Effects of Adoption of Climate Smart Agricultural Practices on Food Insecurity among Rice Farming Households in the Savanna and Rainforest Agro-Ecological Zones in Southwest, Nigeria

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Abstract: - Climate change is a current threat to food production and food security in Nigeria. Temperature rise and variability in rainfall patterns has had serious consequences on production of food in Southwest Nigeria leading to a decline in food production. Climate Smart Agriculture (CSA) is the way to turn around the situation to more resilience and higher agricultural productivity leading to improved food security status. This study therefore examined the effects of adoption of CSA practices on food insecurity among rice farming households in the Savanna and Rainforest agro-ecological zones (SRAEZs) in Southwest, Nigeria. A multistage sampling procedure was used to select 225 and 352 respondents in the SRAEZs respectively, and primary data collected were analysed using descriptive statistics, household food insecurity access prevalence score and ordered logit regression model. The study revealed that majority of rice-based 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 classification measure of food security revealed that 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 in the Savanna and the Rainforest agro-ecological zones respectively.The results of the ordered logit regression model shows that in the Savanna agro-ecological zone, early maturing variety, disease resistant variety, green manure, age of respondents, sex of respondents, years in school, household size, credit access, income and tenure system were significant variables and had positive influence on food insecurity status of respondents while in the Rainforest agro-ecological zone early maturing variety, mixed cropping, agro-forestry, sex of respondents, marital status, farm size, access to credit and tenure system had positive influence on food insecurity status of respondents in the study area. This suggests that these significant variables should be an integral part of food security policies in Southwest Nigeria as this will help to ameliorate the food security status of the vulnerable rice-based farming households.

Key Words: — *Climate Smart Agriculture, Food Insecurity Status, Household Food Insecurity Access Prevalence Score, Ordered Logit Regression Mode.*

I. Introduction

The number of undernourished people in the world is estimated to have reached 821 million in 2017; around one person out of every nine in the world (FAO 2018).

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In Africa, the situation is more pressing in the region of sub-Saharan Africa where an estimated 23.2 percent of the population or between one out of four and one out of five people in the region may have suffered from chronic food deprivation in 2017. The number of undernourished people in sub-Saharan Africa countries, Nigeria inclusive; rose from 212.2 million in 2014 to almost 256.5 million in 2017, an increase of 20.9 percent in three years (FAO 2018).

Specifically, the percentage of food insecure people has been on the increase 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 (GRFC 2019) while the percentage of food insecure households in Nigeria rose from 18% in 1986 to 40% in 2005 (Sanusi *et al.* 2006). Recently, 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).

Climate Smart Agriculture (CSA) however shares Sustainable Development and Green Economy objectives and guiding principles as it also aims for food security and preservation of the natural resources. CSA 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).

Nevertheless, in spite of the conceptual guarantee and prettiness of CSA, empirical evidence of its success under Africa's diverse agro-ecologies and socioeconomic conditions are observed to still be 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 into the effects of these CSA practices on crop yield, revenue 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.

II. Relationship between Climate Smart Agriculture (CSA) and Food Security

The concept of food security has been used extensively at the household level as a measure of welfare. A household is considered food secure if all members at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. 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. CSA prioritizes food security with a consideration of mitigating climate change (Lipper et al., 2014). Food security in an era of climate change may be possible if farmers transform agricultural systems by use of means such as improved crop seed and fertilizer (Bryan et al., 2013).

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. Through Climate Smart practices, more efficient resource use agricultural production systems offer considerable potential for increasing agricultural productivity, incomes, food security and the resilience of rural livelihoods while reducing the intensity of agricultural emissions (FAO, 2010). 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.

III. Materials And Methods

3.1 Study Area

The study area was Southwest Nigeria comprising of Lagos, Ogun, Oyo, Osun, Ondo and Ekiti States. The six States lie between longitude 2o311 and 6o001 East and latitude 6o211 and 8o371 North (Agboola 2003) with a total land area of 77, 818 km2. The study area is bounded 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 climate of the study area experiences a double rainfall maximum characterized by bimodal high rainfall peaks, with a short dry season and a longer dry season falling between and after each peak. The mean annual rainfall is between 1200mm and 1500mm. Atmospheric temperature in Southwest, Nigeria is high throughout the year with an annual mean of 270.

