Effect of Climate Adaptation Strategies on the Production Efficiency of Food Crop Farmers in Ondo State, Nigeria

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ABSTRACT

This study examined the effect of climate adaptation strategies on production efficiency of food crop farmers in Ondo State, Nigeria. Primary data were obtained from 300 randomly selected food crop farmers through a multistage sampling procedure in six food crop producing Local Government Areas of Ondo State. Data on respondents' socio-economic characteristics, perceptions of climate variability and adaptation strategies employed by the farmers were obtained using structured interview schedule. Data were analysed using descriptive statistics and Stochastic Frontier Analysis (SFA) at $p=0.05$ Findings revealed that 82.3% of the farmers were male, 44.3% had formal education with a mean age of 46.5. The climate adaptation strategies employed by the farmers were planting of different crop varieties (20.0%), multiple planting dates (17.0%), crop diversification (16.7%), mulching (16.3%), off-farm employment (16.3%) and land fragmentation (13.7%). SFA estimated Mean for technical (0.59), allocative (0.69) and economic (0.36) efficiencies showed that food crop farmers were not technically, allocatively and economically efficient in the use of production resources. The Stochastic Frontier Analysis showed that Food crop farmer's efficiency increased with multiple planting dates ($\beta = -0.78$, $p<0.05$), crop diversification ($\beta = -1.03$, $p<0.01$) and crop varieties ($\beta = -1.08$, $p<0.01$) but decreased with land fragmentation ($\beta = 1.05$, $p<0.01$). The study concluded that adoption of climate adaptation strategies improved farmers' efficiency in the study area and recommended that farmers should be encouraged to adopt different climate adaptation strategies to reduce the possible effect of climate change.

Keywords: Adaptation strategies, climate variation, production efficiency, technical efficiency.

Introduction

The importance of food as a basic necessity of life is observed in its roles as a means of sustenance for healthy and productive livelihood. This importance is jeopardized by the current climate change in the world. The fact that climate has been changing and will continue to change suggests the need to understand how farmers perceive climate change and how they adapt to this change in order to guide strategies for adaptation in the future. Studies indicated that farmers adapt to reduce the negative impacts of climate change (Mertz *et al.,* 2009; Ishaya and Abaje, 2008; David *et al.,* 2007). Adaptation can be viewed as reducing the severity of many impacts when adverse conditions prevail. Adaptation reduces the level of damages that might have otherwise occurred. The success of adaptation depends critically on the availability of necessary resources, not only on financial and natural resources, but also on knowledge, technical capability, and institutional resources (PCGCC, 2004). Many social, economic, technological and environmental trends also critically shape the ability of farmers to perceive and adapt to climate change. The choice of adaptation methods by farmers depends on various social, economic and environmental factors (Deressa, 2007; Bryan *et al.,* 2013). Knowledge of the adaptation methods and factors affecting farmers' choices enhances efforts directed towards tackling the challenges that climate change is imposing on farmers (Deressa *et al.,* 2009). Thus, for many poor countries that are highly vulnerable, understanding farmers' response to climate change is crucial in designing appropriate adaptation strategies (Mahmud *et al.,* 2008). The vulnerability of poor countries is due to weak institutional capacity, limited engagement in environmental and adaptation issues, and inadequate validation of local adaptation knowledge (Adams *et al.,* 1998). The current and future impacts of climate change in Africa are creating a greater need for people to change behaviour to be able to survive under the new conditions. Areas where so-called adaptation is appropriate, are, for example, disaster management (floods, droughts, storms etc), food security, water resource management, land degradation (erosion, desertification), biodiversity loss, natural resource management, health (HIV/AIDS, malaria etc), migration, rural livelihoods, poverty alleviation and coastal zone management. Common adaptation methods in agriculture include: the use of new crop varieties and livestock species that are more suited to drier conditions, irrigation, crop diversification, mixed farming and changing planting date (Bradshaw *et al.,* 2004; Kurukulasuriya and Mendelsohn, 2006; Nhemachena, and Hassan, 2007). Many definitions for adaptation and mitigation are available in the literature. The most common and probably deeply discussed one is the definition used in the Intergovernmental Panel on Cilmate Change (IPCC) report which says that 'adaptation refers to changes in processes, practices, or structures to moderate or offset potential damages or to take advantage of opportunities associated with changes in climate'. It involves actions to reduce the

