Makerere University Journal of Agricultural and Environmental Sciences
Vol. 11 (2). pp. 139 - 156, 2022
Printed in Uganda.
ISSN 2958-4795

Adoption of Climate Smart Agricultural strategies and their implications for food security in Southwest States of Nigeria

Oni, T.S.[1*], Afolami, C.A.[2], Obayelu, A.E.[2] and Idowu, M.A.[3]

[1]Department of Agricultural Economics and Environmental Policy,
Centre of Excellence in Agricultural Development and Sustainable Environment,
Federal University of Agriculture Abeokuta, Nigeria
[2] Department of Agricultural Economics and Farm Management,
Federal University of Agriculture Abeokuta, Nigeria
[3]Department of Food Science and Technology, Federal University of Agriculture
Abeokuta, Nigeria

[*]Corresponding author: onitemitope65@yahoo.com

Abstract

Climate change is currently a threat to food production and food markets in Nigeria, posing population-wide risks to food supply. Climate Smart Agriculture (CSA) is one of the possible interventions to turn around the situation to more resilient and higher agricultural productivity leading to improved food security status. This study therefore examined adoption of climate smart agricultural strategies and their implications for food security in Southwest States, Nigeria. A multistage sampling procedure was used to select 577 respondents, and primary data collected were analysed using descriptive statistics, household food insecurity access prevalence score and ordered probit regression model. The descriptive statistics results revealed that majority of rice farming households were male, with an average age of 46 years, married, have small rice farm size with four to five household members. The results of the household food insecurity access prevalence score revealed that in the Savanna and Rainforest agro-ecological zones, 39.1% and 33.5% of rice farmers were food secure, 8% and 13.9% were mildly food insecure, 15.1% and 22.2% were moderately food insecure while 37.8% and 30.4% were severely food insecure, respectively. The results of the ordered probit regression model shows that disease resistant variety, farmyard manure, minimum/ zero tillage, irrigation, integrated pest management and control flooding are the CSA that had a significant and positive influence on food security. Age of respondents, years in school, credit access, income and agro-ecological zones were also significant variables that had positive influence on food security status of respondents. It was concluded that adoption of these CSA strategies could help reduce food insecurity for rice farmers. We recommend that these significant variables should be an integral part of food security policies in Southwest States, Nigeria as this will help to improve the food insecurity status of the vulnerable rice farming households.

Key words: Control flooding, food security, household food insecurity access prevalence score, integrated pest management, ordered probit regression model

Introduction

The number of undernourished people in the world is estimated to have reached 768 million in 2020; around one person out of every three in the world (2.37 billion) did not have access to adequate food in 2020 (FAO, 2021). In Africa, the situation is more pressing in the region of sub-Saharan Africa where an estimated 33.7 percent of the population has moderate food insecurity and 25.9 percent of the population in the region was severely food insecure in 2020. The number of undernourished people in sub-Saharan Africa countries, Nigeria inclusive; rose from 212.2 million in 2014 to almost 282.0 million in 2020, an increase of 32.9 percent in six years (FAO, 2021).

Specifically, the percentage of food insecure people has been on the rise in Nigeria, increasing steadily from about 18% in 1986 to about 33.6% in 2004 and 41.0% in 2010 (NBS, 2012). In Nigeria, about 5.3 million people were food insecure in 16 states of the country (Global Report on Food Crises, 2019). Recently, the proportion of hungry people in the country was estimated at over 53 million, which is about 30% of the country's total population of roughly 150 million. The Nigerian Comprehensive Food Security and Vulnerability Analysis (CFSVA) revealed that about 29 percent of households in the poorest wealth quintiles have unacceptable diets (9 percent poor and 20 percent borderline) compared with 15 percent in the wealthiest (2 percent poor and 13 percent borderline) (Kuku-Shittu *et al.*, 2013).

Climate Smart Agriculture (CSA) shares Sustainable Development and Green Economy objectives and guiding principles as it also aims at food security and preservation of the natural resources. It aims to sustainably increase agricultural productivity and incomes, build resilience and capacity of agricultural and food systems to adapt to climate change, and reduce or remove greenhouse gases while enhancing national food security (Neufeldt *et al.,* 2013). FAO (2013) further notes that CSA takes into account the four dimensions of food security in terms of availability, accessibility, utilization and stability. Still, the entry point and the emphasis are on production, farmers, increasing productivity and income, and ensuring their stability. Climate-smart measures includes proven techniques such as mulching, intercropping, integrated pest and disease management, minimum soil disturbance practices, crop rotation, agro-forestry, integrated crop-livestock management, aquaculture, improved water management, better weather forecasting for farmers and innovative practices, such as early warning systems (FAO, 2010; World Bank, 2011).

