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EFFECT OF CLIMATE SMART AGRICULTURAL PRACTICES ON FOOD SECURITY STATUS OF CROP FARMERS IN TORO, BAUCHI STATE, NIGERIA

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ABSTRACT

Climate change remains a threat to agricultural production and the achievement of national food security objective. Adoption of Climate Smart Agricultural Practices (CSA) therefore offers potential pathway to sustainable food production, reduction of greenhouse gases and improved household food security. This study was carried out in Toro, Bauchi State, Nigeria to assess the effect of CSA on food security status of smallholder crop farmers. Primary data were collected through survey questionnaire. Random sampling procedure was used to select respondents in the study area. Ten (10) villages were selected randomly out of the three (3) districts. Fourteen questionnaires were distributed randomly to the farmers in each selected village to make the overall sample size of 140 respondents. Data were analysed using descriptive statistics, food security index and logit regression model. The result revealed that the major CSA measures practiced by the farmers were early planting (64%), mixed cropping (61.6%) and cover cropping (44%).The result of food security index revealed that the food security counts index (P_0) for entire households was 0.488 and food security gap or depth(P_1) was 0.206 while food insecurity severity index (P_2) was 0.128. The logit regression model shows that there was a positive relationship between CSA and food security. The variables of gender, years of schooling, farm size and farming experience were significant. A unit increase in any of these variables could increase the probability of food security of households in the study area. However, age, off-farm income and average distance from farm exert negative influence on food security status of farmers. The study therefore concludes that a massive enlightenment on the danger posed by climate change and the need to adopt climate smart agriculture in order to enhance food security and alleviate poverty among the farmers.

Keywords: Food Security, Climate, Smart, Agricultural Practices, Farmers

Introduction

Agriculture has been high on the political agenda as it is increasingly recognized as one of the biggest drivers of environmental change (Smith *et al*., 2007; Liverman and Kapdia, 2010; Foresight, 2011). Agricultural lands occupy about 40 – 50% of the earth's land surface (Smith *et al*., 2007). It is estimated that agriculture is responsible for about three-quarters of tropical deforestation (Carr, 2004; Skutsch *et al*., 2007; Wollenberg *et al*., 2012) and accounts for about 10 – 12% of the total global anthropogenic emissions of greenhouse gases (GHGs) in 2005 (Smith *et al*., 2007).

Yet, the world needs more food than ever before to sustain the increasing population of people living in extreme hunger, especially in Nigeria where about 70% of the people are engaged in some sort of agricultural activity(FAO, 2018).While there is need to redouble efforts in agriculture in order to fight hunger, there is adequate evidence for us to be wary of its environmental sustainability. The need for a more sustainable approach to agriculture is the key and holds enormous potential to contribute to any strategy to adapt to climate change and reduce emissions particularly in a Nigerian context (Beddington *et al*., 2011).

To this end, over the last decades, there has been development and promotion of several initiatives aimed at promoting sustainable agriculture (Beddington *et al*., 2012). Many of these have emphasized the need for Nigerian farmers to engage in an agricultural system that ensures food security whilst at the same time addressing and adapting to climate change. Also emphasized is the need for policy makers to recognize the nexus between agriculture and environmental change which needs to be balanced and taken into account in decision making for agriculture (Foresight, 2011).

Climate-smart agriculture (CSA) is one approach that has been championed as the "holy grail" of agricultural development (Naess, 2011) ensuring that agriculture is key to climate change adaptation and mitigation (Wollenberg *et al*., 2011; Beddington *et. al*., 2012). Climate-smart agriculture is derived from the acronym SMART which means: specific, measurable achievable, reliable and timely, (McCarthy *et. al*., 2012). According to the Food and Agriculture Organization (FAO 2013), CSA is a method of agriculture that sustainably increases productivity, resilience (adaptation) reduce/removes greenhouse gases (migration) while enhancing the achievement of national food security and development goals.