vulnerability of regions and communities to climate change (IPCC WGII, 2007). Adaptation can be spontaneous or planned action done by governments or civil society, although institutional and economic parameters determine the vulnerability and adaptive capacity of societies. In the international climate change, negotiations' decisions were initiated to develop the adaptive capacity of poor people and the poorer countries to cope with the impacts of climate change (Saleemul *et al.,* 2004). The required capacity to cope with climate change depend largely on financial, human and knowledge resources. Studies on how to adapt to what, when and where has only recently gained attention with very few researchers in the field. Adaptation has the potential to significantly contribute to reductions in negative impacts from changes in climatic conditions as well as volatile short-term changes in local and international markets (Kandlinkar and Risbey 2000). Against the above background and the need to revert the declining productivity in Nigeria, this study was embarked upon to analyse the effect of climate adaptation strategies on the production efficiency of food crop farmers in Ondo State, Nigeria. Therefore, an analysis of adaptation options and constraints to adaptation is important for the agricultural communities in Ondo State. Also, a better understanding of farmer perceptions regarding long-term climatic changes, current adaptation measures and their determinants will be important to inform policy for future successful adaptation of the agricultural sector. Hence, the study describes the socioeconomics characteristic of the respondents and analyzed the effect of climate change adaptation strategies on production efficiency of food crop farmers in the study area.

Material and Methods

Study Area

The study was carried out in Ondo State South-West Nigeria. The state, is situated between longitudes $4°15′$ E and $6°00′$ E and latitudes $5°45′$ N and $7°45′$ N of the equator. The state is bounded by Ekiti and Kogi States in the North; Edo State in the East; Ogun and Osun States in the West and by the Atlantic Ocean in the South. The state has 18 Local Government Areas with a population of about 3,440,000 of which the rural population constitutes about 1.7 million and a land area of 14,606 km^2 (NPC 2006). The major food crop grown in the study area are Maize, Cassava and Yam.

Source of Data

The data used for the research work were mainly from primary sources. The data were collected from rural farmers who commonly grow arable crops such as cassava, yam and maize.

Sampling Procedure

A multi-stage sampling technique was adopted in the selection of respondents for the study. The first stage involved the selection of six Local Government Areas in the study area. The second stage involved a purposive selection of five villages/farming communities from each of the selected local LGAs based on the intensity of farming activities. The third stage of the sampling involved a purposeful

selection of 10 households who are food crop farmers from each of the farming communities, making a total of 300 respondents. The data were collected via the administration of structured questionnaire on personal contact with the respondents.

Data Analysis

Descriptive statistics such as frequency counts, percentages and means were used to describe the socio-economics characteristic, farmers' perception and awareness of climate change in the study area. In order to determine the effect of climate adaptation strategies on the efficiency of arable crop farmers, the study made use of the Stochastic production function in particular, Cobb-Douglas functional form to estimate the coefficients of the parameters of the production function and also to predict technical efficiencies of the farmers. The choice of this model was because it allows for the presence of technical inefficiency while accepting that random shocks (weather or disease) beyond the control of the farmers. The model specifies output (Y) as a function of a set of inputs (Xs) and a disturbance term (e_i) given by:

$$Y_i = (X_i\beta) + (v_i - u_i) \quad \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\mathbf{1}$$

Where:

Y_i = Output of arable crops (Grain equivalent)

X_i = Vector of actual input quantities used by the ith farm

β = Vector of parameters to be estimated.

V_i are random variables which are assumed to be normally distributed. An independent of the U_i, which accounted for measurement error and other factors not under the control of the farmers.

