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EFFECT OF CLIMATE SMART AGRICULTURAL (CSA) PRACTICES ON PROFIT EFFICIENCY OF MAIZE FARMERS IN OYO AND OGUN STATES, NIGERIA

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ABSTRACT

Climate smart agricultural practices remains an adaptive strategies that must be promoted to address climate change problem and declining agricultural productivity with poor resource use among smallholder farmers in Nigeria. This study evaluates the effect of climate smart agricultural practices on profit efficiency of maize farmers in Oyo and Ogun States of Nigeria with a view to ensure resilience in food production and reduction in environmental degradation inhibiting increased food production. A multi-stage sampling procedure was used to select 370 maize farmers across4 Local Government Areas and 16communities in the two States. Primary data were obtained from the farmers through questionnaire administration on their socio-economic characteristics, CSA adopted, maize production resource use and costs during farm season by the farmers. Data were analysis using descriptive statistics and Stochastic Frontier Profit Function. The study showed that CSA adoption was generally low except for the use of improved seed variety that was adopted by more than 50% of the farmers. The parameter estimates of the profit function showed that farm size (ß = 0.5629, p<0.10), average price of labour (ß = 1.7050, p<0.05) and herbicide (ß = 1.7048, p<0.01) were the significant variables in profit efficiency model. Socioeconomic factors influencing profit inefficiency were household size and farming experience. CSA variables affecting profit efficiency were cover cropping, agroforestry and crop rotation. The estimated average estimated profit efficiency was 0.37. Hence, agricultural policy that will increase adoption of CSA and enhance regular farmers' training, improvement of extension services and better credit facility should be established in the study area in order to reduce the shortfall in profit efficiency.

Keywords: Climate, Smart, Agricultural practices, Profit efficiency, Maize farmers

Introduction

Agriculture remains the backbone of Nigeria economy. The sector accounts for 22.35% of the real Gross Domestic Product and about 88.0% of non-oil export earnings (National Bureau of Statistics, 2021). Despite the potential roles of agriculture in Nigeria economic growth and achievement of food security objective, food is produced less than the quantity required by most households creating a demand-supply gap due to low productivity and poor environmental conditions (Otaha, 2013; Eregha *et al*., 2014). Agricultural production in most developing countries particularly Nigeria is weather dependants (Onyeneke, 2010).

This is making climate to be an important resource in food production. Many studies have noted that agriculture would continue to be affected by varying climate (Smith *et al.*, 2014; McCarthy *et al.*, 2001; Onyeneke, 2010). Therefore, promotion of climate smart agricultural practices becomes an option and adaptive option to variability in weather pattern.

It is expected that agricultural production system should be transformed in order to increase productive capacity and stability in the face of climate change. Climate change has caused significant impacts on resources that are useful for agricultural production and food security (FAO, 2013). Persistent increase in temperature and irregular rainfall pattern affects food production with attendant decline in crop and livestock output. Addressing the menace caused by climate change has proved challenging. Low returns from agricultural production has been attributed to varying weather condition with great effect on many ecosystem services such as nutrient cycling, nitrogen fixation, soil regeneration and pest and disease control through biological method. Hence, these have impacted adversely on sustainable food production among smallholder farmers (Lee, 2005; Teklewold *et al.*, 2013).

Climate-smart agriculture (CSA) is climate change adaption technique that encourages development of agricultural systems with a set of practice and approach capable of achieving multiple objectives such as improved food security, increased resilience in food production and low-emissions development (FAO, 2010). CSA focused on the strategic effort of integrating climate change and agriculture in development planning with a view of aggregating opportunities to link adaptation and mitigation efforts. The approach aims to ensure planning around climate change and agriculture is holistic, maximizing multiple outcomes and minimizing tradeoffs in management of food systems that generates significant quantity of green house gas (World Bank, 2011).

The need to ensure the resilience and viability of farms and food systems particularly maize production, which is the most important cereal crop in the economy of African countries and one of the most important food aid commodities, is a pressing and increasingly salient issue of concern (Olaniyan, 2015). Increased productivity and improved resource use thereby depend on sustainable environment and good climate adaptive strategy, for example, the higher the quality of the soil, the higher the resilience of the land to environmental disturbances such as erosion and flooding (Osteen *et al*., 2012). Productivity of land must be ascertained and enhanced for farmers to remain in the business of food production. Moreso, the environmental and climatic impact of agricultural production can be reduced through efficient utilization of productive resources and reduced production loss.

