

ADOPTION OF CLIMATE-SMART AGRICULTURE AND ITS EFFECT ON FOOD CROP PRODUCTION AND NUTRITION SECURITY: MICROECONOMIC-LEVEL EVIDENCE FROM FARMING HOUSEHOLDS IN SOUTHWEST NIGERIA

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ABSTRACT: The impacts of climate change on agricultural productivity and food nutrition security in Nigeria and especially for smallholder farming households is a major concern. This study investigates the adoption of Climate-Smart Agricultural (CSA) and their impact on food crop production and nutrition security in Southwest Nigeria. A multistage sampling technique was adopted and 180 farm households were randomly sampled from Ogun, Ekiti and Oyo states. Descriptive statistics and qualitative analysis were used to evaluate the CSA adoption pattern, food security status and barrier to CSA adoption. The findings indicated that there was high awareness about CSA practices

(86.67%) with 74.44% of the respondents implementing at least one of the CSA technologies. Improved crop varieties (88.89%), irrigation/water conservation (76.67%) and crop rotation (74.44%) were the most adopted practices. The outcomes of food and nutrition security were, however, highly vulnerable with 84.44% of the households expressing concern about food availability and 85.56% of households decreasing the size of their meals. Key factors identified as having an impact on adoption were access to finance (58.89%), extension support (52.78%) and access to inputs (43.89%). The poor extension services (83.89%) and high cost (77.78%) and lack of information (74.44%) were the major constraints. The results indicate that awareness of CSA is high, but that CSA adoption alone will not lead to better food and nutrition security unless accompanying efforts are made to tackle structural constraints. Policy recommendations include enhancing extension services, making credit more accessible, and encouraging farmer associations as a means of disseminating CSA. The study adds empirical evidence to support Nigeria's commitments to SDG 2 (Zero Hunger) and SDG 13 (Climate Action).

Keywords: *Climate change; Extremes; Food security; Southwest; Sustainable farming*

1.0 Introduction

Climate change poses new and unprecedented challenges to the agriculture sector all over the world, including irregular rainfall, higher temperatures, longer droughts, and extreme weather conditions (Amare and Balana, 2023). Smallholder farmers in sub-Saharan Africa are largely rain-fed farmers and are not as adaptive as they need to be to mitigate climatic shocks, which disproportionately affect them (Finizola e Silva *et al.*, 2024). Climate change has been cited as the most important factor accounting for the losses in agricultural production in Nigeria, thus increasing food insecurity among households (Omotoso and Omotayo, 2025).

The agricultural sector still plays a significant role in the Nigerian economy, accounting for about 24% of Gross domestic product (National Bureau of Statistics, 2024), and employs majority of the rural population (more than 70%). The sector has a significant contribution to make to jobs, foreign exchange and poverty alleviation. The impacts of climate change on agriculture, however, are large; the risks involved with future climate change have the potential to increase the sector's ability to feed Nigeria's rapidly expanding population of more than 220 million people (Agyekum *et al.*, 2024).

Climate-Smart Agriculture (CSA) has come to the fore as a potential solution for the multifaceted challenges of adapting to climate change, food security and sustainable agriculture development (Lipper *et al.*, 2014). CSA involves practices and technologies that allow for sustainable productivity gains, improve climate and disaster resilience, and minimize greenhouse gas emissions – when feasible. Some of these practices involve better varieties of crops, crop rotation, mulching, agroforestry, organic manure application, irrigation and water conservation (Agyekum *et al.*, 2024).

While the benefits of CSA adoption are promising, a critical gap in understanding is how CSA adoption is related to improved production and food-nutrition security outcomes for smallholder farmers and how adoption process translates into these outcomes, especially in Southwest Nigeria (Finizola e Silva *et al.*, 2024). This has also prevented the development of effective strategies and policies for the promotion of sustainable agriculture and improvement of the nutritional situation of farmers.

This study aims to examine the effects of CSA technology on production and food-nutrition security of smallholder farming households in Southwest Nigeria. The specific objectives are to: (1) determine food productivity among adopters and non-adopters of CSA practices; (2) estimate food-nutrition security status of adopters and non-adopters; (3) determine factors affecting CSA adoption; (4) determine the effects of CSA adoption on food production outcomes; and (5) determine the effects of CSA adoption on household nutrition security.