U_i are non-negative random variables, called technical inefficiency effects which are assumed to be half normally distributed iid~N (0, $\sigma_\mu{}^2$) (Aigner et al. 1977, Coelli *et al*. 1998 and

Ogundari and Ojo, 2007)

v_i = Decomposed error term measuring technical efficiency of the ith farm.,

u_i = The inefficiency component of the error term. The empirical model of the stochastic production frontier function is specified as follows:

$$LnY = \beta o + \beta_1 lnX_1 + \beta_2 lnX_2 + \beta_3 lnX_3 + \beta_4 lnX_4 + \beta_5 lnX_5 + v_i - u_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.\mathbf{2}$$

Where Y_i = Value of Farm output in (Grain equivalent)

X_1 = Farm size measured in hectares.

X_2 = Planting material measured in Naira.

X_3 = Quantity of herbicides used in litre.

X_4 = Labour used measured in man-days

X_5 = Fertilizer used measured in kg

β_0, β_1, β_2, β_3, β_4, β_5 are parameters to be estimated.

The technical efficiency for individual farm was computed as an index and the average technical efficiency for the production system determined based on a number of socio-economic factors identified to be influencing the technical efficiency of the farms. According to Coelli and Battese (1996) inefficiency model was employed to estimate the parameters of the variables. The model assumes that the inefficiency effect u_i is

independently distributed with mean U_i and variance δ^2. The model is specified as:

$U_i = \gamma_0 + \gamma_1 k_1 + \gamma_2 k_2 + \gamma_3\ k_3 + \gamma_4\ k_4 + \gamma_5\ k_5 + \gamma_6\ k_6 + \gamma_7\ k_7 + \gamma_8\ k_8 + \gamma_9\ k_9 + \gamma_{10}\ k_{10} + \gamma_{11}\ k_{11} + \gamma_{12}\ k_{12} + \gamma_{13}k_{13} + \varepsilon_i$…………………………………………………………………………………………………...**3**

Were

K_1 = Actual age of respondents in years

K_2 = Household size

K_3 = Education level of farmer (dummy variable 1 for formal education and 0 if otherwise)

K_4 = Farming experience measured in years

K_5 = Sex (dummy variable 1 for male and 0 for otherwise)

K_6 = Off-farm employment (income in naira from other sources apart from agriculture)

K_7 = Multiple planting dates (number of different sowing dates as a result of
     climatic variability in the cropping season)

K_8 = Crop diversification (number of crop mix practiced by the farmer as a result of
     climatic variability)

K_9 = Land fragmentation (number of farm plots used for food crop production due to
     Climatic variability)

K_{10} = Changes in farm size (1= if increase in farm size in order to adapt to climatic variability, 0 otherwise)

K_{11} = Number of different crops planted

K_{12} = Years of climatic variability awareness

K_{13} = Social capital (Number of relatives involved in the discussion of farming issues in the village, excluding the farmers' household member)

$\gamma_o - \gamma_{13}$ = Regression estimates

ε_i = a random disturbance following half normal distribution.

The farm specific economic efficiency (EE) is defined as the ratio of minimum production cost (C*) to observed production cost (C). Economic efficiency takes value between 0 and 1. Hence a measure of farm-specific allocation efficiency (AE) is thus obtained from technical and economic efficiencies estimate as

AE = EE/TE

This means that $0 \leq AE \leq 1$.

In order to estimate the economic and allocative efficiencies of food crop farmers, a Cobb-Douglas cost frontier function for food crop farms in the study area was specified as:

$C_i = \alpha_0 + \alpha_1 P_1 + \alpha_2 P_2 + \alpha_3 Q^* + \alpha_4 P_4 + \alpha_5 P_5 + \alpha_6 P_6 + \varepsilon$ …………………………………………...**4**

Where

C = The total production cost of food crop per farmer

P_1 = Cost of planting material (₦)

P_2 = Depreciation cost of farm tools (₦) (It was calculated using straight line method of
     calculating depreciation

Output (Q^*) (₦)

P_4 = Herbicide cost (₦)

P_5 = Wage rate (₦)

P_6 = Fertilizer cost (₦)

$\varepsilon = V_i + U_i$

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5,$ and α_6 are parameters of the cost function and ε represents the error term that is composed of two elements: V_i and U_i.