Among arable crops that are widely grown by smallholder farmers in Nigeria, maize is the most preferred (Olaniyan, 2015). The importance of maize cannot be over-emphasized in the developing world, including its potential to mitigate the present food insecurity and alleviate poverty. Maize is a staple food that is consumed by most households in different forms (IITA, 2010). In sub-Saharan Africa, the absence or shortage of maize invariably leads to famine and starvation. It is estimated that by 2050, the demand for maize in developing countries will double (IITA, 2010) hence, the need for strategic effort to increase maize production.

Farmers' decision with respect to the adoption of CSA and efficient utilization of productive resources will influence the viability of their operations. Emphasis should be placed on the need for farmers to intensify the use ofCSA to reduce the negative impact and adaptation strategy for coping with climate change (Walthall *et al.,* 2013). Smallholder farmers are heterogeneous in nature and they will prefer to adopt combinations of practices in order to address varying constraints they encountered. Considering economic rationality assumption, smallholder farmers who depend on food production for livelihood sustenance would adopt technologies that reduce costs of production with increasing benefits from greater incomes through improved yields. This study therefore, evaluates the effect of CSA adoption on profit efficiency of the farmers in the study area.

Methodology

Study Area

The study was conducted in Oyo and Ogun States. Oyo State is found in southwestern Nigeria and it is an inland State. It covers 27,107.93 square kilometers. The State lies between latitudes 7^{o}N and 9^{o}N of the equator and between longitudes 2.5^{o}E and 5^{o}E of the prime meridian (Oladejo *et al.,* 2011). The State exhibits the typical tropical climate with averagely high temperatures, high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October (Olaoye *et al*.,2013). The mean temperature of the area is 27^{O}C. The pattern of rainfall is bimodal having its peak in June and September, while November to February is characterized by harmattan brought about by the effect of the north easterly trade winds from the Sahara desert. Oyo State has a projected population of 7,743,221, using a population growth rate of 3.2% from 2006 population census (NPC, 2006). Oyo State covers an area ranging from swamp forests to western uplands. In-between are rain forests and deciduous savanna. The dominant sector for the overall development thrust of the State is agriculture. Farming is the major occupation among the inhabitants of the State with favorable climate that support production of maize, yam, cassava, millet, rice, plantains, cocoa, palm produce, cashew etc.

Ogun State lies approximately between latitude 3^{o} N and 4^{o} N and longitude 6^{o}E and 7^{o}E (Ambali *et al.,* 2012). It shares boundary with Republic of Benin in the West, Lagos State and Atlantic Ocean in the South, Ondo State in the East and Oyo State in the North. Ogun State covers a land area of 16,762 sq km with a population of 3, 728, 098 and a population growth rate of 3.2% (NPC, 2006). The State lies within the humid tropical lowland region with two distinct seasons. The shorter dry season lasts for four months usually from November to February (Ambali *et al.,* 2012). The climate of Ogun State is a tropical climate. The rainy season usually starts in March and ends in November. This is usually followed by the dry season. Average annual rainfall ranges from 1,200mm in the Northern part to 1,470mm in the southern part. The monthly temperature ranges from 23^{o}C in July to 32^{o}C in February. The State has good arable land for the production of various food crops, permanent crops and livestock.

Sampling Techniques

This study used multistage sampling procedure for the selection of 370 farmers that are producing maize. The use of multistage sampling was due to large populations that are geographically dispersed. The first stage involved purposive selection of two Agricultural Development Programme zones due to agrarian nature and intensity of maize production of the zones. These zones include Ibadan, Saki, Abeokuta, and Ilaro. The second stage involves random selection of one agricultural block from each of the selected zones. This was done using random sampling generator. Random sampling was employed in this study to ensure equal chances of the element to be selected. The blocks selected are Ido, Saki east, Ilugun and Oke-odan. From each of the selected cells four cells were randomly selected. A simplified formula provided by Kabatesi and Mbabazi (2016) was used to determine the adequate sample size (n) for the population (4810) of maize farmers obtained from maize farmers association of Nigeria. This is given by

$$n = \frac{N}{1+N(e^2)}$$ -----------------------1

$$n = \frac{4810}{1+4810(0.05)^2}$$ n= 370 -------------------------------2

Where: n = is the sample size, N is the population i.e. total number of registered maize farmers and e =0.05 is the level of significance defined to determine the required sample size at 95% confidence level. The selection of 370 respondents is done in proportion to the number of registered farmers across the selected cells.

Data Collection

Primary data were used for the study. The data were collected through the use of structured questionnaire. The use of structured questionnaire was employed due to the fact that it requires a lower cognitive load on the respondents and less thinking from the respondents in the completion of the information required for the study. These questionnaires were administered to the respondents by the trained enumerators. The data were collected on socio-economic as well as demographic characteristics of the respondents. Others were on sustainable practices adopted by the respondents, viz: organic manure, zero tillage, crop rotation, improved variety, organic pesticides etc.