2. Conceptual and Theoretical Frameworks

2.1 Climate-Smart Agriculture Framework

Food and Agriculture Organization (FAO) introduced the Climate-Smart Agriculture (CSA) concept in 2010 as a strategy to help adapt agriculture in the face of climate change while addressing food security (Lipper *et al.*, 2014). The three pillars of CSA are: (1) agricultural productivity and incomes are increased in a sustainable way; (2) adaptation and building resilience to climate change; and (3) reducing and/or removing greenhouse gas emissions whenever possible.

CSA acknowledges the complexity of agricultural systems and the context-specificity of their nature, hence the need for integrated approaches that tackle several objectives at the

same time. In Nigeria, CSA is practiced at the farm level and involves a variety of technologies and management practices that are appropriate for the agro-ecological conditions (Ojo *et al.*, 2024).

2.2 Adoption Theory

There are multiple factors that interact at various levels that affect the adoption of innovations in agriculture. Rogers' Diffusion of Innovations Theory offers a basic perspective of the diffusion of new technologies in social systems over time (Rogers, 2003). This theory proposes that five factors of innovations – relative advantage, compatibility, complexity, trialability, and observability – shape adoption decisions.

Empirical evidence from Africa indicates that personal characteristics (age, gender, education), farming-related factors (farm size, farming experience), financial factors (income, access to credit), environmental conditions and informational factors (extension contact, awareness) are all important determinants of CSA adoption decisions (Finizola e Silva *et al.*, 2024; Agyekum *et al.*, 2024).

2.3 Food and Nutrition Security Framework

Food Security is the state in which everyone, at all times has access to an adequate, safe, nutritious and culturally appropriate food supply to support a healthy, active life (FAO, 2009). The concept includes four components: availability, access, use and stability. Nutrition security includes the ability to meet the nutritional needs and the absence of malnutrition in all its forms.

Adoption of CSA influences food-nutrition security through various pathways such as improved agricultural productivity, diversified production systems, improved household income, and enhanced resilience to climate shocks (Agyekum *et al.*, 2024). These pathways are not inevitable, however, and rely on the levels and mix of CSA practices implemented, and on the wider socio-economic and institutional setting.

3.0 Methodology

3.1 Study Area

The study was carried out in Southwest Nigeria which is one of the six geopolitical zones of Nigeria. The zone is made up of 6 states, which include Ekiti State, Lagos State, Ogun

state, Ondo State, Osun state and Oyo state. The tropical climate of southwest Nigeria is a feature of this region which sees a marked wet and dry period, with the growing of a great variety of foodstuffs such as maize, cassava, yam, rice and other common vegetables. The smallholder-based farming system is the mainstay of agriculture in the area, with the size of farm holding averaging between 1 and 12 hectares (Omotoso and Omotayo, 2025).

The selection of the three States (Ogun, Ekiti and Oyo States) for this study was purposive being a State of prominence in small-scale farming and food crop production. These States illustrate the spread of agricultural practices across the region ranging from forest to derived savanna in Ogun, Oyo and Ekiti respectively.

3.2 Sampling Technique and Sample Size:

The sampling of the farming households was a multistage sampling. In the first stage, 50% of the small scale farm areas/food crop producing states in Southwest Nigeria were randomly selected which included Ogun, Ekiti and Oyo states. In the second stage, 600 samples were drawn from each state, to represent five States, giving a total of 50% Agricultural Development Programme (ADP) areas. In the third stage, two extension blocks were chosen randomly from each of the 4 ADPs which amounted to 12 extension blocks. Four hundred and twenty cells were used in the fourth stage (2 cells from each block). Then 30 households were sampled from each cell and a total of 720 farming households were sampled. For this preliminary analysis, data from 180 respondents were analyzed.

3.3 Data Collection

Both quantitative and qualitative methods were used to collect data. A structured interview guide was developed to gather data on socio-economic characteristics of respondents, adoption of CSA practices, food production and productivity, food and nutrition security status and constraints to the adoption of CSA. Qualitative data on local climate change and CSA practices were gathered through key informant interviews.

3.4 Data Analysis

Descriptive data were analyzed such as frequencies, percentages, and means. Household dietary diversity scores (HDDS) and household food insecurity access scores (HFIAS)

were used to assess food-nutrition security. The analysis concentrated on comparing the key indicators of food production and food security outcomes of the CSA adopters and non-adopters.