3.2 Data and Sampling Procedure

Primary data for this study were collected in 2021 during rice production period through the use of a well-structured questionnaire administered through direct interviews to rice farming households in the study area. A multistage random 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 reason (Otitoju, 2013). The second stage involved purposive selection of Ekiti, Ondo and Ogun out of the six 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 cells 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.

3.3 Analytical Framework

3.3.1 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.

3.3.2 Household Food Insecurity Access Score (HFIAS) Model:

Food security was measure by HFIAS and it was used to categorized respondents as 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 increasingly need to have a universally comparable and cost-effective measure of food security (Coates *et al*., 2007) and have been used in a similar study by Gabriela and Manfred (2007) and Ibrahim *et al*. (2009).

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 known) 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. The total Household Food Insecurity Access Score range from 0 to 27 indicating the degree of insecure food access. While the Household Food Insecurity Access Prevalence indicator (Table 1) was used to categorized households as food secure, mildly food insecure, moderately food insecure, or severely food insecure (Coates *et al.* 2007; Salvador *et al*. 2015).

Table 1: Household Food Insecurity Access Prevalence

HFIAP category	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: Coaste et al. 2006.

3.3.3 Ordered Logit Regression Model:

This study however employed the ordered logit model (the proportional odds model) to analyze determinants of climate smart agricultural practices affecting food insecurity status of rice farming households in the study area. The selection of the model is in line with Greene (2000) since our dependent variable (the household food security status) is both categorical and ordinal. The model is specified explicitly as follows:

$Y_i=\beta_o+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4+\beta_5X_5+\beta_6X_6+\beta_7X_7+\beta_8X_8......\beta_{24}X_{24}+\varepsilon$……………………………….. (Equation 1)

Where:

Y_i = food security status (0 = food secure, 1 = mildly food insecure, 2= moderately food insecure and 3= severely food insecure).

βo= intercept

βi= the coefficients

ε = error term

X_1= Early maturing varieties (proportion of farmland on which practice has been adopted)

X_2=Disease resistant varieties (proportion of farmland on which the practice has been adopted)

X_3= Mixed farming (proportion of farmland on which the practice has been adopted)

X_4= Farm yard manure (proportion of farmland on which the practice has been adopted)

X_5= Green manure (proportion of farmland on which the practice has been adopted)

X_6= NPK (proportion of farmland on which the practice has been adopted)

X_7 =Minimum tillage and refuse management (proportion of farmland on which the practice has been adopted)

X_8 = Retention (proportion of farmland on which the practice has been adopted)

X_9 = Control flooding (proportion of farmland on which the practice has been adopted)

X_{10} = Irrigation (proportion of farmland on which the practice has been adopted)

X_{11} =Integrated pest/weed management (proportion of farmland on which the practice has been adopted)

X_{12} = Agro-forestry (proportion of farmland on which the practice has been adopted)

X_{13} = Age (years)

X_{14} = Sex (1 if male, 0 if otherwise)

X_{15} = Marital status (1 if married, 0 if otherwise)

X_{16} = Years in school (years)

X_{17} = Farm size (acres)

X_{18} = Household size (number)

X_{19} = Extension service (1 if yes, 0 if otherwise)

X_{20} = Credit access (1 if yes, 0 if otherwise male)

X_{21} = Farming experience (years)

X_{22} = Rice experience (years)

X_{23} = Total income (naira)

X_{24} = Tenure system (1 if owner of land, 0 if otherwise)

IV. RESULTS AND DISCUSSION

4.1 Socio-Economic Characteristics of Respondents

Table 2 revealed that about 80.5% and 75.6% of the rice farmers in the SRAEZs respectively fall within 31-50 years of age bracket with an average age of 45.4 and 44.7 years in the SRAEZs respectively. The finding in Table 2 indicates that majority (77.8% and 83.8%) of the rice farmers in the SRAEZs respectively were male, indicating that most communities in the study area are traditionally patriarchal in nature. The results in Table 2 further revealed that about 26.2% and 28.4% of the respondents in the SRAEZs respectively had 6 and below years of formal education. The average years of schooling among the rice farmers in SRAEZs were 12 and 10 years respectively. The result in Table 2 shows that majority (91.6% and 93.5%) of the rice farmers in the SRAEZs were married respectively. The findings have also shown that about 49.3% of the rice farmers in the Savanna agro-ecological zone had a farm size of 2 and below hectares, while majority (54.5%) of the rice farmers in the Rainforest agro-ecological zone had below 2 hectares of farm size and 12.8% had above 4.1 hectares. The average farm sizes in the Savanna and the Rainforest agro-ecological zones were 4.6 and 3.7 hectares respectively.

