INFLUENCE OF ADOPTING CLIMATE SMART PRACTICES ON HOUSEHOLD FOOD SECURITY STATUS IN SOUTHERN NIGERIA

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ABSTRACT

This study examined the influence of adopting climate smart agricultural practices on food security of farm households in Southern Nigeria. Multistage sampling technique was used to select farmers across five states in Southern Nigeria. Household food security (HFS) was assessed using the United States Department of Agriculture's HFS survey module. Data were analyzed using frequency distribution, percentages, mean and Ordered Probit model. The household food security status revealed that 26% of the households were highly food secure: while 29%, 23.2% and 21.8% have marginal, low and very low food security respectively. Ordered Probit of household food security results revealed that households that adopted agroforestry ($\beta = 0.3269$, $p < 0.05$) and use of organic compost ($\beta = -0.2925$, $p < 0.05$) were significantly more likely to be food secure. The study therefore recommended public sensitization by extension agents, better participation from farmers and favourable policy from the government to encourage continuous use of climate smart practices should be put in place as their use tend to have a positive influence on the household food security status in Southern Nigeria.

Keywords: Climate-Smart Practices, Food security, Farm households, Nigeria
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INTRODUCTION

Agriculture plays central role in increasing food availability and incomes, supporting livelihoods and contributing to the overall economy, and is thus a key factor in efforts to improve food security [1]. Nigeria's agricultural sector provides 85% of the national food and fibre needs, employed 65%-70% of the labour force and accounts for almost one third (31.95%) of the Gross Domestic Product (GDP) [2]. The leading agricultural produce are cocoa, cotton, palm oil, maize, rice, sorghum among others, while cocoa and rubber are the major export crops. The country is a home to varieties of agricultural crops and animals [3]. Although, the oil sector provides 95% of foreign exchange earnings and about 80% of budgetary revenues, 49% of Nigerians engage in agriculture as their major occupation. Subsistence agriculture is a major source of income and livelihood for large numbers of people living in rural areas and these small holder farmers provide food directly for household consumption for majority of people in Nigeria [3].

The Intergovernmental Panel on Climate Change (IPCC) estimates that crop and fodder growing periods in western and southern Africa may shorten by an average of 20% by 2050, causing a 40% decline in cereal yields and a reduction in cereal biomass for livestock [4,5,6]. Considering the sensitivity of the prevailing farming systems to drought, crop yields are projected to decline by as much as 50% by 2020 across the continent [7].

Climate-Smart Agriculture (CSA), a concept developed by FAO, is an approach to developing the technical, policy and investment conditions to achieve sustainable agricultural development for food security under climate change [8]. It integrates the three dimensions of sustainable development (economic, social and environments) by jointly addressing the food security, ecosystems management and climate change challenges [8]. It comprised of three main pillars: Sustainably increasing agricultural productivity and incomes; Adapting and building resilience to climate change and reducing and/or removing greenhouse gases emissions, where possible [8].

CSA is not a prescribed practice or a specific technology that can be universally applied. It is an approach that requires site-specific assessments of the social, economic and environmental conditions to identify appropriate agricultural production technologies and practices. A key component of CSA is integrated landscape approach that follows the principles of ecosystem management and sustainable land and water use. At the farm level, CSA aims at strengthening livelihoods and food security, especially of smallholders, by improving the management and use of natural resources and adopting appropriate approaches and technologies for the production, processing and marketing of agricultural commodities. At the national level, CSA seeks to support countries in putting in place the necessary policy, technical and financial mechanisms to mainstream climate change adaptation and mitigation into agricultural sectors and provide a basis for operationalizing sustainable agricultural development under changing conditions.