Conceptually "CSA is an approach for transforming and reorienting agricultural systems to support food security under the new realities of climate change" (Lipper *et al.,* 2014). Climate change disrupts food markets, posing population wide risks to food supply. Increasing the adaptive capacity of farmers as well as increasing resilience and resource use efficiency in agricultural production systems is paramount (FAO 2013). Indeed, climate change alters agricultural production and food systems, and thus the approach to transforming agricultural systems to support global food security and poverty reduction is through CSA. Food security in an era of climate change may be possible if farmers transform agricultural systems by use of means such as improved crop varieties and fertilizer (Branca *et al.* 2011). An integrated, evidence based and transformative approach to addressing food and climate security at all levels is required. It calls for a coordinated action from the global to local levels, from research to policies and investments, and across private, public and civil society sectors to achieve the scale and rate of change required. With the right practices, policies and investments, the agriculture sector can move into CSA pathways, resulting in decreased food insecurity and poverty in the short term while contributing to reducing climate change as a threat to food security over the longer term.

Nevertheless, in spite of this conceptual soundness and potential of CSA, empirical evidence of its success under Africa's diverse agro-ecologies and socioeconomic conditions are still scanty and mixed in terms of results (Neate, 2013; Shittu *et al.,* 2018). For instance, while Brüssow *et al.* (2015) report that implementing a climate-smart approach contributes to improved food security in Tanzania; Asfaw *et al*. (2016) reported no significant impact of these practices on crop outcomes in Niger. Thus, there is a need for continued empirical studies on the effects of these CSA practices on crop yield, farm income and consequent livelihood outcomes. This study contributes strongly to bridging this knowledge gap in the literature by assessing the effects of adoption of CSA practices on food insecurity using recent cross-sectional data from Savanna and Rainforest agro-ecological zones in Southwest, Nigeria.

The study aimed to: i) understand the drivers of adoption of CSA strategies by smallholder rice farmers, ii) draw a typology of households by food security status and, iii) understand the association between CSA strategies and other factors influencing food security.

Materials and methods

Study area

The study area comprises of Ogun, Oyo, Osun, Ondo and Ekiti States. The five States lie between 06°21' and 08°37' North and 02°31' and 06°00' East (Agboola and Olurin, 2003.) with a total land area of 77, 818 km^2. The study area is bordered in the East by Edo and Delta states, in the North by Kwara and Kogi States, in the West by the Republic of Benin, and in the South by the Gulf of Guinea. Two distinct (dry and wet) seasons are dominant in the study area in which subsistence and small-scale farming are practiced (Odekunle *et al.,* 2007). The mean annual rainfall in the study area is between 1200 mm and 1500 mm. Atmospheric temperature in Southwest Nigeria is high throughout the year with an annual mean of 27 ^{0}C.

Data and sampling procedure

Primary data for this study were collected in 2021 during rice production period by the use of a structured questionnaire administered through direct interviews to rice farming households in the study area. A multi-stage sampling technique was used for selection of the respondents. The first stage involved a purposive selection of the two dominant agro-ecological zones (that is, Savanna and Rainforest agro-ecological zones) in the Southwest, Nigeria. Ekiti and Oyo States belong mainly to Savanna dominated agro-ecological zone. While Ondo, Ogun and Osun States mainly belong to Rainforest agro-ecological zone. Lagos State was not included because of administrative reasons (Otitoju, 2013). The second stage involved purposive selection of Ekiti, Ondo and Ogun out of the five States in Southwest Nigeria because of high rate of rice production in the three States (Arimi, 2014; Evans *et al.,* 2018). The third stage involved purposive selection of six (6) Agricultural Development Programme (ADP) zones in the three States based on the predominance of rice farmers in these zones. The fourth stage involved purposive selection of two (2) extension blocks from each Agricultural Development Programme (ADP) based on the predominance of rice farmers in these extension blocks, making twelve (12) extension blocks in all. At the final stage, respondents were randomly selected from each of the cell (cells are different cluster of rice farmers within an extension block) proportionate to the population size of the cells. In all, 225 and 352 rice farming households were sampled in the Savanna and Rainforest agro-ecological zones, respectively.

Data analysis procedures

Descriptive statistics

The data collected from the respondents were analysed using descriptive statistics such as frequency counts, percentages and mean. This tool was used to describe the socio economic characteristics of the respondents in the study area.

Household Food Insecurity Access Score (HFIAS) Model

Food security was measured by the HFIAS and it was used to discern as to whether respondent households were food secure, mildly food insecure, moderately food insecure, or severely food insecure (Coates *et al.,* 2007; Salvador Castell *et al.*, 2015). The HFIAS was developed by the USAID Food and Nutrition Technical Assistance project (FANTA, 2006) in an increasing need to have a universally comparable and cost-effective measure of food security (Coates *et al.*, 2007) and has been used in a similar studies by Ibrahim *et al.* (2009), among others.