Therefore, farm level economic efficiency (EE) will be calculated using the relationship

EE = AE × TE

Where   EE = 1/ Cost Efficiency

Table 1. Distribution of respondents by socio-economic characteristics

Description	Frequency	Percentage
Age (Years)		
≤3	14	4.70
31-40	76	25.3
41-50	122	40.7
51-60	73	24.3
≥ 61	15	5.0
Mean± SD		46.50 ± 9.07
Sex		
Male	247	82.3
Female	53	17.7
Education		
No Formal Education	78	26.0
Primary Education	133	44.3
Secondary Education	80	26.7
Tertiary Education	9	3.0
Farming experience (Years)		
≤ 5	15	5.0
6-10	78	26.0
11-15	63	21.0
16-20	65	21.7
≥ 21	79	26.3
Mean± SD		17.82 ± 9.89
Household Size		
≤ 2	22	7.3
3 – 4	92	30.7
5 – 6	106	35.3
≥ 7	80	26.7
Mean 5.72 ± SD 2.87		

Source: Computed from Field Survey, 2015

Results

Socio-Economic Characteristics of Respondents

Table 1 presents the socio-economic characteristics of the respondents in the study area. The Table shows that majority of the respondents were economically active with age ranging between 41-50 years (40.70%) and average age of 9.071 years while very few (5.0%) were within the age range of 61 years and above. Most of the respondents (82.3%) were male while only few (17.7%) were female. Most of the respondents (88.0%) were married while only (1.7%) were single. They were mostly educated up to primary (44.3%) and secondary (26.7%) school levels with as much as 26.0% of the respondents having no formal education. Table 1 also reveals that most of the respondents sampled for the survey (95.0%) had been cultivating food crops for more than 5 years while only few of the respondents (5.0%) had less than 5 years' experience in food crop farming. Approximately 35% of the respondents had at least 5-6 household members, these large family sizes ensure continuous labour supply on the farm while 7.3% of the respondents had a household member of less than or equal to 2. An Average percentage (50.3%) of the respondents had farming as their major occupation while the remaining 49.7% of the respondents were involved in farming as well as other occupational activities. Most of the food crop farmers (63.7%) had less than 1 hectare of farm size while the average farm size was 1.673 ha in the study area.

Awareness and Perception of Climatic Variability by the Respondents

Table 2 reveals the awareness and perception of climatic variability by the respondents. Table 2 shows that 97.7% of the respondents were aware of climatic variability while only few 2.3% indicated that they were not aware of climatic variability in the study area.

Table 2 also shows that majority of the respondents (76.0%) were aware of climatic variability through personal observation while 13.7% of the respondents were informed about climatic variability through radio and only 5.3% were aware of climatic variability through community meetings. Approximately 49.0% of the respondents sampled for the survey indicated that they had been aware of climatic variability for about 4 years, 37.9% of the respondents have been aware of climatic variability for about 5 – 9 years while 0.3% of respondents had been aware of climatic variability for more than 20 years in the study area. Table 2 further reveals that 44.4% of the respondents perceived that low rainfall pattern was due to climatic variability while 24.3%, 22.3% and 9.0% perceived irregular, high and regular rainfall pattern respectively in the study area. Majority of the respondents (79.3%) perceived that temperature was higher than what it used to be while 2.0% of the respondents indicated that temperature pattern was low due to climatic variability in the study area.

