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RESEARCH ARTICLE OPEN ACCESS

EFFECT OF CLIMATE SMART AGRICULTURE ON FOOD SECURITY OF FARMING HOUSEHOLDS IN DELTA STATE NIGERIA

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ABSTRACT

The effects of climatic change on crop production and food security have resulted in the demand for an intentional shift in farming system. It therefore becomes imperative to improve on farming practices through the use of climate-smart agriculture especially in Nigeria where majority of citizens rely on agriculture for their livelihood. Climate-smart agriculture practices suggest effective ways and strategies to achieve soil moisture conversation, enhance soil fertility, stabilise crop yields and livelihoods as well as achieve food security for the nation. This study, therefore, investigated the effect of climate-smart agriculture on food security of farming households in Delta state, Nigeria. A multistage sampling procedure was used to obtain data from 276 farmers with a structured questionnaire for the study. Climate-smart agriculture practices were measured using CSA index, while food security was measured using 3-dimensions on food availability, accessibility, and affordability. Descriptive statistics and semi-logarithm regression were used as the estimation technique. The results showed that the extent of adoption of CSA practices in the study area was quite low and often on a small scale while farmers mostly adopted intercropping. Also, the findings on the effect of CSA practices varied with each dimension of food security. It was therefore recommended that farmers should be provided awareness on the importance of CSA and given technical assistance and support to transit to the effective farming strategy.

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INTRODUCTION

The importance of achieving and ensuring food security has received a number of recognitions in order to promote sustainable agricultural practices and ensure economic stability (Akinyetun, 2018; Ayinde, Otekunrin, Akinbode & Otekunrin, 2020; Pawlak & Kolodziejczak, 2020). Food security is said to exist when people everywhere, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food choices to stay healthy and well-nourished (Food and Agriculture Organisation - FAO, 2007). The United Nation's Committee on World Food Security (2021) defined Food Security as "having access to the adequate kind of food you like, yet need to stay active and live healthy". Therefore, it serves as the umbrella encompassing appropriate feeding, increased nutrition and healthy lifestyles for all ages at all times. Existing studies have revealed that droughts, floods, rising temperature, heat waves and extreme rainfall have affected the extent of productivity of farmers and contributed to food insecurity in different regions (Ali, Ejiofor, Ifeanyieze, Okadi, Eze, Eze, Onah, Nwakile, Ugwuoke, Mgbenka, Onah, Nwachukwu, Ezebuiro, Omeje, Ekenta& Ogbonna, 2020; Intergovernmental Panel on Climate Change - IPCC, 2018; Etimand Ndaeyo, 2020; Onyeneke, 2019; Onyekwe, Osuafor & Onwuemelie, 2021).