The HFIAS module covers a recall period of 30 days, and consists of two types of questions - nine "occurrence" and nine "frequency-of-occurrence" questions. The respondent is first asked if a given condition was experienced (yes, no, or I don't know) and, if it was, then with what frequency (rarely that is, once or twice in the past four weeks, sometimes that is, three to ten times in the past four weeks or often that is, more than ten times in the past four weeks). The resulting responses were transformed into a continuous indicator and categorical indicator of food security, respectively. When calculating as a continuous indicator, each of the nine questions is scored between 0-3, with 3 being the highest frequency-of-occurrence (often). The score for each is then added together and it ranges from 0 to 27 indicating the degree of insecurity of food access. The Household Food Insecurity Access Prevalence indicator (Table 1) was then used to categorize households as food secure, mildly food insecure, moderately food insecure, or severely food insecure (Coates *et al.,* 2007; Salvador Castell *et al.*, 2015).

Ordered Probit Regression Model

The ordered probit regression model was used to determine the climate smart agricultural technologies and practices affecting food security status of rice farming households in the study area. The various levels of household food security status (which is the dependent variable) were derived from the Household Food Insecurity Access Score. The ordered probit model is thus expressed:

$$Y_i^* = X'\beta + \varepsilon_i \qquad (1)$$

Table 1. Household Food Insecurity Access Score

The Household Food Insecurity Access category for each household was calculated as follows:.
HFIAP category =1 Food Secure, 2=Mildly Food Insecure Access, 3=Moderately Food Insecure Access, 4=Severely Food Insecure Access
HFIA category = 1 if [(Q1a=0 or Q1a=1) and Q2=0 and Q3=0 and Q4=0 and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]
HFIAP category = 2 if [(Q1a=2 or Q1a=3 or Q2a=1 or Q2a=2 or Q2a=3 or Q3a=1 or Q4a=1) and Q5=0 and Q6=0 and Q7=0 and Q8=0 and Q9=0]
HFIAP category = 3 if [(Q3a=2 or Q3a=3 or Q4a=2 or Q4a=3 or Q5a=1 or Q5a=2 or Q6a=1 or Q6a=2) and Q7=0 and Q8=0 and Q9=0]
HFIAP category = 4 if [Q5a=3 or Q6a=3 or Q7a=1 or Q7a=2 or Q7a=3 or Q8a=1 or Q8a=2 or Q8a=3 or Q9a=1 or Q9a=2 or Q9a=3]

Source: Coates *et al.* (2007)

Where:

Yí* is the unobserved discrete random variable, X' is the vector of independent variables defined as (X_1=Age (years), X_2= Sex (1 if male, 0 if otherwise), X_3= Marital status (1 if married, 0 if otherwise), X_4 = Years in school (years), X_5 = Farm size (acres), X_6 = Household size (number), X_7= access to extension service (1 if yes, 0 if otherwise), X_8= Credit access (1 if yes, 0 if otherwise), X_9 = Farming experience (years), X_{10} = Rice farming experience (years), X_{11}= Total income per production season (naira), X_{12} = Tenure system (1 if owner of land, 0 if otherwise), X_{13}= Early maturing varieties (proportion of acreage on which practice has been adopted), X_{14}=Disease resistant varieties (proportion of acreage on which the practice has been adopted), X_{15}= Mixed farming (proportion of acreage on which the practice has been adopted), X_{16}= Farm yard manure (proportion of acreage on which the practice has been adopted), X_{17}= Green manure (proportion of acreage on which the practice has been adopted), X_{18}= NPK (proportion of acreage on which the practice has been adopted), X_{19}= Minimum tillage and refuse management (proportion of acreage on which the practice has been adopted), X_{20}= Retention (proportion of acreage on which the practice has been adopted), X_{21} = Control flooding (proportion of acreage on which the practice has been adopted), X_{22} = Irrigation (proportion of acreage on which the practice has been adopted), X_{23} =Integrated pest/weed management (proportion of acreage on which the practice has been adopted), X_{24}= Agro-forestry (proportion of acreage on which the practice has been adopted) and

X_{25}= Agro-ecological zones (Savanna zone=1, while Rainforest zone = 0), β is the vector of parameters of the regression to be estimated and [i is the vector of error term. Thus, Yí, which is the observed ordinal variable (Greene, 2003), takes on the following values:

Yí = 0 if Yí* d" 0

Yí = 1 if 0 < Yí* ≤ μ_1

Yí = 2 if µ1 < Yí* ≤ μ_2

Yí = 2 if µ1 < Yí* ≤ μ_2

Yí = *J* if µJ -1 < Yí* .... (2)

Model was implemented in STATA econometrics package. The dependent variable is *Yí* = level of food security status (0 = food secure, 1 = mildly food insecure, 2= moderately food insecure and 3= severely food insecure).

Results and discussion

Socioeconomic characteristics of rice farmers

Table 2 presents the results of the socioeconomic characteristics of the respondents interviewed. Most (81.5%) of respondents were male, and 92.7% of them were married. The average age of a rice farmer was 45 years, and a mean household size of seven persons. This suggests that the typical rice farmer was still in his economically active age and has access to family labor, which forms a significant part of farm labour (Idrisa *et al.* 2012; Adegboye 2016). Only 27.6% of the respondents had at least primary education although the average years of formal education obtained was ten years. Most responds (92.2%) had access to extension services in the previous season, indicating a robust presence of agricultural extension services in the study area. Most (73.5%) of the respondents claimed that they had access to credit in the last cropping season. Furthermore, half (50.3%) of the respondents cultivated less than 2 spatially separated hectares of rice. This gives credence to the fact that farmers often cultivate more than one hectare of land that have inherently different characteristics such as trekking distance, land type, ownership status, and farm size, which may influence their decision on which practices and technology to adopt on such farm lands.