There are three (3) main pillars to any CSA approach, the sustainable increase in agricultural productivity and incomes; adapting and building resilience to climate change and reducing or removing greenhouse gases emissions.As such, agriculture is considered to be "climate-smart" when it achieves these three objectives. This concept is therefore, a good way to unite the agendas of agriculture, development and climate change under one brand(McCarthy *et. al*., 2012).The CSA approach has been widely championed with a rapid uptake of the concept by the international environments and cultures to ensure such community, national entities and local institutions, (Branca *et. al*., 2011).

CSA has been applied with positive outcomes in Nigeria (FAO, 2013; Branca *et. al*., 2011). There is even the suggestion that the adoption of CSA practices in northern Nigeria will improve (indigenous) traditional agricultural systems as well as encourage the practice of agro-ecological agricultural knowledge and science and technology for development (IAASTD, 2009). This however, has not been empirically proven and there are few studies supporting this assertion. Establishing the potential applicability of agriculture and Climate-Smart Agriculture in the context of developing society's food security is critical to creating its wide uptake by farmers and enhances the political will required to motivate deep transformations within the policy sector.This study therefore evaluates climate smart agricultural practices with a link to food security status of farmers in the study area.

Methodology

The Study Area

This study was conducted in Toro Local Government Area of Bauchi State. It is located between latitude $9^{O}3$'N and $12^{O}3$'N and longitude $8^{O}5$'N and 11^{O}E. It cover a total land area of 6932Km^2 and a total population of 419,655 (Departments of works, land and survey, projected population, 2008). It has its administrative capital in Toro. It share boundaries with local governments such as Dass to the south, Ningi to the North, Bauchi to the east and Jos occupies the western flanks of the Local

Government Area. The average annual rainfall ranges from 700-820mm per annum. The raining season start from April rising to its peak in August and terminate in October. It has two seasons: wet and dry. Toro local government generally has fair weather with temperature ranges between 35^{O}C for lowland and 31^{O}C of highland (Department of Work, Land Survey, 2008). The vegetation area is Sudan savannah, and it has a vast fertile soil which is an advantage to cattle rearing and agricultural production. The Local Government Area is divided into three (3) districts which include Toro district with headquarter at Toro, Jama'a district with headquarter at Nabordo and Lame district with headquarter at Gumau.

Sampling Technique and Sample Size

Farmers in the study area constituted the population of the study. There are three (3) districts in the study area that make up 11 political wards. Ten (10) villages were selected randomly out of the three (3) districts. Fourteen copies of questionnaires were distributed randomly to the farmers in each selected village to make the overall sample size of 140 respondents.

Data collection and analysis

The main sources of information was primary data. The data were collected through the administration of well structural questionnaires complemented by oral interview during the survey period. The questionnaire was set based on the objectives of the study. Data for this study were analyzed using descriptive statistics, food security index and logit regression.

Food Security Index

The approach taken in this study for the determination of food security index followed the identification and aggregation procedures. Identification is the process of defining a minimum level of nutrition necessary to maintain healthy living. This is referred to as the food security line below which people are classified as food insecure and subsisting on inadequate nutrition. The food security line used in this study is based on the daily recommended level of calorie and protein which are 2260 kcal and 65g respectively (FAO,2012). In order to generate food security indices the nutrient content of the crop consumed was used to drive both calorie and protein availability.

Food Security Index (k) = Household daily per capita calorie protein consumed (x)

Household daily per capita calorie protein required (y)

Or

$$Ki = \frac{x_i}{y}$$

Where; Ki represents Food Security Index of *ith* household, x_i is Actual Daily Calorie Intake of i th households and y is the recommended daily calorie requirement of the *ith* household. For a household to be food secured k must be greater than or equal to one (1) (K ≥1). If k is less than 1 (K>1) the farmers is food secure. It must be satisfied for both protein and calorie requirements. The quantity of crops produced and purchased were converted to kilogram and further to calorie and protein respectively and was divided by adjusted farmers size and by 365 day to obtain the calorie and protein consumed per day per farmers and then compared with the standard (2260kcal and 65g) respectively.