Table 3 revealed that about 56.5% and 45.5% of the rice farmers in the Savanna and Rainforest agro-ecological zones respectively had above 15 years of farming experience. The average farming experiences among the rice farmers in Savanna and Rainforest agro-ecological zones were 21 and 16 years respectively. Table 3 also revealed that about 56.4% and 45.5% of the rice farming households in the Savanna and Rainforest agro-ecological zones respectively had above 15 years of rice farming experience. The average rice farming experiences among the respondents in Savanna and Rainforest agro-ecological zones were 9.7 and 8.7 years respectively.

Household Food Security Status of the Rice Farming Households

This section depicts the categorisation of household food security status of the rice farmers by using the Household Food Insecurity Access Prevalence (HFIAP) indicator (Table 1). The HFIAP indicator was used to observe household food security; and food insecurity prevalence (Salvador et al. 2015 Coates et al. 2007). Based on the HFIAP classification measure of food security as presented in Table 4, about 39.1% and 33.5% of rice farming households in the Savanna and the Rainforest agro-ecological zones (SRAEZs) were classified as food secure respectively while the remaining 60.9% and 66.5% were food insecure in the study area respectively.

To further look into the depth of food insecurity prevalence level among the respondents in the study area, the findings of food insecurity status of the rice farming households in the SRAEZs 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.

Table.2. Distribution of Respondents by their Socio-Economic Characteristics

	Savanna (n=225)		**Rainforest (n=352)**	
Variables	Frequency	Percent	Frequency	Percent
Age (years)	Mean = 45.4		Mean = 44.7	
≤ 30	5.0	2.2	21.0	6.0
31-40	78.0	34.7	83.0	23.6
41-50	103.0	45.8	183.0	52.0
51-60	29.0	12.9	60.0	17.0
> 60	10.0	4.4	5.0	1.4
Sex				
Female	50.0	22.2	57.0	16.2
Male	175.0	77.8	295.0	83.8
Education (years)	Mean = 12.1		Mean = 10.4	
≤ 6	59.0	26.2	100.0	28.4
7-12	91.0	40.4	178.0	50.6
≥ 13	75.0	33.3	74.0	21.0
Marital Status				
Single	11.0	4.9	11.0	3.1
Married	206.0	91.6	329.0	93.5
Widow/Widower	8.0	3.6	12.0	3.4
Farm Size (ha)	Mean = 4.6		Mean = 3.7	
≤ 2	11.0	49.3	192.0	54.5
2.1- 4	37.0	16.4	115.0	32.7
4.1 and above	76.0	33.8	45.0	12.8

Source: Computed from field data, 2021.

Table.3. Distribution of Respondents by their Socio-Economic Characteristics

	Savanna (n=225)		**Rainforest (n=352)**	
Variables	Frequency	Percent	Frequency	Percent
Farming experiences (years)	Mean = 20.7		Mean= 16.3	
≤ 5	21.0	9.3	21.0	6.0
6-10	57.0	25.3	97.0	27.6
11-15	20.0	8.9	74.0	21.0
> 15	127.0	56.4	160.0	45.5
Rice farming experiences (years)	Mean = 9.7		Mean = 8.7	
less than 5	21.0	9.3	21.0	6.0
6-10	57.0	25.3	97.0	27.6
11-15	20.0	8.9	74.0	21.0
Above 15	127.0	56.4	160.0	45.5
Distance (km)	Mean = 7.5		Mean = 5.6	
1-2	67.0	29.8	114.0	32.4
3-4	81.0	36.0	139.0	39.5
Above 5	77.0	34.2	99.0	28.1

Source: Computed from field data, 2021.

Table.4. Household Food Insecurity Access Prevalence of Respondents

	Savanna		**Rainforest**	
Food Security Status	Frequency	percent	Frequency	percent
Food secure	88	39.1	118	33.5
Mildly food insecure access	18	8.0	49	13.9
Moderately food insecure	34	15.1	78	22.2
Severely food insecure	85	37.8	107	30.4
Total	**225**	**100.0**	**352**	**100.0**

Source: Computed from field data, 2021.