4.0 Results and Discussion

4.1 Socioeconomic Characteristics of Respondents

The socioeconomic characteristics of the farming households are presented in Table 1. The results show that majority of respondents were males (67.22%), while females constituted 32.78%. This gender disparity in agricultural participation reflects broader patterns in Nigeria, where men typically have greater access to land and agricultural resources. Finizola e Silva *et al.*, (2024) found that gender is one of the personal and socioeconomic characteristics associated with farmers' adoption decisions, with female-headed households often facing additional constraints in accessing information and productive resources.

The age distribution revealed that 41.11% of respondents were in the 30-39 age category, 26.67% were 40-49, 6.67% were 50-59, 18.33% were 60-69, and 7.22% were 70-79. The predominance of younger and middle-aged farmers suggests a relatively active agricultural labor force in the study area. Agyekum *et al.*, (2024) identified age as a significant socioeconomic factor influencing CSA adoption in West Africa, with younger farmers generally more receptive to new technologies.

Marital status distribution showed that 50.56% of respondents were single, 23.89% were married, and 25.56% were divorced. The relatively high proportion of single respondents indicates that many farmers may be operating with household structures different from those of married farmers, which could affect labor availability and food security outcomes.

Educational attainment varied among respondents, with 35.00% having no formal education, 25.00% having attended primary education, 13.33% having attended secondary education, and 26.67% having attended tertiary education. While a substantial proportion had some form of formal education, more than one-third had no formal education. Finizola e Silva *et al.*, (2024) found that educational level is among the factors positively affecting CSA adoption by African smallholders, as education enhances farmers' ability to access and process technical information.

Farm size distribution showed that 15.56% of respondents had farms of 1-4 hectares, 61.11% had 5-8 hectares, and 23.33% had 9-12 hectares. The concentration in the middle farm-size category suggests that most respondents were smallholder farmers with moderate landholdings. Farming experience followed a similar pattern, with 25.56% having 1-5 years of experience, 61.11% having 6-10 years, and 13.33% having 11-15 years.

Annual income distribution revealed that 67.78% of respondents earned between ₦500,000 and ₦1,000,000, 20.00% earned between ₦1,500,000 and ₦2,000,000, 5.00% earned between ₦2,500,000 and ₦3,000,000, and 7.22% earned between ₦3,500,000 and ₦4,000,000. The concentration in the lowest income category indicates that most respondents were operating within limited financial means, which has implications for their capacity to invest in CSA technologies. Finizola e Silva *et al.*, (2024) categorized financial factors as one of the main groups affecting CSA decisions in Africa. Extension contact was reported by 48.33% of respondents, while 51.67% had no extension contact. This finding is significant because extension agents serve as one of the main sources of knowledge and support regarding sustainable agriculture techniques for farmers. Agyekum *et al.*, (2024) found agricultural extension services to be an important predictor of CSA adoption in West Africa.

Table 1: Socio-economic characteristics of Farming households (n=180)

Variables	Frequency	Percentage (%)
Gender		
Male	121	67.22
Female	59	32.78
Age		
30-39	74	41.11
40-49	48	26.67
50-59	12	6.67
60-69	33	18.33
70-79	13	7.22
Marital Status		
Single	91	50.56
Married	43	23.89

Divorced	46	25.56
Educational level		
No formal education	63	35.00
Primary	45	25.00
Secondary	24	13.33
Tertiary	48	26.67
Farm Size		
1-4	28	15.56
5-8	110	61.11
9-12	42	23.33
Farm experience		
1-5	46	25.56
6-10	110	61.11
11-15	24	13.33
Annual Income		
500000-1000000	122	67.78
1500000-2000000	36	20.00
2500000-3000000	9	5.00
3500000-4000000	13	
Extension service		
Yes	87	48.33
No	93	51.67
Farmer Association		
Yes	150	83.33
No	30	16.67

4.2 Awareness and Adoption of Climate-Smart Agricultural Technology

Table 2 presents the awareness and adoption of CSA practices among respondents. The results revealed that 86.67% were aware of CSA practices, while 13.33% were not aware. The high level of awareness indicates good exposure to CSA principles and techniques among farmers in the study region. The study also showed that 74.44% of respondents

used at least one CSA technology, whereas 25.56% did not. This finding suggests that while awareness is high, there remains a gap between awareness and adoption, as some farmers familiar with CSA practices do not apply them practically. Finizola e Silva *et al.*, (2024) noted that CSA adoption in Africa is affected by several interacting factors, including personal, farm-related, financial, environmental, and informational conditions, indicating that awareness alone is insufficient for mass acceptance.