For the purpose of this study, a farmer's household is a group of individuals who contributed to and shared a common economic resources base and relied on the income form that base for the greater part of their food acquisition and utilization. The nutrient composition of commonly eaten foods in Nigeria (World Bank, 2012) was used to estimate the calorie intake of farmers. On the other hand, the equivalent male adult scale to determine adjusted farmers size computed by FANTA (2006) was used. Most studies focus attention on calorie availability and consumption in assessing food security status of respondents (Fan,*et. al*. 2004), because according to them most diets contain adequate amounts of all other nutrients required for good and healthy living ones it is taken in quantity that is enough to meet the individuals energy requirements.

Logit Regression Model

Logit model was used to assess the factors that determine the relationship between food security of farming households and climate smart agricultural practices by farmers in Toro. Logit regression analysis is a uni/multivariate technique which allows for estimating the probability that an event occurs or not, by predicting a binary dependent outcome from a set of independent variables. The linear probability model is depicted by (Johnson and Wichern, 1992) as:

$$P_i = \in (\gamma = 1/X_i) = \beta_1 + \beta_2 X_i \qquad (1)$$

Where *Xi* refers to the variables that influenced the food security/insecurity while *Y* refers to whether the farmers are food secured or otherwise. Let us consider the following representation of determinants of food security.

$$P_1 = \in (\gamma = 1/X_i) = \frac{1}{1+exp[-(\beta_1+\beta_2X_i)]} = \frac{1}{1+exp(-Z_i)} \qquad (2)$$

Where,

$$Z_i = \beta_1 + \beta_2 X_i \qquad (3)$$

This equation 3 is known as the (cumulative) logistic distribution function. Here Z_i ranges from $-\infty$ to $+\infty$; P_i ranges between 0 and 1; P_i is non-linearly related to Z_i (i.e X_i) thus satisfying the two conditions required for a probability model. In satisfying these requirements, an estimation problem has been created because P_i is non-linear not only in *Xi* but also in the *β*'*s*. This means that one cannot use OLS procedure to estimate the parameters. Here, P_i is the probability of households being food insecure given by:

$$\frac{1}{1+exp(-Z_i)} \qquad (4)$$

Then (1-*Pi*), the probability of being food secure is:

$$(1 - P_i) = \frac{1}{1-exp(Z_i)} \qquad (5)$$

Therefore, one can write

$$\frac{P_i}{(1-P_i)} = \frac{1+\exp(Z_i)}{1+exp(-Z_i)} \qquad (6)$$

$P_i/(1-P_i)$ is the odds ratio in favour of farmers being food secure, that is the ratio of the probability that a farming household is food secure to the probability that they are insecure. Taking natural log of (Z), we obtain:

$$L_i = ln[P_i/(1 - P_i)] = Z_i = \beta_0 + \beta_1 X_1 + \cdots + \beta_6 X_6 + e \qquad (7)$$

That is, the log of the odds ratio is not only linear in Xs, but also linear in the parameters. L is called the logit. The parameters to be estimated include the following:

Zi = Food security status (1 = food secure, 0 = otherwise)

β_0= intercept
β_1 = Estimated parameters
Xi-n= set of independent variable
X_1=gender (male =1and female=1)
X_2=Age of farmers (in years)
X_3=Marital status
X_4=Year of schooling (years)
X_5= Farm size (hectare)
X_6= Farming experience (years)
X_7=Household size (number)
X_8=Membership of association
X_9=Off farm income generation (naira)
X_{10}=Access to credit facility (amount of credit received)
X_{11}=Access to agricultural extension service (number of contact)
X_{12}=Average distance from farm (kilometer)
X_{13}=Number of climate smart practice (Number)
e = error term