Analytical Techniques

Data collected were analyzed using descriptive statistics which were used to describe the socio-economic and demographic characteristics of the respondent as well as rate of adoption of CSA practices. Stochastic Profit Frontier Function (SPFF) was used to estimate profit efficiency and the effect of CSA adoption on profit efficiency of maize farmers in the area. The explicit Cobb-Douglas functional form for the farmers following Ogundari (2006) and Kaka *et al.* (2016) is therefore specified as follows:

$$In\Pi = ln\beta_0 + +\beta_1 In\, P_{1i} + \beta_2 In\, P_{2i} + \beta_3 In\, P_{3i} + \beta_4 In\, P_4$$ ----- (3)

Where:

Πi represents normalized profit of i[th] farmer computed as total revenue less variable cost divided by farm specific maize price;

P_1 = Average price per man day of labour ;
P_2 = Average price per kg of fertilizer ;
P_3 = Average price per kg of seed
P_4 = Average price per litre of herbicide
P_5 = Average price per litre of insecticide
Z_1 = Farm size (ha)

The variance of the random errors, $\sigma_v{}^2$ and that of the profit inefficiency effect $\sigma_u{}^2$ and overall variance of the model s^2 are related thus: $s^2 = \sigma_v{}^2 + \sigma_u{}^2$, measure the total variation of profit from the frontier which can be attributed to profit inefficiency (Battese and Corra, 1977). Battese and Coelli (1995) provided log likelihood function after replacing $\sigma_v{}^2$ and $\sigma_u{}^2$ with $s^2 = \sigma_v{}^2 + \sigma_u{}^2$ and thus estimating gamma (γ) as: $\gamma = \frac{\sigma_u{}^2}{\sigma_v{}^2 + \sigma_u{}^2}$.The parameter γ represents the share of inefficiency in the overall residual variance

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with values in interval 0 and 1. A value of 1 suggests the existence of a deterministic frontier, whereas a value of 0 can be seen as evidence in the favour of OLS estimation.

The inefficiency model (Ui) is defined by:

$$U_i = \partial_0 + \partial_1 X_1 + \partial_2 X_2 + \text{---------} \delta_{13} X_{13} + \varepsilon$$

Where U_i = Profit inefficiency

X_1 = Age of the farmer (years)
X_2 = Education (years)
X_3 = Household size (number)
X_4 = Farming Experience (years)
X_5 = Membership of association (years)
X_6 = Access to credit (yes=1, 0 otherwise)
X_7 =Extension contact (number of contact during the production season)
X_8 =Organic manure (dummy)
X_9= Cover cropping (dummy)
X_{10} = Agroforestry (dummy)
X_{11}= Crop rotation (dummy)
X_{12} = Improved variety (dummy)

Results and Discussion

Rate of Adoption of Sustainable Agricultural Practices

The results presented in Table 1 showed the rate of adoption of CSA among farmers. It was revealed that use of cover cropping and agroforestry were adopted by 10.5 and 46.8% respectively. Adoption of improved seed was the highest with 92.4%. Generally, adoption of CSA among farmers was generally low except the use of improved seed that was adopted by more than 50.0% of the farmers. This finding follows several reports in the literature that adoption of CSA is low among smallholder farmers in sub-Sahara Africa (Giller *et al*., 2009; Usman *et al.*, 2021).

Many studies conducted to find the reasons for low adoption concluded that there are interacting manifold social, economical and ecological factors and which by nature vary from place to place (Sterve, 2010). According to Kaliba *et al.* (2018), low farm productivity, high incidence of food insecurity and poverty are in Sub-Saharan countries, caused by low adoption of agricultural technologies.

Table 1: Rate of Adoption of climate Smart Agricultural Practices

CSA	Frequency*	Relative Frequency
Cover cropping	39	10.54
Agroforestry	173	46.76
Crop rotation	39	10.54
Improved variety	342	92.43
Mixed cropping	69	18.65
Cover cropping and Agroforestry	28	7.57
Cover cropping and Crop rotation	7	1.89
Cover cropping and Improved variety	32	8.65
Cover cropping and Mixed cropping	8	2.16
Agroforestry and Crop rotation	12	3.24
Agroforestry and Improved variety	173	46.76
Agroforestry and Mixed cropping	46	12.43
Crop rotation and Improved variety	29	7.84

Crop rotation and Mixed cropping	21	5.68
Improved variety and Mixed cropping	61	16.49