Among specific CSA practices, improved crop varieties had the highest level of adoption, with 88.89% of respondents reporting their use. This may be attributed to the direct benefits of improved varieties for farmers, including better adaptation to climatic conditions and higher yield potential. Crop rotation was adopted by 74.44%, while irrigation/water conservation was reported by 76.67%. These practices are particularly important for climate change adaptation, as crop rotation contributes to soil health and agricultural production management, while water conservation helps farmers cope with erratic rainfall and drought stress. Mulching was adopted by 54.44%, organic manure application by 51.11%, and agroforestry by 69.44%. The findings indicate that CSA implementation typically involves multiple practices rather than a single technology. This is consistent with Agyekum *et al.*, (2024), whose systematic review showed that farmers commonly combine different CSA practices. Extension programs should therefore promote CSA as a package of complementary activities rather than individual technologies. Extension agents were identified as the major source of CSA information, with 67.78% of respondents reporting them as a source. This demonstrates that agricultural extension remains relevant for disseminating technical knowledge among farmers. Extensionist are needed to demonstrate and explain these techniques so that farmers know which practices to adopt and when to apply them. Farmer groups were reported as a source by 31.67%, while radio/TV and other farmers were reported by 15.56% and 14.44%, respectively.

Table 2: Awareness and Adoption of Climate-Smart Agricultural Technology

Variables	Yes (%)	No (%)
Are you aware of Climate-smart Agricultural (CSA) practices?	156 (86.67)	24 (13.33)
Do you practice any CSA technology	134 (74.44)	46 (25.56)
Which CSA practices do you use?		

Improved crop varieties	160 (88.89)	20 (11.11)
Crop rotation	134 (74.44)	46 (25.56)
Mulching	98 (54.44)	82 (45.56)
Organic manure application	92 (51.11)	88 (48.89)
Irrigation/water conversation	138 (76.67)	42 (23.33)
Agroforestry	125 (69.44)	55(30.56)
Source of CSA information		
Extension agents	122 (67.78)	55 (30.56)
Farmer groups	57 (31.67)	123 (68.33)
Radio/TV	28 (15.56)	152 (84.44)
Other farmers	26 (14.44)	154 (85.56)

4.3 Food Production and Productivity

Table 3 presents the perceived benefits of CSA to food production and productivity. The results revealed that only 17.78% of respondents reported increased yield, while 82.22% did not perceive any yield increase. Similarly, 27.22% reported reduced production costs, 13.33% reported improved soil fertility, and 22.78% reported reduced climate risks. These findings indicate that most respondents did not perceive significant benefits of CSA in these areas.

The low levels of reported benefits may be significant, given that CSA would be expected to increase crop yields and enhance adaptability to climatic changes. However, this does not necessarily imply that CSA is ineffective; rather, it may reflect the fact that benefits from CSA depend on the intensity, duration, and combination of practices adopted. Agyekum *et al.*, (2024) reported that farmers using CSA practices across West Africa experienced benefits including improved soil fertility, higher yields, improved household income, climate resilience, and food security. Nevertheless, these advantages are affected by technical capacity, availability of funds, access to inputs, and extension support.

Table 3: Food Production and Productivity

Benefits	Yes (%)	No (%)
Increased yield	32 (17.78)	148 (82.22)
Reduced production cost	49 (27.22)	131 (72.78)
Improved soil fertility	24 (13.33)	156 (86.67)
Reduced climate risks	41 (22.78)	139 (77.22)

4.4 Food and Nutrition Security Status

Table 4 presents the food and nutrition security status of respondents. The results showed high levels of vulnerability among surveyed households. Only 18.89% of respondents reported eating three meals per day, while 44.44% ate one meal and 24.44% ate two meals daily. Although meal frequency is not a complete indicator of food security, the high number of people reporting one or two meals may indicate limitations to household food access.

Food access outcomes provided further evidence of food insecurity. About 84.44% of respondents reported worrying about food availability during the previous 12 months. Additionally, 85.56% reported reducing meal size, 82.22% reduced the number of meals, and 72.78% were unable to eat preferred foods. These results indicate problems with both the quantity and quality of food available to households.