Climate Smart Agricultural strategies adopted by rice farmers

The results presented in Figure 1 reveal that the adoption of the climate smart agricultural technologies and practices was generally low among the rice farmers in the study area. Irrigation schemes (9%), mixed cropping system (2.5%), controlled flooding (26%) and farm yard manure (27.0%) were the least adopted CSA practices.

Table 2. Distribution of respondents by their socioeconomic characteristics

Variables	Frequency	Percentage	Mean
Age (years)			45.35
Less than 30	26	4.5	
31-40	161	27.9	
41-50	286	49.6	
51-60	89	15.4	
Above 60	15	2.6	
Sex			
Female	107	18.5	
Male	470	81.5	
Education (years)			10
Less than 6	159	27.6	
7-12	269	46.6	
13 and above	149	25.8	
Household (number)			6.5
1-4	193	33.4	
5-8	322	55.8	
9 and above	62	10.7	
Marital status			
Single	22	3.8	
Married	535	92.7	
Widow/Widower	20	3.5	
Farm size (hectare)			3.74
Below 2	290	50.3	
2.1- 4	162	28.1	
4.1 and above	124	21.5	
Distance to farm (km)			6.4
1-2	182.0	31.5	
3-4	219.0	38.0	
Above 5	176.0	30.5	
Access to extension services			
No	45.0	7.8	
Yes	532.0	92.2	
Credit facilities			
Yes	424.0	73.5	
No	153.0	26.5	

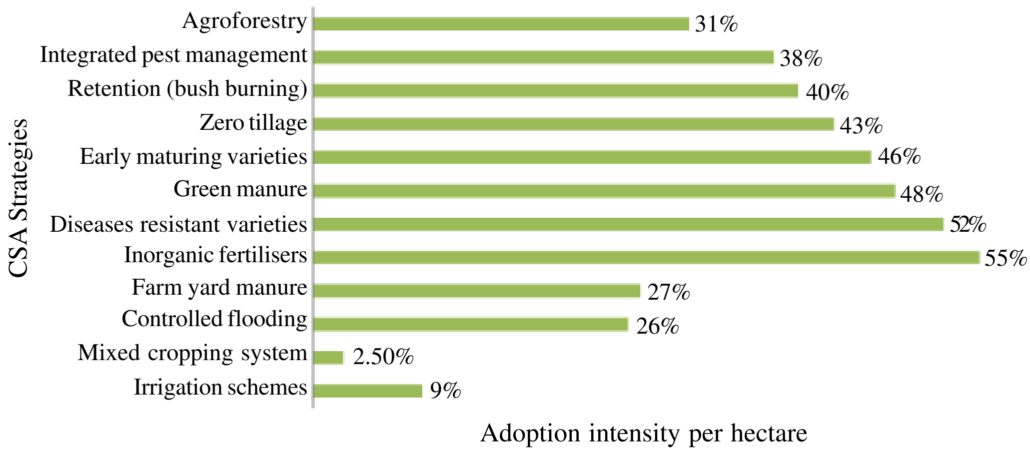

Figure 1. Distribution of adoption of Climate Smart Agricultural technologies and practices on the rice farmers' hectares.

Whereas, inorganic fertilisers (55%), diseases resistant varieties (52%), green manure (48%) and early maturing varieties (46%) were adopted on almost half of the rice farms; and zero tillage, retention (bush burning) and integrated pest management and agroforestry were adopted on 43.0%, 40%, 38% and 31.0% of the rice farms, respectively. This revealed moderate adoption level among the respondents.

Analysis of farm households' food security status

Table 3 depicts the categorisation of household food security status of the rice farmers obtained using the Household Food Insecurity Access Score (HFIAS). Results indicated that 39.1% and 33.5% of rice farming households in the Savanna and the Rainforest agro-ecological zones were classified as food secure, respectively, implying that the remaining 60.9% and 66.5% were food insecure in two zones, respectively. The results from the pooled sample also show that 35.7% of the respondents were food secure while 64.3% were food insecure. This implies that only the food secure household members have access to safe and sufficient food needed to sustain them and live a healthy life. This agrees with the findings of Otekunrin *et al.,* 2021, who found the food security among households residing in rural Oyo State, Nigeria to be 12.8%.