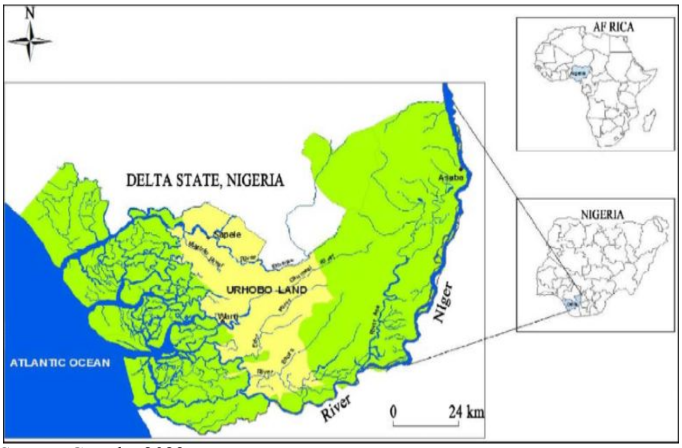
However, some studies have shown that these problems can be improved by implementing climate-smart agricultural (CSA) practices (IPCC, 2018; Olorunfemi, Olorunfemi& Oladele, 2020; Tesfaye, Blalock &Tirivayi, 2021; Waaswa, Kurunwa, Anthony & Joel, 2021). CSA Practices has been seen as an integrated approach adapted by farmers to reduce their vulnerability to climate-related challenges. In line with enhancing agricultural productivity and resilience against climate change challenges, the Nigerian government implemented the National Agricultural Technology and Innovation Policy (NATIP) 2022 – 2027. The policy though its 6-year plan, is adopted to lay a solid foundation for modernising the Nigeria'sagricultural sector and promoting agricultural value chains and investments. It focused on digital and climate-smart agriculture to make farming more sustainable and resilient to climate change. An examination of the techniques adopted for CSA practices include: Organic farming practices such as crop rotation, mulching, cover cropping and composting (Olorunfemi Olorunfemi & Oladele, 2020; Saadu, Ibrahim, Nazifi & Akinyemi, 2024); Conservation agriculture such as minimum tillage, crop diversification, soil cover (Bazzana, Foltz & Zhang, 2021); Agroforestry (Branca, Tennigkeit, Mann & Lipper, 2012; Ogbodo,Waige, Shuaibu, Dube & Anarah, 2019); Sustainable Water Management (Bazzana*et al.,* 2021; Branca, Tennigkeit, Mann & Lipper, 2012) among others.These practices have mitigated the effects of climate aberration by improving the quality of the soil, air, water and the overall landscape for farming. These techniques serve as a way of incorporating the specificities of adaptation and mitigation into policies and programmes (Babatunde, 2017). The level of adoption of CSA practices differsacross countries, regions, locations (rural / urban), farm-holders (small, medium, large) as well as size of farm plots. While most previous studies have considered CSA practices among small farm-holders, there are still limited studies on medium and large farm-holders. Existing studies have shown different results on the level of adoption of CSA across different localities. Specifically, findings from the research of Zakaria, Azumah, Appiah-Twumasi & Dagunga, (2020) revealed that smallholder farmers have low adoption of the practice in Zabzugu and South Tongu Districts of Ghana. Similarly, Oyawole, Dipeolu, Shittu, Obayelu & Fabunmi (2020) discovered the low adoption rate of CSA among maize farmers from Northern Nigeria as well as the work of Mutengwa, Mnkeni & Kondwakwenda (2023) among smallholder farmers in Southern Africa. Some factors influencing to the low adoption of CSA practices are: costs and constraints of such measures (Mutengwa, Mnkeni & Kondwakwenda, 2023), lack of access to resources (Mutengwa, Mnkeni & Kondwakwenda, 2023); better coordination and inclusiveness among stakeholders and less reliance on donor aid (Atta-Aidoo & Antwi-Agyei, 2025; Onyeneke, 2019; Mutengwa, Mnkeni & Kondwakwenda, 2023); Social pressure (Aidoo, Antwi-Agyei, Dougill, Ogbanje, Akoto-Danso& Eze 2022). Factors contributing to the increased adoption of CSA include education (Adebisi, Adebisi, Oludare & Odum, 2022; Etim & Ndaeyo, 2020); family size and farm income (Adebisi et al., 2022); access to information on climate change (Saadu, Ibrahim, Nazifi& Akinyemi, 2024); access to extension visits (Wakweya, 2023; World Bank, 2016) among others. Further studies have shown that adoption of CSA practices resulted into increased outputs and income for farmers in the long run (Etim & Ndaeyo, 2020; FAO, 2014; Onoja, Agbomedarho, Etela & Ajie, 2019; Tabe-Ojong, Aihounton & Lokossou, 2023; World Bank, 2016). Additionally, agroforestry have been found to influence food security in Nigeria (Oyawole*et al.,* 2020); hence, adoption of CSA practices is expected to have greater influence on the achievement of the global Sustainable Development Goals (SDGs), specifically SDG 1 (No-poverty), SDG 2 (Zero hunger), SDG 3 (Good Health and Well-being) and SDG 13 (Climate action).