Furthermore, the estimated impacts of both historical and future climate change on cereal crop yields in different regions indicate that the yield loss can be up to 60% for maize, which is a staple and the second most grown crop in Nigeria [8, 9], about 35% for rice, 20% for wheat and 50% for sorghum depending on the location. However, Nigeria has the highest population growth among the ten largest countries in the world, and is expected to become the third largest in the world by 2050 [10], underscoring the need for increased agricultural production to cater for the food need for both the present and future generations. Consequently, there is an urgent need for a more sustainable approach to agriculture, which will simultaneously improve agricultural productivity and reduce yield variability over time under adverse climatic conditions, as well as mitigate agriculture's contribution to climate change.

Although several farm level studies suggest that adoption of CSA technologies can improve crop yields, increase input use efficiency, increase net income and reduce GHG emissions [11, 12, 13], the adoption of such practices remains generally low, particularly in sub-Saharan Africa and in some cases their applicability in smallholder systems contested [14, 15].

However, current government efforts towards reversing this trend in order to re-strategize and develop an approach that will ensure that better progress in food security is necessary as part of efforts to achieve the Sustainable Development Goals (SDGs), to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture and take urgent action to combat climate change and its impacts among other goals. The study focuses on smallholder farmers because they have been identified as one of the groups most vulnerable to the adverse effect of climate change especially in sub-Saharan region [16]. Furthermore, there is more than enough food in the world to cater for everyone, but the proportion of people affected by hunger and malnutrition is still on the increase [17]. Reducing this outrageous trend must be a top priority for governments and other international institutions.

There are little research evidences on adoption of climate-smart practices and household food security among smallholders in Nigeria. Since the majority of Nigerians (70 percent) live in rural areas, this study will present a clear image of what needs to be done to ensure food security in Southern Nigeria. There is need for such baseline information, especially relating to designing appropriate strategies and policies for mitigating the effect of climate change on agriculture. This work therefore, will go a long way to providing vital information on the effect of adoption of climate smart agriculture on food security status, since their livelihood depends on agriculture. The findings of this study will be relevant to the agrarian rural poor, the researchers, Non-Governmental Organizations, policy makers, the government and international organizations for information and policy.

MATERIALS AND METHODS

Study area

The study was conducted in selected farming communities reputed for maize and rice production in Southern Nigeria. Southern Nigeria lies between longitudes 3°and 14° and latitudes 4° and 14°. It has a land mass of 206,888 sq.km and a population of 64,987,376 [18]. There are two basic seasons; wet season which lasts from April to October; and the dry season which lasts from November till March. February – March, is the hottest period of the year when temperatures range from 33^0C to 38^0C. Southern Nigeria is divided into two agro-ecological zones namely, rain forest and derived savannah and in addition to its huge population, it is also endowed with significant agricultural, mineral, marine and forest resources. Its multiple vegetation zones, plentiful rain, surface water and underground water resources and moderate climatic extremes, allow for production of diverse food and cash crops. Majority of the population is involved in the production of the food crops such as cassava, maize, rice, yams, various beans and legumes, tomatoes, melons and vegetable. The rain forests have been well exploited for timber and wood products of exotic and popular species.

Sampling procedure

The respondents were drawn in a multi-stage sampling process as follows, the first stage was a purposive selection of three States (Cross River, Ebonyi and Ondo States) in the rain forest zone and two States (Ogun and Oyo States) in the derived savannah zone based on their level of production in maize and rice production. The second stage was by purposive selection of three Agricultural Blocks per crop in each of the zones of the states. The third stage involves a purposive selection of 12 cells across six blocks among those that are located in the main area where each of Rice and Maize are produced in the States. The final stage was by random selection of 7 members of the Rice/Maize farmers' groups in each of the selected cells. This process yielded a total of 521 farm households

Method of data analysis

The data for this study were analysed by a combination of descriptive statistics and Ordered Probit regression model. The specific method used in achieving the study objectives were as follows:

Perception of farmers to climate variables: the respondents were asked question about whether or not they had experienced changes to regional climate within the past 25years, they were asked about their perceived experience in relation to a series of climatic events commonly associated within the global climate change effects in Nigeria. To these they could respond that the changes they experienced declined substantially, declined slightly, remain the same, increased slightly or increased substantially.