The food group results showed that cereals and animal products were each reported by 86.67% of respondents, legumes by 77.22%, fruits by 51.11%, and vegetables by only 31.67%. The low percentage reporting vegetable intake may indicate low dietary diversity. However, since the data only record consumption of food groups and not amounts and frequencies, conclusions regarding nutritional adequacy must be drawn with caution.

These findings are relevant to CSA because climate change may impact household food security by reducing crop yields, increasing production costs, causing water shortages, and increasing risks of crop failure. Agyekum *et al.*, (2024) noted that CSA has the potential to improve food security, but its benefits depend on farmers' capacity to overcome constraints such as inadequate finance, information, extension, and productive inputs.

Table 4: Food and Nutrition Security Status

Variables	Frequency (%)	Percentage (%)
Number of meals consumed daily		
One	80	44.44
Two	44	24.44
Three	34	18.89
More than three	22	12.22
During the Last 12 months, did your household experience		
Worried about food availability		
Yes	152	84.44
No	28	15.56
Reduced meal size		
Yes	154	85.56
No	26	14.44
Reduced number of meals		
Yes	148	82.22
No	32	17.78
Unable to eat preferred foods		
Yes	131	72.78
No	49	27.22
Food group		
Cereals	156	86.67
Legumes	139	77.22
Vegetables	57	31.67
Fruits	92	51.11
Animal products	156	86.67

4.5 Impact of CSA on Household Food and Nutrition Security

Table 5 presents findings on the perceived impact of CSA on household food and nutrition security. The results are varied regarding the contribution of CSA to household food and

nutrition security. For the statement that CSA increased food availability, 30.56% selected the undecided category, 33.33% disagreed, and 36.11% strongly disagreed. The lack of responses in the "yes" and "strongly agree" categories suggests that respondents did not feel that CSA had significantly increased their access to food. Similarly, the outcome regarding improvement of household income was unfavorable. Only 8.33% were undecided, 22.78% disagreed, and 68.89% strongly disagreed that CSA had increased their family's earnings. This may be related to the economic and infrastructural limitations mentioned earlier. Agyekum *et al.*, (2024) found that although CSA can improve household income, inadequate finance, high implementation costs, lack of inputs, and limited institutional support can restrict the realization of these benefits.

In contrast, respondents had a somewhat better impression of food quality improvement. About 63.33% were undecided, 20.56% disagreed, and 16.11% strongly disagreed that CSA improved food quality. Although there is no strong positive correlation, this does show less negative sentiment compared to household income. The result regarding reduction in food shortages showed that 45.56% were undecided, 33.33% disagreed, and 21.11% strongly disagreed that CSA reduced food shortages. This indicates that respondents did not strongly link CSA usage to reduced food scarcity at home. This finding contrasts with the broader evidence reviewed by Agyekum *et al.*, (2024), which suggests that CSA adoption can contribute to improved food security in West Africa. The discrepancy could be due to the specific CSA practices used, the degree of implementation, limitations faced during implementation, and socioeconomic factors affecting households. Overall, although there is a high level of CSA usage among respondents, there are no perceived improvements in their access to food and nutrition security. This is significant as it shows that adoption rates alone are not sufficient to measure success for a CSA program

Table 5: Impact of CSA on Household Food and Nutrition Security

Statement	SA (%)	A (%)	U (%)	D (%)	SD (%)
CSA increased food availability	-	-	55(30.56)	60 (33.33)	65 (36.11)
CSA improved household income	-	-	15 (8.33)	41 (22.78)	124 (68.89)
CSA improved food quality	-	-	114 (63.33)	37 (20.56)	29 (16.11)
CSA reduced food shortage	-	-	82 (45.56)	60 (33.33)	38 (21.11)

4.6 Factors Affecting CSA Adoption

Table 6 presents the factors affecting CSA adoption among respondents. Access to finance was identified by 58.89% of respondents as a factor affecting CSA adoption. This result shows that financial resources are important for farmers to use and adopt climate-smart technology. CSA may require investments in better seeds, water supply, organic fertilizers, machinery, and labor. Agyekum *et al.*, (2024) identified access to credit and financial resources as important determinants of CSA adoption across West Africa. Finizola e Silva *et al.*, (2024) similarly classified financial conditions as one of the major categories influencing CSA adoption among African smallholder farmers. The cost of technology was identified by 38.33% of respondents, while 29.44% were undecided, and 32.22% indicated that it was not a factor. This shows that cost is an important but not necessarily all-encompassing factor for CSA uptake. High labor and technology costs have been identified as barriers to CSA adoption in West Africa (Agyekum *et al.*, 2024).