While numerous studies have explored CSA adoption across Africa, limited empirical evidence exists on its effects and implementation in Delta State, Nigeria. The choice of the State is because it is known to be characterised by dominant crop farming and also vulnerable to climate related shocks. This study addressed this gap by focusing on the extent of adoption of CSA practices among small, medium and large-scale farm-holders in Delta State. Additionally, this study, investigated the effect of CSA on food security of farming households in Delta State, Nigeria. The study used a multistage sampling procedure to obtain data from 276 crop farmers with a structured questionnaire. The study was restricted to crop farmers. The study contributed to the literature by considering a multi-dimensional measures to food security. The study therefore seeks to:

(i) Assess the extent of adoption of CSA practices among farming households in Delta State, Nigeria
(ii) Analyse the effect of CSA practices on the food security of farming households in Delta State, Nigeria

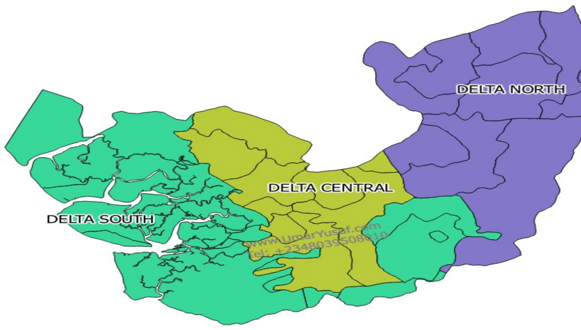
MATERIALS AND METHODS

Study area: This study was conducted in Delta State, located in the South-South geo-political zone of Nigeria. Delta State lies between latitude 5º00´and 6º45´ N and longitude 5º00´ and 6º30´ E. It shares boundaries with Edo State to the North, Anambra and Rivers States to the East and Bayelsa State to the South-East. The State covers a total land area of 16,842 km^2. It also experienced a humid tropical climate, characterised by high temperature and significant rainfall through out the year. The annual mean temperature ranges between 25^{0}C and 32^{0}C while annual precipitation varies from 1,900mm to 2,700mm depending on the location. Inspite of the oil industry being quite dominant in the State, agriculture remains a dominant economic activity in Delta State, with crop farming, fishing and oil palm production being widely practised. The State is known for cultivating cassava, yam, maize, rice, plantain and palm oil which serve both subsistence and commercial purposes (Ofuoku & Okompu, 2020). This study focused on crop farming households that could make use of climate-smart agricultural practices.



Source: Google, 2023

Figure 1. Map of Delta state



Source: Google, 2023

Figure 2. Map of the three Agricultural zones in Delta state

Sampling procedure: A multi-stage sampling procedure was used in the selection of respondents. In the first stage, an agrarian State was purposively selected from the South-South region of Nigeria. The second stage involves the purposive selection of three (3) agricultural zones because of its agricultural strata. The third stage was selection of each stratified agricultural zone whereby one (1) Local Government Area was selected with a purposive sampling. The selected LGAs were based on their agrarian activities, making the total selected LGAs equals 3. In the fourth stage, 4 agricultural villages were then selected randomly from the 3 sampled LGAs to give a total of 12 agricultural villages. Lastly, in the fifth stage, 25 farmers were randomly selected across the 12 agricultural communities. Thus, a total number of 300 respondents was selected as the sample size; however, the total number of respondents' questionnaire retrieved were from 276 crop farmers. Table 1 depicts the sample distribution of the respondents by the selected local government areas.

Table 1. Sample distribution

Selected Local Government Areas	Frequency	Percentage (%)
Isoko North	102	37.0%
Ndokwa West	102	37.0%
Warri South	72	26.0%
Total	276	100.0

Source: SPSS Output and Authors' Compilation; Researcher, 2023

***Analytical techniques*:** Descriptive statistics including frequencies, percentages and means were used to profile the demographic characteristics of respondents and the extent of CSA practices adopted by farming households in the study area. Also, regression analysis was used to analyse the objective that focused on effect of CSA on food security of farming households. The analysis provided a better fit by stabilizing variance across different ranges of the independent variables and captures the underlying pattern more accurately.