Food security status was assessed using the USDA Food Scoring Approach containing 18 questions for household with children, 10 of which are applicable for household without children. Households classification are based on number of affirmative responses. Each question asks whether the condition or behaviour occurred at any time during the previous 12 months [19] and specifies lack of money and other resources to obtain food as the reason.

Ordered Probit model was used to analyse the influence of adoption of CSPs and other selected socioeconomic characteristics on household food security status. Following [20] the model is specified as

$$y_i^* = W^! \beta_i + \varepsilon_i \text{………………..(1)}$$

Where y_i^* is the latent variable that determines the exact level of household food security status, y when it assumes the value of 0, 1, 2 and 3 representing the household food security status.

$$y = \begin{cases} 0 \; if \; y^* \leq 0, \\ 1 \; if \; 0 < y^* \leq \mu_1, \\ 2 \; if \; 1 \; \mu_1 \leq y^* \leq \mu_2, \\ 3 \; if \; \mu_2 < y^*. \end{cases}$$

μ_1 and μ_2 are thresholds value for all the food security status categories.

β_i= vectors of the regression coefficients of the explanatory variables in the model and ε_i = error term, W = vectors of explanatory variables including socioeconomic, land and adoption variables.

W_1= Age of household head (in years), W_2=Gender of household head (Male =0, Female = 1), W_3= Marital status of household head (married=0, otherwise=1), W_4= Education level of household head (number of years of formal education), W_5= Access to credit (access=1, 0 otherwise), W_6= Farmers association (member=1, 0 otherwise), W_7= Nativity (1=native, 0 otherwise), W_8= Access to tarred road (1=yes, 0 otherwise), W_9= Access to potable water (1=yes, 0 otherwise), W_{10}= Extension contact (access=1, 0 otherwise), W_{11}=Market location (1 if located in the community, 0 otherwise), W_{12}= Household size (number of members), W_{13}= Household income(naira), W_{14}= Farm size (Ha), W_{15}= Simpson index, W_{16} = Land acquisition (1=inherited, 0 otherwise), W_{17}= Land type (1=lowland, 0=upland), W_{18}= Zero tillage (proportion of parcel on which practice was adopted), W_{19}= Agroforestry (proportion of parcel on which practice was adopted),W_{20}= Use of organic compost (proportion of parcel on which practice was adopted)

RESULTS AND DISCUSSION

Perception of Farmers to Climate Variables

The results on Table 1 reports the response of respondents. It revealed that most of respondents (65%) perceived that average day time temperature increased substantially. In addition, 47.6% of them perceived an increase in the length of dry season or prevalence of droughts in the last 25 years, this implies that an average respondent in the study area perceived that the length of dry season had increased, compared to the last 25 years. This is in accordance with the findings of Adebayo *et al*. [21] who reported that 82% of respondents perceived an increase in day time temperature in Nigeria.

Table 1: Distribution of Farmers by their Perception to Change in Climate Variables

Climate Variables	Increased substantially	Increased slightly	Remain the same	Declined slightly	Declined substantially
Daytime temperature	346(65)	109(20.5)	46(8.6)	19(3.6)	12(2.3)
Dry season length	253(47.6)	163(30.6)	67(12.6)	40(7.5)	9(1.7)
Volume of rainfall	86(16.2)	80(15)	79(14.8)	148(27.8)	139(26.1)
Rainy season length	66(12.4)	74(13.9)	64(12)	180(33.8)	148(27.8)
Incidence of flood	92(17.3)	111(20.9)	174(32.7)	96(18)	59(11.1)
Intensity of storms	115(21.6)	105(19.7)	196(36.8)	73(13.7)	43(8.1)
Intensity of harmattan	90(16.9)	111(20.9)	139(26.1)	108(20.3)	84(15.8)
Prediction of rainfall	51(9.6)	66(12.4)	134(25.2)	130(24.4)	151(28.4)

