmers to enhance their capacity to adopt CSA technologies.
4. Encourage farmers' participation in cooperatives and other farmer groups to foster knowledge sharing and collective action.
5. Design and implement targeted training programmes for farmers with lower education levels to build their capacity for CSA adoption.
6. Prioritise farmers with smaller farm sizes in intervention programmes to promote inclusive and equitable adoption of CSA practices.

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