The regression equations were specified explicitly following the Ordinary Least Square (OLS) approach. The regression models were stated as follows in equation 1 and 2:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \mu \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . eqn. 1$$

The model in equation 1 is transformed to a semi-log expression by taking the natural logarithm of the dependent variable while leaving the independent variables unchanged. Hence, equation 2 can be expressed as:

$$LogY_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \mu \quad \ldots\ldots\ldots\ldots\ldots\ldots . eqn. 2$$

where Y_i is the dependent variable, which is Food Security; X_1 = gender of farming household head (1=male; 0 = female); X_2 = age of farming household head (years); X_3 = household size; X_4= household monthly income (₦); X_5 = Membership of association (1=member; 0=non-member); X_6= farm size (hectares); X_7 = farming experience (years); X_8 = number of crops cultivated; X_9 = extension contacts (1=Yes; 0=No); X_{10} = distance of farm from home (km); X_{11}= Use of CSA practices (2=Small; 1=medium; 0=large); β_0 = Constant term; $\beta_1 - \beta_{11}$ = Intercept for the independent variables; μ = Error term.

Variables Description: The model depicted in equation 1 and 2 showed the variables used to examine the effect of CSA on food security in the study area. The adoption of CSA was measured using similar parameter as in Adebisi et al. (2022); Respondents were asked if they 'frequently use', 'occasionally use', 'rarely use' and 'do not use' several CSA practices such as: intercropping, mulching, crop rotation, planting of improved varieties, mono cropping, agroforestry, mixed cropping, row planting, minimum tillage. Each of the four-point likert scale are then used to generate the use of CSA index as described in equation 3.

$$Adoption\ of\ \ CSA\ Index_i = \frac{[(N_1 \times 3) + (N_2 \times 2) + (N_3 \times 1) + (N_4 \times 0)]}{M}$$
- eqn. 3

where:
N_1 = Number of farming households that frequently use a CSA practice
N_2 = Number of farming households that occasionally use a CSA practice
N_3 = Number of farming households that rarely use a CSA practice
N_4 = Number of farming households that did not use a CSA practice
M = Total number of respondents (n) x 3

The adoption of CSA was later grouped based on the criteria low, moderate and high to reveal the level of its adoption. Food security, the dependent variable, was measured using 3-dimensions which are: food availability, accessibility and affordability. Each of these dimensions was treated as a separate dependent variable in this study. This multi-dimensional approach is supported by previous studies (Bashir & Schilizzi, 2013; Mashi, Inkani & Oghenejabor, 2022; Onyekwe, Osuafor & Onwuemelie, 2021) which emphasised the need for a holistic understanding of food security. Food availability was assessed through questions on input availability (seeds, fertiliser, irrigation water); farming system types (traditional versus diversified farming practices); and access to farm credit. Food accessibility was captured by questions related to household income, access to market and the ease of accessing food outlets. Food affordability is particularly a critical factor in the Nigerian content. It was assessed based on the monthly food expenditure as cost often determines food purchase for many households. While existing studies might have incorporated food utilization and food stability, these indicators were excluded in this study due to the need for clinical testing, which is not the focus of this study.