Dryness of the soil	201(37.8)	136(25.6)	111(20.9)	37(7)	47(8.8)
Unusually high rainfall	79(14.8)	123(23.1)	180(33.8)	67(12.6)	83(15.6)

Figures in parenthesis are percentages

Furthermore 27.8% of the respondents perceived a decline in the average volume of rainfall while 33.8% perceived decline in the rainy season length, which however implies that an average respondent felt that the volume of rainfall and the rainy season length had decreased relative to the last twenty-five years. The results as presented in Table 1 also shows that the respondents do not perceive any change in relation to incidence of flood (32.7%), intensity of storms (36.8%) and intensity of harmattan (26.1%) which implies that on the average, respondents in the study area perceived that incidences of flood and river overflow beyond its bank, frequency and intensity of storms and intensity of harmattan has not changed compared to the last twenty-five years. Furthermore, 28.4% of the respondents perceived a substantial decline in the prediction of rainfall which implies that an average respondent in the study area perceived a decrease in the prediction of rainfall within the last twenty-five years. Lastly, while 37.8% perceived a substantial increase in the dryness of soil and unusually high rainfall (33.8%) in the study area. This imply that an average respondent in the study area felt an increase in the dryness of soil and incidences of unusually high rainfall and thunderstorms to those obtainable in the last twenty-five years.

Distribution of respondents by adoption of climate smart practices

The results presented in Table 2 below revealed that adoption of the CSPs was generally low among cereal farmers in southern Nigeria. Agroforestry (9%) and use of organic compost (8.8%) were the least adopted practices. Minimum tillage was adopted 34% of the Farmers while residue retainment was adopted by 52.1% of the household head.

Table 2: Distribution of Farmers by Adoption of Climate-Smart Practices

Climate-Smart Practices	Frequency	Percent
Agroforestry		
Not adopted	1217	91.0
Adopted	121	9.0
Organic Compost		
Not adopted	1220	91.2
Adopted	118	8.8
Minimum Tillage		
Not adopted	883	66.0
Adopted	455	34.0
Residue retainment		
Not adopted	641	47.9
Adopted	697	52.1

Farm household's food security status

The results of the analysis of households' food security using the USDA food security assessment is presented in Table 3. The Result revealed that about 55% of the sampled households were food secure while 45% were food insecure. This represents an improvement in the food security status 35% reported by Davies [22].

Table 3: Household Food Security Status

Food Security Status	Frequency	Percentage
High Food Security	129	26
Marginal Food Security	144	29
Low Food Security	115	23.2
Very Low Food Security	108	21.8

Influence of adoption of CSPs and other socioeconomic characteristics on food security status of farm households

The parameters of the Ordered Probit model were estimated by maximum likelihood estimation. Estimation results are shown in Table 4 for the food security model. The standardized coefficient estimates are shown, a goodness-of-fit statistic, the adjusted log likelihood index ratio, is also presented in the result. The log likelihood function of the estimated model is -681.34 with the associate chi-square value of 57.95 is significant ($p<0.0001$), implying that ordered Probit can be relied upon to predict the determinants of food security status among farm households in the study area. The main focus of this discussion is on the Z-value which reflects the statistical significance of the independent variables. The changes in the probability levels of the dependent variables was estimated and this provide some interpretation of the substantive effect of the independent variables. The result indicated that age of the household head which was measured in years has a positive and significant coefficient ($p<0.05$). This implies that as the age of the household head increases, their households tend to be more food secure. This is similar to the findings of [23] who argued that as the age of an individual increases, the typical income stream rises in the early years which implies an increased probability of being food secure, reaches a plateau in middle years and then followed by a sudden decline upon retirement, which implies a decreasing probability of being food secure.