Notes: Less than or equal to 1= food secure (FS), between 1.1- 4 = mildly food insecure access (MFIA), between 4.1-6 = moderately food insecure (MFI) and greater than 6 = severely food insecure (SFI).

4.2 Effects of CSA Practices on Food Insecurity Status

The findings of this study revealed the variables that are relevant in explaining the effects of CSA practices on households' food insecurity status in the Savanna and the Rainforest agro-ecological zones of Southwest, Nigeria (Table 5, Table 6 and Table 7). The ordered logit regression model was used to identify the effects of CSA practices on food insecurity of rice farming households in the study area. The overall ordered logit regression model was significant (P<0.01) based on the chi-square estimates, thus implying that the explanatory variables are relevant in determining the rice farming households' food insecurity in the area.

The coefficients of determination (R^2) in the Savanna and the Rainforest agro-ecological zones were found to be 15% and 21% respectively, implying that the variation in food insecurity status is due to the stated CSA practices and socio-economic characteristics of the respondents.

Out of the twenty four (24) explanatory variables fitted into the ordered logit regression model, ten (10) explanatory variables (early maturing variety, disease resistant variety, green manure, age of respondents, sex of respondents, years in school, household size, credit access, income and tenure system) were found to be statistically significant in the Savanna agro-ecological zone (Table 5), whereas eight (8) explanatory variables (early maturing variety, mixed cropping, agro-forestry, sex of respondents, marital status, farm size, access to credit and tenure system) were found statistically significant in the Rainforest agro-ecological zone (Table 5). Furthermore, Table 6 and Table 7 shows that marginal effects (ME) of each explanatory variable on the probability of food insecurity status. The marginal effects provide insights into how the explanatory variables shift the probability of household food security between the four ordinal levels.

Specifically, the coefficients of adoption of early maturing variety were significant in the two agro-ecological zones at 10% and 1% level respectively. In the Savanna zone, the coefficient of early maturing variety positively influenced food security, suggesting that households that adopted early maturing variety on large proportion of their farms (high adopters) has a greater likelihood of being food secure. On the other hand, in the Rainforest zone, the coefficient of early maturing variety negatively influenced food security, suggesting that rice farming households' that adopted early maturing variety on small proportion of their farms (low adopters) have a greater likelihood of being food insecure. In the Savanna zone, the coefficient of disease resistant variety was significant (P<0.05) and negatively influenced food security, suggesting that households who adopted disease resistant variety on small proportion of their farms have a greater likelihood of being food insecure.

However, in the Rainforest zone, agroforestry was significant (P<0.05) and negatively influenced food security status, implying that rice farming households' that adopted the practice of agroforestry on a small proportion of their farms (low adopters) are more likely to be food insecure. This disagrees with the findings of Peralta and Swindon 2016 that says adopting agroforestry may lead to a decrease in the crop output and productivity initially before the tree species begin to yield benefits to the farmers. In the Rainforest zone, the coefficient of mixed farming negatively influenced food security status, suggesting that the households that adopted early maturing variety on small proportion of their farms (low adopters) have a greater likelihood of being food insecure. However, other household and farm characteristics significantly influenced food security in the study area. The variables are significant in explaining household food security.

The positive sign of the coefficient of age was significant (P<0.05) and indicated that an increase in age leads to an increase in the probability of a household being food secure. However, the results similar with Olagunju *et al*. 2012 & Joseph, 2012; Bogale & Shimelis 2009 which indicated that the likelihood of food insecurity decreases with an increase in age because older people have better experience in subsistence agriculture and are able to accumulate better wealth. The positive effect between educational level of rice farming households and food security implies that educated rice farming households are more likely to be food secure than an uneducated farmer in the study area. Also, the higher the number of years the farmers spend in school, the probability of the farmers being food secured. Similar results were also found by Taruvinga *et al*. (2013) where higher education level was associated with higher food security.