RESULTS

Demographic Characteristics of the Respondents

The results in Table 2 revealed that women were mostly involved in crop farming than men as more than half (54.7%) of the respondents were female. In respect to religion, majority of the respondents (91.7%) were Christians. This indicates that farming in the study area was dominated by Christians. A total of 79.6% of the farmers had secondary and post-secondary education. This suggests that the population has relatively moderate level of education attainment. The average household size of farmers was 5 members which is an indication the farming household is fairly large and could enhance the farming activities. The average age of the farmers was about 48 years. This indicates that most farmers were economically active. However, youth were not actively involved, with about 7% of the respondents within the age range of 30 and below. Furthermore, the farming experience stood at 24 years. This implies that most respondents have been engaged in farming as their primary occupation for a long period and that could enhance their risk management in production. Majority of respondents (78.3%) did not belong to any farmer association indicating a less interaction or exchange of innovation among these farmers and their resources can be hardly pooled to foster production growth. The average farmer cultivated two types of crops on their farms. The average farm size cultivated was 12.9 hectares which indicates large scale farming by the farmers in the Delta state, Nigeria.

Table 2. Demographic characteristics of the respondents

N = 276			
Variables considered	Frequency	Percentage (%)	Mean ± SD / Mode
Gender			
Female	151	54.70%	
Male	125	45.30%	0.55 ± 0.50
Religion			
Christianity	253	91.70%	
Traditional	22	8.00%	1.08 ± 0.31
Others	1	0.30%	
Educational level			
No formal education	28	10.10%	
Primary	56	20.30%	
Secondary	107	38.80%	2.31 ± 0.91
Post-secondary	85	30.80%	
Household size			
1-5	140	50.72%	
6-10	132	47.83%	5.5 ± 2.1
>10	4	1.45%	
Age (years)			
21-30	20	7.25%	
31-40	65	23.55%	
41-50	80	28.99%	47.8 ± 11.9
51-60	60	21.74%	
>60	51	18.48%	
Farming experience (years)			
1-10	75	27.17	
11-20	43	15.58	
21-30	54	19.57	23.9 ± 15.6
31-40	52	18.84	
41-50	52	18.84	
Membership of farming group			
Member	60	21.70	0.22 ± 0.41
Non-member	216	78.30	

Source: SPSS Output and Authors' Compilation; Researcher, 2023

Adoption of Climate Smart Agricultural Practices and Techniques adopted: The extent of adoption of CSA practices in Delta State, is low, as only 11.6% are users of CSA practices. 52.9% of them do not understand the importance of such practices. Scale of deployed CSA was small (89.1%). Additionally, intercropping was the most predominant CSA practices engaged among crop farmers in Delta State, Nigeria (74.6%) followed by cover cropping (30.4%) as well as minimum tillage (23.6%). The least of the CSA practised by the crop farmers are Growing Crops and Trees (7.6%), Composting (7.2%) and Irrigation (6.9%).

Table 3. Climate Smart Agriculture Awareness and Perception (n=276)

Adoption and Perception of CSA	Frequency	Percentage (%)
Have you adopted climate-smart agricultural practices such as, intercropping, cover cropping, minimum tillage?		
Yes	32	11.60%
No	244	88.40%
Do you understand the importance of CSA?		
Yes	130	47.10%
No	146	52.90%

Source: SPSS Output and Authors' Compilation; Researcher, 2023

Table 4. Distribution of Climate Smart Agricultural Practices

CSA Practices	Frequency	Percentage (%)
Intercropping		
Yes	206	74.6%
No	70	25.4%
Mono-cropping		
Yes	56	20.3%
No	220	79.7%
Crop Rotation		
Yes	44	15.9%
No	232	84.1%
New Crop Varieties		
Yes	58	21.0%
No	218	79.0%
Cover Cropping		
Yes	84	30.4%
No	192	69.6%
Growing Crops and Trees		
Yes	21	7.6%
No	255	92.4%
Minimum Tillage		
Yes	65	23.6%
No	211	76.4%
Mulching		
Yes	61	22.1%
No	215	77.9%
Row Planting		
Yes	63	22.8%
No	213	77.2%
Irrigation		
Yes	19	6.9%
No	257	93.1%
Composting		
Yes	20	7.2%
No	256	92.8%
Others		
Yes	37	13.40%
No	239	86.60%

Source: SPSS Output and Authors' Compilation; Researcher, 2023

Impact on CSA Adoption: Cost (100%), source of input (66.7%), and education (awareness/information) (63.0 %) were all major challenges to CSA adoption. Nevertheless, the majority (76.1 %) of the farmers agreed that cultural affinity did not affect the practice of CSA.