Table 2: Distribution of respondents by climatic variability awareness, sources and Perception

Description	Frequency	Percentage
Awareness of climatic variability		
Yes	293	97.7
No	7	2.3
Sources of Awareness		
Radio	41	13.7
Television	2	0.7
News paper	2	0.7
Community Meetings	16	5.3
Friends and Relatives	1	0.3
Extension Agent	2	0.7
Market Centre	1	0.3
Personal Observation	228	76.0
Years of Awareness		
≤ 4	143	48.8
5-9	111	37.9
10-14	33	11.3
15-19	5	1.7
≥ 20	1	0.3
Mean 4.92 ± SD 3.29		
Climatic variability perception of respondents		
Rainfall pattern		
Low	133	44.4
High	67	22.3
Regular	27	9.0
Irregular	73	24.3
Temperature Pattern		
Low	6	2.0
High	238	79.3
Medium	23	7.7
Regular	33	11.0

Computed from Field survey 2015.

Adaptation Strategies to Climatic Variation by the Respondents

Table 3 shows the various adaptation strategies used by food crop farmers to mitigate the effect of climatic variability in the study area during the 2015/2016 cropping season. The result indicates that 20.0% of the respondents plant different crop varieties as a measure of

adaptation strategy to combat the effect of climatic variability in the study area. About 17.0% of the food crop farmers adapted by planting on multiple dates. Crop diversification was the next most used strategy (16.7%) by the respondents while 16.3% of the respondents embraced mulching and off-farm employment only 13.7% of the farmers adopted land fragmentation.

Table 3: Distribution of respondents by adaptation strategies for climatic variation

Adaptation strategy	Frequency	Percentage
Mulching	49	16.3
Planting Different Crop Varieties	60	20.0
Off Farm Employment	49	16.3
Multiple Planting Dates	51	17.0
Crop diversification	50	16.7
Land Fragmentation	41	13.7

Computed from Field Survey, 2015

Effect of climate adaptation strategies on the production efficiency of food crop farmers in the study area

The sigma squared (δ^2) was 5.154 for the production function and significantly different from zero at $P \leq 0.01$. This indicates a good fit and correctness of the distributional form assumed for the composite error term. The gamma estimate (γ) which was 0.3996 indicates the amount of variation resulting from the technical inefficiencies of the food crop farmers. Gamma indicates that the systematic influences that are unexplained by the production function are the dominant sources of random error. The variation in food crop farmers output in the study area was 60.04% and is due to differences in technical inefficiency. Thus, on average, the farmers are realising about 39.96% of their potential output.

The mean Technical Efficiency (TE) of the food crop farmers was 0.5820 which implies that the food crop farmers still have an advantage to improve their TE by 41.80% taken into consideration the current level of climatic variability, technology and the inputs used.

Typical of the Cobb-Douglas production function, the estimated coefficients for the specified function can be explained as the elasticity of the explanatory variables. The result obtained from the Stochastic production function indicates that the efficiency of the farmers was affected not only by the traditional input variables: farm size, planting material, herbicides and labour input but equally by socio – economic factors: age, household size, education, experience, sex and climate adaptation strategies measured by off-farm employment, changes in farm size, crop diversification, land fragmentation, multiple planting dates, varieties of different crop produce, years of climatic variability awareness and socio capital.

Technical inefficiency estimates of food crop farmers

This section presents the results of socio-economic variables and climate adaptation strategies influencing the production efficiency of food crop farmers in the study area. As presented in Table 5, with technical inefficiency. However, only the variable of farming experience was statistically significant at 1% alpha level. Farmer's age and sex were negatively correlated with technical inefficiency.

Respondent's household size, education and farming experience were positively correlated Evidence in Table 5 reveals that the coefficient of the variable of multiple planting dates, crop diversification, varieties of different crops planted and social capital had a significant negative correlation with technical inefficiency while land fragmentation had a positive correlation with technical inefficiency.

The result of the maximum likelihood estimates of the stochastic frontier cost function for the climate adaptation strategies of the food crop farmers in the study area is presented in Table 6. The sigma squared (δ^2) estimate (0.855) which was significant at $p < 0.01$ attests to the goodness of fit of the model. The variance ratio (γ) indicated that inefficiency exists among the food crop farmers as shown by the one percent significant value 0.980 ($p < 0.01$) of gamma estimate. This result shows that about 98.00% of the variation in food crop farming is due to differences in their cost of inefficiency.