*** Multiple responses were allowed**

Maximum Likelihood Estimates of the Stochastic Profit Frontier Function

The estimates of the parameters of the stochastic profit frontier model are presented in Table 2. The model showed that there was presence of profit inefficiency among the farmers. The generalized likelihood ratio test defined by the Chi-square ($\chi 2$) distribution was greater than critical chi-square values at 1% level of probability. These values maximize the joint densities in the estimated model. The implication is that the form of the model adopted in the estimation of this study is an adequate representation of the data. The estimated gamma parameter (γ) is 0.959 and significant at 1 percent level of probability. This implies that about 95 percent of the variation in actual profit from maximum profit (profit frontier) among farmers mainly arose from differences in farmers' practices rather than random variability.

The estimated parameter obtained for farm size, price of labour and price of herbicide showed that there are significant effects of these variables on normalized profit of the farmers. Cost of seed was significant this implied that increase in the price of these variables, farmers' profit efficiency will decrease. Labour and herbicide exert positive relationship with profit which showed that these variables would increase profit efficiency of the farmers. The socio economic variables influencing profit inefficiency were household size and farming experience while CSA variables influencing profit inefficiency were the use of organic manure, cover cropping and agroforestry. Cover cropping and agroforestry were found reducing profit inefficiency among farmers.

Table 2: Maximum likelihood estimate of stochastic frontier profit function of maize farmers

Variable	Coefficient	t-value
Constant	-25.6258***	-4.1592
Farm size	0.5629*	1.8037
Average of seed	-0.3047	-1.4134
Average price of fertilizer	0.6347	1.4821
Average price of labour	1.7050**	4.0453
Average price of herbicide	1.7048***	3.4071
Average price of insecticide	0.3625	0.8473
Inefficiency model		
Constant	2.5407*	2.1975
Age	-0.0450	-1.2061
Education	-0.0163	-0.2481
Household size	0.5837*	4.3092
Farming experience	-0.1637**	-3.2838

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Membership of association	-0.1322	-1.0636
Extension contact	0.4627	1.4150
Access to credit	1.1677	1.5522
Cover cropping	-5.2575***	-3.6449
Agroforestry	-3.6114***	-3.5212
Crop rotation	1.8806**	2.1936
Improved variety	-0.7444	-1.0107
Mixed cropping	-0.9963	-0.9750
Diagnostic statistics		
Sigma square	4.6047***	5.0282
Gamma	0.9592***	79.6352
Log-likelihood	-577.090	

*, **, *** significant at 10%, 5%, and 1% levels, respectively

Source: Computed from 2018 Field Survey data

Profit efficiency score among farmers

The results in Table 3 present the frequency distribution of profit efficiency among maize farmers in the study area. The results revealed that farm profit efficiency index varied from one farmer to another and ranged from a minimum of 0.006 to a maximum of 0.94, with a mean value of 0.37. The result showed that less than one percent (20.54%) had profit efficiency score between 0.11-0.20. Those with efficiency score between 0.31 and 0.41 are 6.49%. Based on the mean efficiency estimate of the farmers, the average farmer requires 60%, that is, {1-(0.34/0.94) x 100} cost savings to attain the status of the most profit efficient farmer. The least performing participating farmer would need 94% cost savings that is {1-(0.006/0.94x 100} to attain status of most profit efficient farmer. The average value of 37% of potential maximum profit is gained as a result of production efficiency. The shortfall of 63% is the difference between observed profit and the frontier profit.

Table 3: Frequency distribution of farmers' profit efficiency

Profit efficiency estimate	Frequency	Percentage
>0.1	76	20.54
1.1-2.0	59	15.95
2.1-3.0	24	6.49
3.1-4.0	24	6.49
4.1-5.0	20	5.41
5.1-6.0	27	7.30
6.1-7.0	46	12.43
7.1-8.0	64	17.30
8.1-9.0	29	7.84
Total	370	100.00

Average	0.37
Minimum	0.006
Maximum	0.94

Source: Computed from 2018 Field Survey data

Conclusion and Recommendations

Adoption of climate smart agricultural practices was generally low and interdependent. The parameter estimates of the profit function showed that rent on land, price of labour and herbicides were the factors that could explain the variation that exist in the profit of the farmers It was revealed that production system did not reach profit frontier.

The shortfall of 63 percent was observed between the estimated profit and the frontier profit. Adoption of CSA and socioeconomic factors of farmers provide a significant amount of information to explain farmers' inefficiency in profit of the farmers.The study recommends regular farmers' training, improvement of extension services and better credit facility in order to increase adoption of CSA and reduce the shortfall in farmers' profit efficiency.

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