Furthermore, the breakdown of the findings of food insecurity groups revealed that 8% and 13.9% were mildly food insecure, 15.1% and 22.2% were moderately food insecure while 37.8% and 30.4% were severely food insecure in the Savanna and the Rainforest agro-ecological zones, respectively. These findings were similar to those of Obayelu and Oyekola, 2021, who found the prevalence of food insecurity among households residing in urban slums to be 80.9%. Hence, the high values of

Table 3. Classification of respondents' household according to food security status

Food security status	Cut-off rate based on affirmative response to the 9 frequency of occurrence questions	Savanna		Rainforest		All sample	
		Frequency	%	Frequency	%	Frequency	%
FS	<1	88	39.1	118	33.5	206	35.7
MFIA	Between 1.1- 4	18	8.0	49	13.9	67	11.6
MFI	Between 4.1-6	34	15.1	78	22.2	112	19.4
SFI	Greater than 6	85	37.8	107	30.4	192	33.3
Total		225	100	352	100	577	100

Source: Computed from field data, 2021

Notes: Food Secure-(FS), Mildly Food Insecure Access (MFIA), Moderately Food Insecure (MFI) and Severely Food Insecure (SFI) food insecurity implies that household members experiencing food insecurity face uncertainties about their ability to obtain safe and sufficient food, consequently, diminishes dietary quality, number of labour, disrupts normal eating patterns, and can have negative consequences for nutrition, health and well-being hence putting their health and well-being at grave risk. This agrees with the findings by FAO (2021), which stated that child mortality tends to be higher and life expectancy lower in countries with higher rates of food insecurity.

Determinants of food security among the farming households

Table 4 presents the results of the ordered probit regression, which was used to analyze the factors influencing the food security status of the rice farming households. The cut-off points shown at the top of the output in Table 4 indicate where the latent variable is cut to make the four food security groups. If the latent variable Y* takes the value less than "0.7998, the ordinal dependent variable will take the value of 0 (food secure). If it is between "0.7998 and "0.1694, the ordinal dependent variable is 1 (mildly food insecure). If the Y* is between "0.1694 and 0.84118, the ordinal dependent variable will take the value of 3 (moderately food insecure) and if it is more than 0.84118, the households will be severely food insecure (Table 4).

A total of 25 explanatory variables were included in the econometric model of which 12 explanatory variables had significant influence on household food security in the study area. The likelihood ratio chi-square of -686.25 with a p-value of 0.00 suggests that the fitness of the model was good. There was no intercept because it was not identified independently of the cut-points, and the STATA package sets the constant to zero and estimates the cut points for separating the various levels of the response variable. The pseudo-R-square associated with ordered logit model was observed as inappropriate measure of the predictive power of ordered response models. Therefore, the chi-squared value and the log-likelihood ratio criteria were used to evaluate the effectiveness of the model in line with Megan (2010).

Age of respondents, years of education, credit access, income, agro-ecological zones, disease resistant variety, farmyard manure, minimum tillage, control flooding, irrigation scheme and integrated pest management had significant influence on food security status of the households.

The results of the marginal effect estimates are presented in Table 5 and confirms that age of respondents, years of education, credit access, income, Agro-ecological zones, disease resistant variety, farmyard manure, minimum tillage, control flooding, irrigation scheme and integrated pest management were the significant explanatory variables that influenced the food security status of among the mildly food insecure, moderately food insecure and severely food insecure categories in the study area.

Table 4. Ordered probit regression estimates of factors influencing food security in Southwest, Nigeria

Number of observations = 577   Prob> chi^2 = 0.00   Pseudo R^2 = 0.09
LR $chi^2(33)$ = 135.9   log-likelihood = -686.25

Variables	Estimated β values	Standard error	P ># z#
Cut1	-0.7998	1.2898	
Cut2	-0.1694	1.2890	
Cut3	0.8418	1.2886	
Age of respondents	-0.0277**	0.0125	-2.21
Sex of respondents	0.0661	0.1942	0.34
Marital status	-0.2594	0.2619	-0.99
Years in school	0.0435**	0.0185	2.35
Farm size	0.0411	0.0267	1.54
Household size	0.0486	0.0346	1.40
Extension service	-0.4660	0.3193	-1.46
Credit access	0.5230**	0.1859	2.81
Farming experience	-0.0054	0.0128	-0.43
Rice experience	0.0176	0.0180	0.98
Total income	9.89e-06***	2.73e-06	3.62
Tenure system	-0.1314	0.1212	-1.08
Agro-ecological zone	0.0655***	0.0197	3.20
Early maturing variety	0.0986	0.0785	1.26
Disease resistant variety	0.8716*	0.4985	1.75
Mixed cropping	0.1067	0.0793	1.35
Farm yard manure	1.0579**	0.4877	-2.17
Green manure	0.0521	0.0728	-0.72
NPK	-0.0481	0.0449	-1.07
Minimum/zero tillage	0.4505*	0.2634	-1.71
Retention	-0.4838	0.3997	-1.21
Control flooding	0.9374*	0.4744	-1.98
Irrigation scheme	0.9162**	0.3403	2.69
IPM	0.6367**	0.2426	2.62
Agroforestry	-0.1299	0.0773	-1.68

Source: Field survey, 2021. Notes: IPM- Integrated pest management, NPK –Nitrogen, Phosphorus and Potassium; *, **, *** represent 10%, 5% and 1% level of significance, respectively