Effect of Climate Smart Agricultural Practices on Farming Household Food Security: Regression analysis were used to assess the effect of climate smart agriculture (CSA) practices on food security of farming households (considering food availability, food accessibility and food affordability). The estimations were depicted in Table 7. The diagnostics parameters of the model revealed a coefficient of determination (R^2) of 0.4372, 0.5006, and 0.2334 accounted for the variation in food availability, food accessibility and food affordability of the farming households. Specifically, it implies that 43.7%, 50.1% and 23.3% of the total variation in the - food availability, food accessibility and food affordability are explained by the independent variables included in the model. The models were found to be statistically significant at 1%. Age was found to be significantly and negatively related to food availability and food accessibility. This suggests that a unit increase in age of farming household head decreases food availability and food accessibility of farming household by 1.4% and 0.3%, respectively. Household size is significant and positively related to food availability and food affordability of farming households. A unit increase in household size increases food availability and food affordability of farming households by 8.8% and 7.4%, respectively. Increase in monthly income increases food availability, food accessibility and food affordability. This is possible because farming households with increased income has more capacity to purchase more inputs or improved inputs which are then committed to farm production.

Table 5. Climate Smart Agriculture: Recommendation and Level of Engagement

	Levels	Frequency	Percentage
Recommend CSA to another farmer	No	18	6.5
	Yes	258	93.5
Scale of deployed CSA	Large	2	0.7
	Medium	28	10.1
	Small	246	89.1

Source: SPSS Output and Authors' Compilation; Researcher, 2023

Table 6. Factors impacting on current state of climate smart practice by respondents

	Levels	Frequency	Percentage
Cost	Agree	276	100.0
	Disagree	0	0.0
	Don't Know	0	0.0
Cultural affinity	Agree	13	4.7
	Disagree	210	76.1
	Don't know	53	19.2
Education (awareness/information)	Agree	174	63.0
	Disagree	98	35.5
	Don't know	4	1.4
Source of input	Agree	184	66.7
	Disagree	92	33.3
	Don't Know	0	0.0
Time	Agree	135	48.9
	Disagree	129	46.7
	Don't know	12	4.3
Others	Bad Climate	1	0.4
	Bad Climate and Inadequate Fertilizer	1	0.4
	Inadequate Fertilizer	2	0.7
	Inadequate Fertilizers and Labour	1	0.4
	Inadequate Labour	3	1.1
	Insecurity	2	0.7
	Old Age	4	1.4

Source: SPSS Output and Authors' Compilation; Researcher, 2023

A member of an association is less likely to have more food availability, food accessibility and food affordability compared to a non-member of an association. Unexpectedly, farm size is significant but negatively related to food availability and food accessibility. This implies that farming households that cultivate larger farmland has lower yield and this reduces food availability and food accessibility by 10.4% and 1.4%, respectively. This is quite possible because when proper farm management practices are lacking in farm production, expanding farm size may not necessarily translate to improved yield.

An additional increase in farming experience leads to a decrease in food availability and food accessibility since those with longer farming experience have reduced food availability and accessibility probably due to their inability to adopt new practices in farming. Increase in number of cultivated crops by farming households increases their food availability by 31.9%. This implies that farming households that cultivate more crops are more likely to be food secured in respect to food availability. As season changes, farming households with multiple crops are more likely to have food available at home even in lean seasons. Having contact with extension agents, increases food availability by 56.8% as well as increases food accessibility by 33%. Distance from home to farm increases food availability by 4.2% while it reduces food accessibility by 1.1%. This suggests that farming households with farther farmlands are more food secured by cultivating virgin farmlands which are far away from places of residence with possible higher yields while those with farther farmlands have less access to food than their counterparts with farms closer to homes. The deployment of climate smart agricultural (CSA) practices by these farming households at medium and large scale compared to small scale farmers have no significant effect on food availability, food accessibility and food affordability, respectively. This implies that medium and large practices of CSA do not significantly contribute to food availability, food accessibility and food affordability of farming households. This could be due to the low awareness of CSA practices among the crop farmers in Delta State, Nigeria.