Extension support was identified by 52.78% of respondents as an important factor. This result is consistent with the finding that extension agents were the primary source of information on CSA for this study. Thus, extension services have a dual function: to disseminate information and promote adoption. Ojo *et al.*, (2024) emphasized that extension agents are critical to CSA dissemination in Nigeria, although constraints affecting their effectiveness need to be addressed. Availability of inputs was identified by 43.89% of respondents. This result shows that farmers may not be able to apply CSA knowledge if there is a lack of necessary resources and access to them. Agyekum *et al.*, (2024) similarly identified limited access to productive farm inputs as one of the barriers to CSA adoption in West Africa.

Government support was identified by only 7.78% of respondents, while 69.44% said it was not a factor. This implies that respondents did not view direct government support as an important factor influencing their decision to adopt CSA. However, government policies may affect adoption indirectly through extension services, credit facilities, availability of inputs, infrastructure development, and climate data. Therefore, low direct response is not a sign that government policies are generally insignificant. Awareness of CSA benefits was identified as a factor by 26.11%, while 47.22% indicated that it was not a factor. This is consistent with the relatively high level of CSA awareness found in this study. It implies

that the main problems may have moved from awareness to practicalities needed for implementation, especially finance, extension support, and availability of inputs.

Table 6: Factors Affecting CSA Adoption

Factor	Yes (%)	Undecided (%)	No (%)
Access to finance	106 (58.89)	41 (22.78)	33 (18.33)
Cost of technology	69 (38.33)	53 (29.44)	58 (32.22)
Extension support	95 (52.78)	53 (29.44)	32 (17.78)
Availability of inputs	79 (43.89)	54 (30.00)	47 (26.11)
Government support	14 (7.78)	41 (22.78)	125 (69.44)
Awareness of CSA benefits	47 (26.11)	48 (26.67)	85 (47.22)

4.7 Major Constraints to CSA Adoption

Table 7 presents the major constraints to CSA adoption. Poor extension services were the most common constraint, with 83.89% of respondents identifying it as a problem. This is significant since extension agents were found to be one of the primary sources of CSA information. Thus, although farmers rely heavily on extension services for information about CSA, the service system may not be adequate or accessible enough for them. Ojo *et al.*, (2024) identified several constraints limiting the effectiveness of extension agents in disseminating CSA practices among Nigerian farmers. The second most frequently reported constraint was high cost, with 77.78% of respondents identifying it. This shows that financial barriers remain a major obstacle to CSA implementation. Farmers may not have enough money for better seeds, water supply systems, machinery, and labor needed to implement some climate-smart agricultural techniques. This finding is consistent with Agyekum *et al.*, (2024), whose systematic review found high labor costs, lack of credit, and inadequate financial support as major barriers to CSA adoption in West Africa.

Lack of information was reported by 74.44% of respondents. Interestingly, this coexists with the high awareness rate of 86.67%. This paradox can be explained as the difference between general knowledge and specific technical details. Farmers may know about CSA but may not know how to implement it properly. Agyekum *et al.*, (2024) identified limited information about CSA options as a significant barrier and recommended more practical training to improve farmers' understanding of CSA practices. Inadequate inputs were

reported by 67.22% of respondents. This result shows that knowledge and willingness to adopt CSA may not translate into practice where farmers cannot access appropriate inputs. Agyekum *et al.*, (2024) similarly identified limited access to productive farm inputs as a major constraint to CSA adoption across West Africa.

Lack of finance was reported by 49.44% of respondents. Although lower than the proportions reporting poor extension services, high cost, lack of information, and inadequate inputs, almost half of the respondents still considered it a constraint. This shows the importance of financing capacity in affecting adoption. Finizola e Silva *et al.*, (2024) identified financial conditions as one of the major categories influencing CSA adoption across Africa. These results indicate the need for integrated approaches to promote CSA usage. Extension services for agriculture must be improved through regular farmer education programs, field visits, and better communication between farmers and extensionist. Affordable access to credit is needed, and the availability and cost-effectiveness of appropriate CSA inputs must also increase. Farmer associations, which have an already high membership rate of 83.33% in this study, could be important platforms for delivering training, facilitating access to inputs, and promoting collective action. Evidence from Southeast Nigeria supports this approach, showing that cooperative membership, extension exposure, credit access, and targeted farmer education are important for CSA adoption (Ojo *et al.*, 2024).