Table 5. Results of the marginal effects on probability of food security of rice farmers in Southwest Nigeria

Variables (Xs)	Food secure		Mildly food insecure		Moderately food insecure		Severely food insecure	
	ME (y_0)	SE	ME (y_1)	SE	ME (y_2)	SE	MEE (y_3)	SE
Age of respondents	0.0139***	0.0027	0.0005	0.0004	-0.0008	0.0006	-0.0036	0.0025
Sex of respondents	-0.0146	0.0429	-0.0018	0.0055	0.0031	0.0091	0.0134	0.0393
Marital status	0.0573	0.0579	0.0074	0.0077	-0.0121	0.0125	-0.0526	0.0531
Years in school	0.0152***	0.0040	-0.0006	0.0006	0.0011	0.0009	0.0047	0.0037
Farm size	-0.0091	0.0059	-0.0012	0.0008	0.0019	0.0013	0.0083	0.0054
Household size	-0.0107	0.0076	-0.0013	0.0010	0.0023	0.0016	0.0098	0.0070
Extension service	0.1029	0.0705	0.0133	0.0097	-0.0218	0.0157	-0.0945	0.0647
Credit access	0.1155***	0.0411	-0.0150***	0.0064	0.0244***	0.0101	0.1060***	0.0378
Farming experience	0.0012	0.0028	0.0002	0.0003	-0.0003	0.0006	-0.0011	0.0026
Rice experience	-0.0038	0.0039	-0.0005	0.0005	0.0008	0.0008	0.0035	0.0036
Total income	2.18e-06***	0.0000	-2.84e-07***	0.0000	4.63e-07***	0.00000	2.01e-06***	0.0000
Tenure system	0.0290	0.0268	0.0037	0.0035	-0.0062	0.0058	-0.0266	0.0245
Agro-ecological zone	0.005**	0.002	-0.025**	0.011	-0.001**	0.000	0.005**	0.002
Early maturing variety	-0.0217	0.0173	-0.0028	0.0023	0.0046	0.0038	0.0200	0.0159
Disease resistant variety	0.1929*	0.1093	-0.0214**	0.0111	-0.0417*	0.0245	0.1726*	0.0958
Mixed cropping	-0.0235	0.0175	-0.0030	0.0023	0.0049	0.0038	0.0216	0.0160
Farm yard manure	0.2235**	0.0972	-0.0332**	0.0166	-0.0371***	0.0142	-0.2196**	0.1020
Green manure	0.0115	0.0161	0.0015	0.0021	-0.0024	0.0034	-0.0105	0.0147
NPK	0.0106	0.0099	0.0013	0.0013	-0.0022	0.0021	-0.0097	0.0091
Minimum/zero tillage	0.0986*	0.0570	0.0133	0.0083	-0.0199*	0.0116	-0.0919*	0.0540
Retention	0.1081	0.0899	0.0121	0.0092	-0.0243	0.0216	-0.0959	0.0774
Control flooding	0.2122*	0.1080	0.0178***	0.0071	-0.0513*	0.0289	-0.1787**	0.0845
Irrigation scheme	0.1957***	0.0693	-0.0282***	0.0122	-0.0347***	0.01237	-0.1892***	0.0711
IPM	0.1415***	0.0539	-0.0162***	0.0067	-0.0311***	0.0135	-0.1266***	0.0472
Agroforestry	0.0286	0.0171	0.0037	0.0023	-0.0061	0.0038	-0.0263*	0.0156

*, **, *** represent 10%, 5% and 1% level of significance respectively; ME- marginal effects, SE- standard error

Among the mildly food insecure, moderately food insecure and severely food insecure categories, disease resistant variety, farmyard manure practice, minimum tillage, control flooding, irrigation scheme and integrated pest management practices were all negatively associated. On the other hand, in the food secure category, all the above stated explanatory variables were positively related. This positive sign implies that as the adoption of CSA technologies and practices increases on the farms, the level of food insecurity decreases. This may be due to the net positive impact of these practices on soil properties, which ensure adequate supply of nutrient and moisture and pest and disease control cumulatively increasing productivity and income.

The effect of agro-ecological zones was captured by a dummy (Savanna =1, Rainforest= 0). The results show that rice farmers in the Savannah agro-ecological zone are more likely to adopt disease resistant rice variety, farm yard manure practice, minimum/zero tillage practice, control flooding technology, irrigation scheme technology and integrated pest management practice relative to Rainforest agro-ecological zone as expected since they are affected more by the adverse effects of intensity of sun over time, high temperature over time, and high incident of drought. Thus, the result shows that different factors are affecting household food security across agro-ecological zones. Therefore, there is need to put into consideration the agro-ecological zones of households while planning and designing policies for food security.