Table.5. Effects of CSA Practices on Food Security Status

	Savanna		Rainforest	
Number of observations	351	Pseudo R^2 0.15	No. of observation 225	Pseudo R^2 0.21
LR chi2(35)	144.17	likelihood -394.87	LR chi2(35) 85.42	likelihood -232.621
Prob.> chi2	0.00		Prob.>chi^{2}0.00	
Variables	**Estimated β values**	**P >|z|**	**Estimated β values**	**P >|z|**
Cut1	-1.9771		-1.4749	
Cut2	-1.0544		-1.0162	
Cut3	-0.0196		0.3682	
Early maturing	1.0086*	0.090	-3.1027**	0.035
Disease resistant	-1.3236**	0.022	1.9221	0.181
Mixed cropping	-1.1827	0.361	2.6682*	0.097
Farm yard manure	-0.3958	0.508	-2.3123	0.126
Green manure	-1.9389*	0.059	-0.1735	0.815
NPK	0.5612	0.241	-12.0502	0.986
Tillage	-0.3843	0.769	-1.6937	0.279
Retention	-0.1127	0.846	-0.3227	0.780

Control flooding	0.0241	0.980	-0.8054	0.437
Irrigation	0.5036	0.316	13.4007	0.985
IPM	0.1028	0.739	0.7004	0.134
Agro-forest	0.0093	0.734	0.2061**	0.040
Age	0.0369**	0.029	0.0108	0.635
Sex	0.4454*	0.067	-1.1221*	0.018
Marital status	0.1898	0.611	-0.9320**	0.034
Years in school	0.0515**	0.023	0.0285	0.522
Farm size	0.0354	0.251	0.2828***	0.010
Household size	0.1192***	0.005	-0.0348	0.665
Extension service	-0.5299	0.149	-1.0022	0.414
Credit access	0.5692**	0.027	0.7650**	0.030
Farming experience	-0.0043	0.801	-0.0132	0.605
Rice experience	0.0287	0.201	-0.0454	0.325
Total income	0.0000***	0.000	2.9500	0.643
Tenure system	-0.5894***	0.001	0.5525**	0.020

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

Table.6. Results of the Marginal Effects on Probability of Respondents in the Savanna Zone

Variables (Xs)	ME(y_0)	SE	ME(y_1)	SE	ME(y_2)	SE	ME(y_3)	SE
Early maturing	0.622**	0.280	0.362***	0.027	-0.140	0.931	0.509**	0.191
Disease resistant	0.444**	0.107	0.030	0.321	0.202	0.228	0.211	0.658
Mixed cropping	-0.570	0.392	0.049	0.320	0.255***	0.091	0.865***	0.204
Farm yard manure	0.519*	0.298	-0.007	0.377	-0.199	0.541	-0.312	0.825
Green manure	0.043	0.184	-0.001	0.042	-0.019	0.092	-0.022	0.117
NPK	0.994	1.790	0.000	0.117	-0.005	2.059	-0.989**	0.533
Tillage	0.382	0.437	0.170	0.323	-0.128	0.639	-0.271	0.704
Retention	0.080	0.286	-0.001	0.078	-0.036	0.147	-0.041	0.197
Control flooding	0.198	0.253	-0.004	0.187	-0.089	0.205	-0.103	0.340
Irrigation scheme	-0.997	0.854	0.000	0.128	0.006	1.987	0.990	2.970
IPM	-0.173	0.113	0.007	0.160	0.081	0.123	0.084	0.269
Agroforestry	0.051*	0.028	-0.001	0.050	-0.023	0.046	-0.026	0.082
Age	-0.002	0.005	0.000	0.002	0.007**	0.003	0.001	0.005
Sex	0.254	0.297	0.018	0.229	-0.082	0.504	-0.190	0.460
Marital status	0.232*	0.127	-0.005	0.228	-0.106	0.211	-0.120	0.372
Years in school	-0.007	0.011	0.000	0.007	0.003	0.008	0.003	0.012
Farm size	-0.070**	0.033	0.001	0.069	0.032	0.063	0.036**	0.012
Household size	0.008	0.020	-0.000	0.008	-0.003	0.011	0.004***	0.001
Extension service	0.249	0.313	-0.005	0.246	-0.114	0.261	-0.129	0.426
Credit access	-0.190*	0.102	0.004	0.187	0.087	0.173	0.098	0.305
Farming experience	0.003	0.006	-0.000	0.003	-0.001	0.004	-0.001	0.006
Rice experience	0.011	0.011	-0.000	0.011	-0.105***	0.011	-0.005	0.018
Total income	-7.36e-07	0.000	1.70e-08	0.000	3.37e-07	0.000	3.81e-07	0.000
Tenure system	-0.1375**	0.0706	0.135***	0.0031	0.263**	0.124	0.071	0.220