Table 7: Major Constraints to CSA Adoption

Constraints	Yes (%)	No (%)
Lack of finance	89 (49.44)	91 (50.56)
High cost	140 (77.78)	40 (22.22)
Lack of information	134 (74.44)	46 (25.56)
Poor extension services	151 (83.89)	29 (16.11)
Inadequate inputs	121 (67.22)	59 (32.78)

5.0 Conclusion and Policy Recommendations

5.1 Conclusion

This study involved the assessment of the adoption of the Climate-Smart Agricultural practices and its impacts on food crop production and nutrition security of farming

households in Southwest Nigeria. The results indicate a complex situation of high awareness and moderate adoption of CSA practices, but high levels of food and nutrition insecurities among farming households.

The study results indicated that 86.67% of the respondents reported knowledge of CSA practices, 74.44% food and nutrition security outcomes, however, were not good. More than 84% of households feared that they would not be able to eat enough food, and over 85% said they had to cut down on the size of their meals. The overall perception of the reduction in food availability, increase in household income and food shortages due to CSA was negative, implying that the adoption of CSA is not sufficient to ensure that food and nutrition security outcomes are improved.

Access to finance (58.89%), extension support (52.78%) and inputs (43.89%) were the key factors influencing CSA adoption. The main factors that hindered adoption were poor extension service (83.89%), high cost (77.78%), lack of information (74.44%) and lack of inputs (67.22%). The results emphasize the importance of combined approaches and solutions to address technical and structural barriers to CSA adoption.

The study provides empirical micro-economic based evidence of the linkage between the adoption of CSA and food-nutrition security in Southwest Nigeria. The conclusions are consistent with the Nigeria's SDG 2 (Zero Hunger) and SDG 13 (Climate Action) targets and suggest how resilience of smallholder farming households can be improved to positively affect the nutrition outcomes.

5.2 Policy Recommendations

The following policy recommendations are suggested based on the findings:

1. Poor extension services was the most common constraint (83.89%) and extension agents were the main source of CSA information (67.78%), hence, there is a need to strengthen extension services in terms of capacity, outreach, and effectiveness. This should involve regular training sessions for extension agents, provision of communication and transportation facilities, and the incorporation of demonstration into extension activities.

2. Access to credit and finance services is affected by adoption (58.89%) and lack of finance as a constraint (49.44%) and policies should increase rural credit facilities, develop customized financial services for smallholder farmers and facilitate the linkages between farmer associations and financial institutions.
3. Improve the Availability and Affordability of CSA Inputs: The results revealed that lack of inputs (67.22%) and high prices (77.78%) are factors that limit adoption, which points to interventions needed to improve the availability and affordability of CSA inputs such as better seeds, organic fertilizers, and water-saving technologies. Smallholder farmers might lower the cost burden if there were subsidy programs for their benefit.
4. Use farmer associations as a platform for dissemination of CSA messages: 83.33% of the respondents were members of farmer associations, which can be a good platform for providing training, accessing inputs and for collective action. Policies need to encourage the development of farmer associations and farmer cooperatives as means to promote CSA.
5. The paradox of high awareness (86.67%) and high reported lack of information (74.44%) suggests that further efforts are needed to provide more in-depth and hands-on practical training rather than awareness alone, to develop technical skills. Farmer field schools and demonstration plots should be scale up.
6. Promote Integrated CSA Packages: Farmers adopt several CSA practices and not single technologies, therefore, extension programmes should promote CSA as 'packages' of complementary packages of practices depending on agro-ecological conditions.
7. Address Gender and Social Inclusion: As women make up only 32.78% of the respondents, policies must take a specific approach to address the problems faced by women farmers in accessing information, inputs and credit in CSAs.
8. Monitor and Evaluate CSA Impacts: Not every CSA is able to provide food and nutrition security, and systematic monitoring and evaluation of CSA programmes is required to better understand what works, for whom, and under which conditions.

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