Result and Discussion

Climate smart agriculture measure practice by respondents

Result in Table 1 shows that majority (64%) of the famers in the study area mostly practiced early planting as a climate smart agriculture, followed by mixed cropping (61%) and cover cropping (44%). Another (21%) practiced plots fragmentation, followed by multiple planting date (15%) while (12%) practice irrigation/dry season farming. This implies that the farmers put effort in mitigating the effect of climate change in the study area. The farmer's decision to adopt or reject CSA is influenced by the simultaneous effect of a number of factors related to the farmer's objectives, constraints, and characteristics, the bio-physical characteristics of the location, asset ownership, and the attributes of the technology (Aryal *et. al*. 2018; Aryal *et al.* 2017; Mwungu *et al*., 2018). For example, it was hypothesized that a farmer's age can either create or reduce confidence in new technology. More experienced farmers can be conservative, thereby avoiding new technologies. On the other hand, experienced farmers can also be willing to try new technologies if they have done it once and obtained positive results.

Table 1:Distribution based on Climate Smart Agriculture Measures Practiced on Farms

CSA	Frequency*	Percentage (%)
Early planting	80	64
Mixed cropping	77	61.6
Cover crops	55	44
Multiple planting date	19	15.2

Plots fragmentation	27	21.6
Irrigation/dry season farming	17	12.6

***** Multiple responses allowed

Food Security by the respondents

The food security analysis revealed that the total household expenditure was obtained ₦4,319 per month for the respondents in the study area. The finding in Table 2 revealed that the food security status of the respondents in the study area was categorize in to two which is: food security and food insecurity. The FGT, analysis showed that the food insecurity counts index (P_0) for the entire households which represents the proportion of households below the food security line was 0.488 which implies that 48% of the farming households in the study area were food secure. This could probably be the reason why 52% of them were food insecure.

The food security depth (P_1) which represents the expenditure proportion required to allow households below the food security line acquire the minimum food expenditure that moves them out of food insecurity was 0.206. This implies that 21% (₦907) of the food security line is required to bring them out of food insecurity. The food security severity (P_2) which measures the severity of food insecurity was found to be 0.128. This means that among the food insecure households, 13% were severely food insecure. The result connotes that most rural households are food insecure. For instance, John *et. al*. (2013) found that majority (60%) of farming households in forest communities of central region of Ghana were food insecure. This implies that the study area was potentially food insecure since the number of food insecure households was greater than food secure households.

Table 2: **Distribution of households based on food security**

Food security Category	Frequency	Percentage
Food secure	60	48
Food insecure	65	52
Total	125	100
FGT Food Security Indices		
Incidence (P_0)	0.488	
Depth (P_1)	0.206	
Severity (P_2)	0.128	
Food Security Line		
THFE	₦6478.5 per month	
2/3*THFE	₦4319 per month	

THFE= Total Household Food Expenditure

Determinant of Food Security

Table 3 shows the relationship between food security and climate smart agricultural practices among the respondents as determine using the logit regression model. The result showed that the coefficient obtain for gender was significant at 10% level of probability and had positive coefficient. This implies that as the male gender dominates food production, food security is likely to increase by 1.27%. Study by Fawehinmi and Adeniyi (2014) found that gender statistically influence food security positively among male headed households.

The coefficient obtained for age was significant at 5% level of probability and had negative coefficient of (-0.0830) which implies that an increase in age would decreases farming activities and consequently promote food insecurity. It is a well-known fact that the older the farmers, the less capacity they have in the process of making or providing enough food to their families. This corroborated the findings of Sokoya *et al*. (2006) that farmers tend to be less productive as they advance in age because their natural strength diminishes, likewise their mental capability.