Table 7. Semi-log regression for Effect of CSA on food availability, food accessibility and food affordability of farming households in Delta State, Nigeria

Variables	Dependent Variables		
	Model 1: Food Availability	**Model 2:** Food Accessibility	**Model 3:** Food Affordability
Gender (Reference outcome: Female)			
Male	-0.073 (0.134)	-0.032 (0.031)	0.060 (0.046)
Age	-0.014** (0.006)	-0.003** (0.001)	0.001 (0.002)
Household Size	0.088*** (0.033)	-0.021*** (0.008)	0.074*** (0.011)
Household Income	0.000005* (0.000003)	0.000003*** (0.0000006)	0.000003*** (0.0000009)
Membership of association (Reference Outcome: Non-member)			
Member	-0.338* (0.173)	-0.085** (0.041)	0.079 (0.059)
Farm size	-0.104*** (0.009)	-0.014*** (0.002)	-0.001 (0.003)
Farming experience	-0.007* (0.004)	-0.002* (0.001)	0.004** (0.001)
Number of Crops cultivated	0.319*** (0.060)	-	-
Extension contacts (Reference outcome: No)			
Yes	0.568*** (0.164)	0.330*** (0.037)	-0.053 (0.055)
Distance of farm from home	0.042*** (0.012)	-0.011*** (0.0003)	-0.003 (0.004)
Scale of CSA practices (Reference outcome: Small)			
Medium	1.057 (0.836)	0.002 (0.195)	-0.330 (0.286)
Large	0.594 (0.814)	-0.119 (0.191)	-0.285 (0.278)
Constant term	7.842*** (1.058)	0.549*** (0.248)	10.216*** (0.361)
Number of observations	276	276	276
F-Statistics (Prob.)	17.03*** (0.000)	24.05*** (0.000)	7.31*** (0.000)
R-squared	0.4372	0.5006	0.2334
Adjusted R-squared	0.4116	0.4797	0.2165

****, ** and * represent 1%, 5%, and 10% significant levels respectively. Standard Errors are represented in brackets () (Source: Researcher, 2023)*

DISCUSSION

Educational result in Table 2, collaborates the findings of Mia et al. (2023) where 67.2% member of the farming community, using CSA, had secondary and post-secondary education. Results from Table 3, indicating a low adaptation of CSA practices in Delta State, corresponds to the findings of Mutengwa, Mnkeni&Kondwakwenda (2023) and Oyawole et al., (2020) whose studies were from Southern Africa and Northern Nigeria respectively. It is good that intercropping was predominantly practiced among crop farmers in Delta State, since intercropping serves as an adaptation measure to reduce risk of total crop failure, nitrogen fixation for leguminous crops, reduces pest and or disease infestation (Onyeneke, 2019). Minimum tillage is a soil conversation practice. Soil conservation methods aid in the prevention of unanticipated climatic changes. It is also an adaptive approach that raises soil fertility, hence increasing farmer productivity. Computation from Table 6 implies that cost, awareness and source of input in the study area, is a major constrain in imbibing agricultural adaptation and mitigation measures that would in turn affect sustainable production (Onyeagocha, et al., 2018), collaborating the findings that majority (89.1 percent) of the farmers practice Climate Smart Agriculture on a small scale. In Table 7, age was found to be significantly and negatively related to food availability and food accessibility. This suggests that a unit increase in age of farming household head decreases food availability and food accessibility of farming household by 1.4% and 0.3%, respectively. This indicates that farming households with younger household heads have more food available and accessible to them than their counterparts with aged household heads. This is in line with the recent finding of Oyawole et al., (2020) in Nigeria.