*Source: Field survey, 2021. Notes: *, **, *** represent 10%, 5% and 1% level of significance respectively. ME- marginal effects, SE- standard error.*

Table.7. Results of the Marginal Effects on Probability of Respondents in the Rainforest Zone

Variables (Xs)	ME(y_0)	SE	ME(y_1)	SE	ME(y_2)	SE	ME(y_3)	SE
Early maturing	-0.175*	0.102	-0.066*	0.036	0.021	0.016	0.219*	0.125
Disease resistant	-0.225**	0.096	0.085**	0.034	-0.022	0.870	-0.287**	0.120
Mixed cropping	-0.212	0.237	0.070	0.059	-0.033	0.040	-0.249	0.258
Farm yard manure	-0.071	0.111	0.025	0.035	-0.012	0.023	-0.084	0.124

Green manure	-0.393*	0.216	0.055**	0.024	-0.098*	0.058	-0.350**	0.147
NPK	-0.094	0.077	-0.040	0.035	0.009	0.008	0.125	0.108
Tillage	0.068	0.233	0.025	0.085	-0.010	0.036	-0.083	0.281
Retention	0.019	0.104	0.007	0.038	-0.003	0.016	-0.024	0.126
Control flooding	-0.004	0.168	-0.001	0.067	0.001	0.022	0.005	0.212
Irrigation scheme	-0.085	0.081	-0.035	0.037	0.009	0.007	0.112	0.114
IPM	-0.018	0.054	-0.007	0.021	0.003	0.008	0.022	0.067
Agro-forest	0.001	0.004	0.0006	0.001	-0.000	0.007	-0.002	0.006
Age	0.006**	0.002	0.002**	0.001	-0.001	0.006	-0.008**	0.003
Sex	-0.078*	0.042	-0.030*	0.017	0.011	0.008	0.097**	0.053
Marital status	-0.033	0.065	-0.013	0.025	0.005	0.009	0.041	0.081
Years in school	-0.009**	0.003	-0.003**	0.001	0.001	0.000	0.011**	0.004
Farm size	-0.006	0.005	-0.002	0.002	0.008	0.001	0.007	0.006
Household size	-0.020**	0.007	-0.008**	0.003	0.002	0.001	0.026***	0.009
Extension service	0.092	0.064	0.036	0.026	-0.013	0.011	-0.116	0.080
Credit access	-0.099**	0.045	-0.039**	0.019	0.014	0.009	0.124**	0.056
Farming experience	0.000	0.003	0.000	0.001	-0.000	0.004	-0.009	0.003
Rice experience	-0.005	0.003	-0.001	0.001	0.007	0.006	0.006	0.004
Total income	-2.32e-06***	0.000	-9.15e-07***	0.000	3.30e-07*	0.000	2.91e-06***	0.000
Tenure system	0.103***	0.030	0.040***	0.013	-0.014	0.009	-0.129***	0.037

*Source: Field survey, 2021. Notes: *, **, *** represent 10%, 5% and 1% level of significance respectively. ME- marginal effects, SE- standard error.*

V. Conclusion

This study examined the effects of adoption of climate smart agricultural practices on food insecurity among rice farming households in the Savanna and Rainforest agro-ecological zones in Southwest, Nigeria. Based on the Household Food Insecurity Access Prevalence model of food security, 39.1% and 33.5% of rice farmers were classified as 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 in the Savanna and the Rainforest agro-ecological zones respectively. In the Savanna zone, early maturing variety, disease resistant variety, green manure, age of respondents, sex of respondents, years in school, household size, credit access, income and tenure system on food insecurity status of respondents while in the Rainforest zone early maturing variety, mixed cropping, agro-forestry, sex of respondents, marital status, farm size, access to credit and tenure system.

It is therefore recommended that government policies to consolidate farmland holdings to promote monocropping should be carefully considered before being introduced to rural farmers, as land system has been shown to positively influence food security in the two agro-ecological zones had positive influence on food insecurity status of respondents in the study area. Also, this suggests that all the significant variables should be an integral part of food security policies in Nigeria as this will help to ameliorate the food security status of the vulnerable rice farming households.

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