Table 4: Influence of Adopting of CSPs and other Socioeconomic Characteristics on Household Food Security Status

			High food security		Marginal Food security		Low Food security		Very low food security	
Characteristics	**Coef.**	**Z**	**0.2841**	**Z**	**M.E 0.2961**	**Z**	**0.2311**	**Z**	**0.18859**	**Z**
Age	0.0094**	2.05	0.0032*	2.05	0.0005*	1.77	-0.0011*	-1.96	-0.0025**	-2.06
Gender	-0.2604*	-1.78	-0.0832*	-1.89	-0.0198	-1.35	0.0270**	2.07	0.0760*	1.66
Marital status	0.2399	1.29	0.0856	1.24	0.0056	1.56	-0.0322	-1.19	-0.0590	-1.43
Years of schooling	0.0172*	1.66	0.0058*	1.66	0.0009	1.51	-0.0021*	-1.65	-0.0046*	-1.65
Access to credit	-0.2257*	-1.96	-0.0754**	-2	-0.0131	-1.58	0.0262*	1.97	0.0622*	1.92
Farmers association	0.0975	0.45	0.0322	0.46	0.0061	0.38	-0.0111	-0.48	-0.0273	-0.43
Nativity	0.2303*	1.8	0.0749*	1.88	0.0159	1.38	-0.0251**	-2	-0.0657*	-1.69
Access road	0.7302***	2.84	0.1929***	3.99	0.0897**	2.01	-0.0362***	-2.85	-0.2465***	-2.48
Access to potable water	0.2040	1.12	0.0723	1.08	0.0055*	1.84	-0.0271	-1.04	-0.0508	-1.23
Access to extension contact	0.0838	0.74	0.0280	0.75	0.0049	0.66	-0.0098	-0.76	-0.0231	-0.73
Access to market	-0.1691	-1.19	-0.0591	-1.16	-0.0060*	-1.64	0.0218	1.11	0.0433	1.27
Household size	0.0100	0.81	0.0034	0.81	0.0005	0.79	-0.0012	-0.81	-0.0027	-0.81
Income	1.79E-08*	1.67	6.07E-09*	1.67	9.29E-10	1.52	-2.16E-09*	-1.64	-4.84E-09*	-1.67
Farm size	0.0042	0.96	0.0014	0.95	0.0002	0.93	-0.0005	-0.95	-0.0011	-0.95
Simpson index	0.6272***	3.06	0.2126***	3.08	0.0325**	2.22	-0.0757***	-2.81	-0.1694***	-3.06
Farm ownership	0.1454	1.38	0.0493	1.39	0.0075	1.27	-0.0176	-1.36	-0.0393	-1.38
Type of land	0.0988	0.68	0.0335	0.68	0.0051	0.68	-0.0119	-0.68	-0.0267	-0.68
Minimum tillage	0.1014	0.86	0.0344	0.86	0.0053	0.84	-0.0122	-0.86	-0.0274	-0.87
Agroforestry	0.3269**	2.09	0.1108**	2.07	0.0169*	1.87	-0.0395**	2	-0.0883**	2.09
Use of organic Compost	0.2925**	2.11	0.0992**	2.1	0.0152*	1.85	-0.0353**	2.01	-0.0790**	2.12
/cut1	0.7384	-0.1433								
/cut2	1.4189	0.5326								
/cut3	2.1921	1.3012								
Wald chi2(21)	57.95									
Prob>chi2	0									
Log-Pseudolikelihood	-681.34									
Pseudo R2	0.0391									

Gender of the farmer also has a negative significant coefficient (p<0.10), this implies that male headed household have reduced probability of being food secure than female headed household. In the same vein, years of formal education have a positive significant coefficient (p<0.10) this implies that increase in the years of formal education will increase the probability of being food secure. Furthermore, access to credit have a negative significant coefficient (p<0.10) this implies that households that does not have access to a credit source have reduced probability of being food secure. In the same vein, nativity have a positive significant coefficient (p<0.01) which implies that household that are native of the study area have increased probability of being food secure while access to good roads have a significant positive coefficient which implies that households that have a good road network have increased probability of being food secure.