A unit increase in household size increases food availability and food affordability of farming households by 8.8% and 7.4%, respectively. This suggests that larger farming household size provides more hands to work on farm which in turn could result in higher farm output. However, a negative relationship was observed between household size and food accessibility. This implies that a unit increase in household size decreases food access of farming households. This suggests that food access reduces with more mouths to feed in large farming households. Increase in monthly income increases food availability, food accessibility and food affordability. This is possible because farming households with increased income has more capacity to purchase more inputs or improved inputs which are then committed to farm production. However, previous studies have considered off-farm income reduces food insecurity (Oyawole et al., (2020). More so, increase in use of improved inputs is expected to increase farm yield thereby making food to be more available, accessible and affordable. Having contact with extension agents, increases food availability by 56.8% as well as increases food accessibility by 33%. This could be linked with improved farming practices being delivered to farmers by these extension agents (Wakweya, 2023). Climate-smart Agriculture does not have significant effect on food accessibility and affordability while it has significant effect on food availability among farmers in Delta state. This variance collaborates with literature (Carletto et al., 2013 in Ogundari, 2017). Ogundari, (2017) reported that despite the existing literature on food security measures, there is a lack of globally uniform indicator(s) to measure and investigate household food security various levels, as these metrics only determine one dimension at a time (Bashir and Schilizzi, 2013). Food security is influenced by social, economic, and environmental factors, according to several studies (Ogbodo, 2019). It is stated in FAO, (2008) that when any aspect of food security is not favourable, the result is food insecurity. The report findings collaborating with (Akinyemi, 2018) agrees that Delta state is largely food-insecure.

CONCLUSION AND RECOMMENDATIONS

This paper investigated the effect of CSA on food security among farming households in Delta State, Nigeria. Specifically, it identified that the extent of adoption of CSA practices in the study area is generally low based on lack of awareness and understanding about the importance of climate-smart practices in the area. The farmers that are aware of CSA mostly adopted intercropping while most of the CSA practices adopted are on a small scale. Regression analysis were used to analysed the effect of CSA on the multi-dimensional components of food security (food availability, food accessibility and food affordability). The results on the effect of CSA on food availability revealed that increase in household size, household income, crop cultivated, use of extension agent and distance of farm from home significant contribute to increase in food availability in Delta State while increase in age, association member, farming size and experience have negative effects on food availability and vice versa. In addition, increase in household income and use of extension agents are responsible for positive improvement in food accessibility while age, household size, association member, distance from home, farm size and experience have inverse effect on food accessibility and vice versa. More so, household size, household income and farming experience have positive and increasing effect on food affordability. However, the findings showed that CSA practices do not have significant effect on food accessibility, availability and affordability. This could indeed be linked to the low level of adoption of CSA and its implementation of a small scale could allow its impact of food metrics not to be immediately noticeable in the study area.

It is therefore recommended that:

- A prolific creation of awareness on the importance of CSA in necessitating food security be instituted.
- Provision of technical assistance and support for farmers transitioning to CSA and ensure guidance and expertise are offered to them.
- Development of policies that incentivize the adoption of sustainable agriculture practices such as subsidies, extension services or tax incentives.
- Public-private partnership of government, non-profit organizations should leverage on current global SDGs goals drive to provide an enabling environment and incentives for a wider scale adaptation of climate smart agriculture.
- Nigeria should discover suitable rationale to assess the degree agricultural production is sustainable, using appropriate indicators through the SDG process.

Ethical Approval and Consent: In order to prevent bias, respondents were made aware that their participation in the study was voluntary and that all information collected would be treated with the utmost confidentiality. Additionally, respondents were fully informed that the study was only being conducted for academic purposes and that the researchers would follow all protocols, including permission from the Departmental Ethics Committee to conduct this research.

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