The coefficient obtained for the farm size was significant at 5% level of probability with a positive coefficient of 0.1674. The sign of the coefficient shows that an increase in farm size, could lead to the increase farming activities, thereby enhancing their food security status. This indicated that climate smart agriculture practice by the farmers decreased as the farm size increase. This result is consistent with the result of (Belay, *et. al.* 2017) who stated that bigger farm size accrues benefits of economies of scale to farmers and also provide a means of diversifying production. In the process, they tend to adopt technologies that will save their time and increase their farm yield. The coefficient obtained for the farming experience was significant at 10% level of probability and with positive coefficient of 0.0984. This result is in line with the report of Food and Agriculture Organization (2012) who stated that farmers with 14 years of farming experience are regarded as "experienced farmers". It indicates that farmers with experience will easily practice Climate Smart Agriculture to mitigate the effect of climate changes to increase food security. Kassie *et. al*. (2010) noted that farmers who have experience the havoc caused by natural disaster such as drought, flood and other vagaries of nature on crops are likely to adopt CSA and other crop improvement technologies such as crop rotation and drought-resistant seeds. This will consequently enhance their food security status.

The coefficient of off farm income was significant at 10% level of probability with negative coefficient of -1.0609. This result implies that off-farm income had negative effect on the food security status of respondents. This means that a unit increase in this variable could lead to an improvement in the level of food insecurity while decrease of this variable could increase the level of household food insecurity. This is expected because rising off farm income makes it possible for farmers to adopt high yielding varieties, apply fertilisers and pesticides, and use farm machinery, leading to higher crop yields and hence food availability. The coefficient of distance from farm was significant at 10% level of probability but with negative coefficient. This indicates that the farther the abode of the farmers is from the farms, the more food insecure they tend to be. Conversely, the closer the farmers are to their farms, the more food secure they possibly tend to be. Teklewold *et al*. (2013) noted that apart from affecting the access to the market, distance can also affect the accessibility of new technologies and information, thus having a negative relationship.

The coefficient obtained from number of practices was significant at 10% level of probability. This indicates that a unit increase in the coefficient of these variables will improve food security status. This implies that farmers were deliberate in putting effort to practice CSA thereby promoting their productivity and thus ensuring that they were food secure. This finding was confirmed by FAO (2013) who

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reported that agricultural policies such as CSA are the basis for achieving food security and improving livelihoods and that an effective combination of sustainable agriculture and climate change policies can boost green growth, protect the environment and contribute to the eradication of hunger and reduce high poverty rate in the rural areas.

The chi-square value was positive and significant. On the overall, the parameter estimates shows that the variables included in the study were appropriate and a good fit to the model. Based on the finding of the study, the hypothesis which states that there is no significant relationship between the socio-economic characteristics of farmers and their food security status is rejected while the alternative hypothesis which states that there is a significant relationship between the socio-economic characteristic of farmers and their food security status is accepted.

Table 3: Determinant of the food security status of the respondents

Variable	Coefficient	Standard error	T-value
Constant	2.1115	1.6029	1.32
Gender	1.2721	0.7512	1.69*
Age	-0.083	0.0358	-2.32**
Marital status	0.0182	0.1946	0.09
Year of schooling	0.022	0.0541	0.41
Farm size	0.1674	0.0731	2.29**
Farming experience	0.0984	0.0506	1.95*
Household size	0.0273	0.0677	0.400
Membership of association	0.1234	0.3093	0.400
Off farm income generation	-1.0609	0.544	-1.95*
Access to credit facility	0.404	0.6741	0.600
Access to agriculture service	0.5468	0.4982	1.100
Average distance from farm	-0.2212	0.1191	-1.86*
Number of CSA practice	-0.2013	0.1174	-1.71*
Log likelihood function	-69.439		
Pseudo R2	0.182		
Prob> chi2	0.0298		

Note: ***significant at 5% and * significant 10% levels of probability

Conclusion and Recommendations

Climate smart agricultural practices had positive influence on food security status of the farmers. The food insecurity incident became higher with increase in household size, age and poverty but it declined with increase in level of education, decreased in age and household size. The study suggests that a decrease in these variables will lead to a reduction of food insecurity and poverty thereby making them to be food secure and out of the hold of hunger in the study area.

By this study, it is recommended that mass literacy programmes should be introduced to enlighten the farmers about the different mitigation measures to climate change. This will have the double benefits of poverty alleviation and they will be food secured.

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