In addition, increase in the income (p<0.10) and Simpson index (p<0.01) of household head tends to increase their probability of been food secure. With respect to the climate smart variables, adoption of agroforestry (p<0.05) and use of organic compost (p<0.05) was found to have a positive significant coefficient this implies that households that uses a large proportion of their land for agroforestry and also applies organic compost on their farms tend to be more food secure than others, this may be because the tree species they had on their plots yield huge benefits thereby improving the household food security status.

The marginal effect results revealed that in the high and marginal food security categories, a unit increase in the age of the household head will increase the probability of being food secure by 0.0032 (p<0.05) and 0.0005 (p<0.10) respectively while it will decrease the probability of being food secure in the low and very low food security category by 0.0011 (p<0.10) and 0.002 (p<0.05), respectively. Male headed household will increase the probability of being low and very low food secure by 0.0270 (p<0.05) and 0.0760 (p<0.10) and also decreases the probability of being high and marginal food secure by 0.0832 (p<0.10) and 0.0198, respectively. Also, a unit increase in the years of education of the household head will increase the probability of being food secure by 0.0058 (p<0.10) and 0.0009, respectively while it will decrease the probability of being food secure in the low and very low food security category by 0.0021(p<0.10) and 0.0046 (p<0.10), respectively. Households who had access to good road network tend to have an increased probability of being high and marginal food secure by 0.1929 (p<0.01) and 0.0897 (p<0.05), respectively and reduced probability of being low and very low food secure by 0.0362 (p<0.01) and 0.2465 (p<0.01).

Households that are natives of the study area have increased probability of high and marginal food secure by 0.0749 (p<0.10) and 0.0159 and reduced probability of being low and very low food secure by 0.0251 (p<0.05) and 0.0657(p<0.10). In the same vein, a unit increase in household income of the household tend to increase their probability of being high and marginal food secure by 6.07E-09 (p<0.10) and 9.29E-10, respectively and also decrease the probability of being low and very low food secure by 2.16E-09 (p<0.10) and 4.84E-09 (p<0.10), respectively.

Moreover, a unit increase in Simpson index have decreased probability of being low and very low food secure by 0.0757 (p<0.01) and 0.1694 (p<0.01) respectively and also increase the probability of being high and marginally food secure by 0.2126 (p<0.01) and 0.0325 (p<0.05) respectively.

The marginal effect in household that uses a large proportion of land for agroforestry revealed that they tend to have reduced probability of been low and very low food secure by 0.0395(p<0.05) and 0.0883(p<0.05), respectively and an increased probability of being high and marginally food secure by 0.1108 (p<0.05) and 0.0169(p<0.10), respectively. While use of organic compost revealed that they tend to have reduced probability of been low and very low food secure by 0.0353 (p<0.05) and 0.0790 (p<0.05) respectively, and an increased probability of being high and marginally food secure by 0.0992 (p<0.05) and 0.0152 (p<0.10), respectively.

CONCLUSION

Farmers perception of climate change agrees with meteorological data, in that day time temperature and length of dry season had increased, while the average volume of rainfall and length of rainy season had reduced which may have a negative effect on farmers' livelihood pattern in the study area which may in turn affect their production efficiency and income. The food security status determined in this study show that more effort must be made to improve the food security status of households in the study area in order to achieve the sustainable development goals which is to end hunger, achieve food security and improved nutrition. Education and enlightenment programmes on adoption of CSPs should be encouraged by extension agents and also target small holders as they have shown to have increased probability of being food secure through increase in formal education.

Furthermore, youths and young adults should be encouraged to engage in agricultural production because they are still economically active in this age as it increases the probability of their household food security status. Government should invest more in providing basic amenities to the rural populace as access to good road network and nearness to market tend to improve the household food security. Small holder farmers should be encouraged to continue the use of CSPs as their use tend to have a positive influence on the household food security status.

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