Agroforestry negatively influenced food insecurity (at 5%) among the severely food insecure category, implying that households that adopted agroforestry are more likely to be food insecure which is against a priori expectations, One possible explanation could be the reduction in effective crop area available for cultivation necessitated by adopting agroforestry, which may lead to a decrease in the crop output and productivity initially before the tree species begin to yield benefits to the farmers (Peralta and Swindon, 2016).

Access to credit positively influenced food security (at 1%) among the food secure category, implying that a unit increase in access to credit is expected to lead to 0.041 increases in the probability of a household being food secure. Thus, access to credit is also a vital tool to enable food insecure households to improve their food security status. Credit enables farmers to acquire more technology which might be expensive to purchase. This agrees with the findings of Amao and Ayantoye (2015), who opined that access to credit in the form of loanable funds (soft loans) can be used to expand production through the purchase and use of modern improved inputs.

Age also positively influenced food security (at 1%) among the food secure category, an increase in age leads to 0.003 increase in the probability of a household being food secure. Our results corroborate with Bogale and Shimelis (2009) who indicated that the likelihood of food insecurity decreases with an increase in age because older people have better experience in subsistence agriculture and have had time to accumulate wealth.

Years of education also positively influenced food security (at 1%) among the food secure category, with an increase in years of education leading to 0.004 increases in the probability of a household being food secure. This result was similar with Taruvinga *et al*. (2013) where higher education level was associated with higher food security.

Conclusion

From this study we conclude that the adoption of the climate smart agricultural technologies and practices was generally low among rice farmers in Southwestern Nigeria. The findings indicate that irrigation schemes, mixed cropping system, controlled flooding and farm yard manure were the least adopted CSA technologies and practices. The results further indicated that adoption of early maturing rice varieties, disease resistant variety, farmyard manure, age of respondent, years of schooling, credit access, income and agro-ecological zones influenced the food security status. The findings revealed that CSA practices have the potential to alleviate food insecurity among rice farmers if widely adopted. It is therefore recommended that all the significant variables should be treated as an integral part of food security policies in Southwest Nigeria as this will help to ameliorate the food insecurity status of the vulnerable rice farming households in the study area.

Acknowledgements

The authors appreciate the Centre of Excellence in Agricultural Development and Sustainable Environment (CEADESE), Federal University of Agriculture, Abeokuta for the financial support. They also express gratitude to rice farmer associations of the two agro-ecological zones in Southwest, Nigeria for their time, support and help during the course of this research study.

References

Adegboye, M.A. 2016. Socio-economic status categories of rural dwellers in Northern Nigeria. Adv Res.7(2):1–10.

Agboola, T. and Olurin, T.A. 2003. Land use and land cover change in the Niger delta Excerpts from a research report presented to the center for Democracy and Development.

Amao, J.O. and Ayantoye, K. 2015. Correlates of food insecurity transition and its determinants among farming households in North Central, Nigeria. *Journal of Economics and Sustainable Development* 6(24):230-244.

Arimi, K. 2014. Determinants of climate change adaptation strategies used among fish farmers in Epe Local Government Areas of Lagos state, Nigeria. *Journal of the Science of Food and Agriculture* 94 (7):1470–1476.

Asfaw, S., Battista, F. and Lipper, L. 2016. Agricultural technology adoption under climate change in the Sahel: micro-evidence from Niger. *J. Afr. Econ.* 25(5):637–69. doi: 10.1093/jae/ejw005

Bogale, A. and Shimelis, A. 2009. Household-level determinants of food insecurity in rural areas of Dire and Dawa, Eastern Ethiopia. *Afr J Food Agric Nutr Dev.* 9(9):1914–26.

Branca, G., McCarthy, N., Lipper, L. and Jolejole, M.C. 2011. Climate smart agriculture: A synthesis of empirical evidence of food security and mitigation benefits from improved cropland management. FAO Working paper No. LAC3/10. Rome, Italy.

Brüssow, K., Faßea, A. and Grote, U. 2015. Adopting climate-smart strategies and their implications for food security in Tanzania. Tropentag Conference on International Research on Food Security, Natural Resource Management and Rural Development organised by the Humboldt-Universität zu Berlin and the Leibniz Centre for Agricultural Landscape Research (ZALF).

Coates, J., Swindale, A. and Bilinsky, P. 2007. Household food insecurity access scale for measurement of household food access: Indicator Guide (v.3) Washington, DC: Food and Nutrition Technical Assistance Project, Academy for EducationalDevelopment.http://www.fantaproject.org/sites/default/files/resources/HFIAS

Evans, S., Osabuohien., Uchechukwu, E. O. and Romanus, A. O. 2018. Rice production and processing in Ogun State, Nigeria: Qualitative insights from farmers' association for the assessment of large-scale irrigation efficiency with GIS. Irrig. Drain. 63, 440–450. https://doi.org/10.1002/ird.1833

FAO, IFAD, UNICEF, WTP and WHO 2021. The state of food security and nutrition in the World. Transforming food systems for food security, improved nutrition and affordable healthy diets for all. Rome FAO. https://doi.org/10.4060/cb4474en

Food and Agriculture Organization. 2010. Climate Smart Agriculture: Policies, practices and financing for food security, adaptation and mitigation. Rome, Italy.

Food and Agriculture Organization. 2013. Multiple dimensions of food security. The state of food insecurity in the world. Rome, Italy.

Food and Nutrition Technical Assistance (FANTA). 2006. Developing and validating simple indicators of dietary quality and energy intake of infants and young children in developing countries: Summary of findings from analysis of 10 data sets. Working Group on Infant and Young Child Feeding Indicators FANTA Project, Academy for Educational Development (AED), Washington, D.C., USA.

Global Report on Food Crises 2019. An Analysis of Food Crises in 2018.

Greene, William H. 2003. Econometric analysis (5th ed.). Upper Saddle River, NJ: Prentice Hall.

Ibrahim, H., Uba-Eze, N. R., Oyewole, S. O. and Onuk, E. G. 2009. Food security among urban households: A case study of Gwagwalada area council of the Federal Capital Territory Abuja, Nigeria. *Pakistan Journal of Nutrition* 8(6):810–813. doi:10.3923/pjn.2009.810.813

Idrisa, Y.L., Ogunbameru, B.O. and Shehu, H. 2012. Effects of adoption of improved maize seed on household food security in Gwoza Local Government Area of Borno state, Nigeria. *Agric Sci Res J.* 2(2):70–6.

Kuku-Shittu, O., Mathiassen, A., Wadhwa, A., Myles, L. and Ajibola, A. 2013. Comprehensive food security and vulnerability analysis Nigeria. Development Strategy and Governance Division.

Lipper, L., Thornton, P., Campbell, B.M., Baedeker, T., Braimoh, A., Bwalya, M., Caron, P., Catteneo, A., Garrity, D., Henry, K., Hottle, R., Jackson, L., Jarvis, A., Kossam, F., Mann, W., McCarthy, N., Meybeck, A., Neufeld, H., Remington, T., Thisen, P., Sessa, R., Shula, R., Tibu, A. and Torquebiau, E.F. 2014. Climate smart agriculture for food security. *Nature and Climate Change* 4:1068–1072.

Megan, G. 2010. Three essays on buyer power theory, dominant HMOs and technology transfer. Unpublished PhD Dissertation submitted to Department of Economics, Northeastern University. Available at: http://hdl.handle.net/2047/d20000287

NBS, Nigeria Poverty Profile. 2012. *Nigerian Bureau of Statistics.*

Neate, P. 2013. Climate-smart agriculture success stories from farming communities around the world. Wageningen, Netherlands: CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) and the Technical Centre for Agricultural and Rural Cooperation (CTA).

Neufeldt, H., Jahn, M., Campbell, B.M., Beddington, J.R., DeClerck, F. and De Pinto, A. 2013. Beyond climate-smart agriculture: toward safe operating spaces for global food systems. *Agric Food Security* 2(12):1–6.

Obayelu, O.A. and Oyekola, T. 2021. Food insecurity in urban slums: Evidence from Ibadan Metropolis, Southwest Nigeria. *J. Adv. Dev. Econ*. 2018, 7: 1–17.

Odekunle, T.O., Orinmoogunje, I.O. and Ayandele, A. 2007. Application of GIS to assess rainfall variability impacts on crop yield in Guinea Savanna part of Nigeria. *African Journal of Biotechnology* 6 (18):2100-2113.

Otekunrin, O.A., Otekunrin, O.A., Sawicka, B. and Pszczó³kowski, P. 2021. Assessing food insecurity and its drivers among smallholder farming households in rural Oyo State, Nigeria: The HFIAS Approach. Agriculture 2021, 11, 1189. https://doi.org/10.3390/ agriculture11121189

Otitoju, M. A. 2013. The effects of climate change adaptation strategies on food crop production efficiency in south western Nigeria.

Peralta, A. and Swinton, S.M. 2016. Food vs. wood: Dynamic choices for Kenyan smallholders. *Sustainable Agric Res.* 5(1):97–108

Salvador Castell, G. 2015. Household food insecurity access scale. *Nutrición hospitalaria* 31 (Suppl 3):272–8. Available at: http://www.ncbi.nlm.nih.gov/ pubmed/25719795.

Shittu, A.M., Kehinde, M.O., Ogunnaike, M.G. and Oyawole F.P. 2018. Effects of land tenure and property rights on farm households' willingness to accept incentives to invest in measures to combat land degradation in Nigeria. *Agric Resour Econ Rev.* 2018; 47(2):357–87.

Taruvinga, A., Muchenje, V. and Mushunje, A. 2013. Determinants of rural household dietary diversity: The case of Amatole and Nyandeni districts, South Africa. *International Journal of Development and Sustainability* 2(4):2233–2247. Available at: http://isdsnet.com/ijds-v2n4-4.pdf

World Bank, 2011. Climate-smart agriculture: Increased productivity and food security, enhancing resilience and reduced carbon emissions for sustainable development, opportunities and challenges for a converging agenda: Country examples. The World Bank. Washington, D.C., USA.