The estimated coefficient of the parameters of the cost function were positive and significant at different probability level except for the coefficient of the variables of cost of herbicide and depreciated value of farm tools that were not significant. The coefficient of the variables of cost of planting materials and wage rate were significant at $p < 0.05$ while output in naira and cost of fertilizer were significant at $p < 0.01$.

Table 4: Maximum Likelihood estimates of parameters of Stochastic Frontier Function of arable crop farmers.

Variables	Parameters	Coefficient of Stochastic frontier	t-value
Constant	β_0	6.1164***	5.1041
Farm size (X_1)	β_1	0.9674***	4.0664
Planting Material (X_2)	β_2	0.2417***	3.3993
Herbicide (X_3)	β_3	0.2254	1.4981
Labour (X_4)	β_4	0.1153	1.1931
Fertilizer (X_5)	β_5	0.0824	0.5582
INEFFICIENCY MODEL			
Constant	λ_0	12.2772***	2.1415
Age	λ_1	-0.2712***	4.3015
Household size	λ_2	0.0070	0.0573
Education	λ_3	0.5343	0.4590
Experience	λ_4	0.2167***	3.6676
Sex	λ_5	-0.3610	-0.3944
Off farm Employment	λ_6	-0.6726	-0.3014
Multiple planting Date	λ_7	-0.7854**	-2.6482
Crop Diversification	λ_8	-1.0325***	-3.0740
Land Fragmentation	λ_9	1.0489***	3.6119
Changes in Farm Size	λ_{10}	0.9618	0.8397
Varieties of different Crop Produce	λ_{11}	-1.0767***	3.1850
Awareness	λ_{12}	-0.1007	-0.9125
Social Capital	λ_{13}	-0.3300*	-1.6694

DIAGNOSTIC STATISTICS

Sigma square	δ^2	5.1540***	4.0886
Gamma	γ	0.3996**	2.3309
Mean Technical Efficiency		0.582	
log likelihood function		-610.5802	
LR test of the one-sided error		41.4211	

Computed from Field Survey, 2015. Where ***, **, *, represent significant levels at 1%, 5% and 10% level.

Table 6: Maximum Likelihood estimates of parameters of Stochastic Frontier Cost Function of food crop farmer.

Variables	Parameters	Coefficient of Stochastic frontier	t-value
Constant	α_0	2.8140**	2.3008
Planting Material Cost (₦)	α_1	0.0723**	2.0989
Herbicide Cost (₦)	α_2	0.0184	0.2892
Wage Rate (₦)	α_3	0.0829**	2.9671
Output (Q*)	α_4	0.7202***	3.8848
Depreciated Cost of Farm Tools (₦)	α_5	0.0798	1.2974
Fertilizer Cost (₦)	α_6	0.2831***	7.2966

Computed from Field Survey, 2015. Where ***, **, *, represent significant levels at 1%, 5% and 10% level.

Frequency distribution of respondents' Technical, Allocative and Economic efficiency

The frequency distribution of respondents' Technical, Allocative and Economic efficiency estimates of the food crop farmers is presented in Table 7. The Table shows that the predicted technical efficiency differs substantially among the food crops farmers as it ranges from 0.010 – 0.840. The mean TE was estimated to be 0.582. This implies that there is a potential of approximately 41.8% for the food crop farmers to improve their output in the study area.

The allocative efficiency (AE) of the farmers ranged between 0.014 and 0.999 with a mean value of 0.6958. This implies that if the average farmer was to achieve the allocative efficiency level of his most efficient counterpart, the average farmer could realise a cost saving of about 30.35percent. The predicted economic efficiency of the farmers ranged between 0.010 and 0.777 with a mean value of 0.3939. This implies that if an average farmer was to achieve the economic efficiency level of his most efficient counterpart, the average farmer could realise 49.31% cost savings.

Table 7. Distribution of food crop farmers' climate adaptation strategies by technical, economic and allocative efficiency

Efficiency	Technical Frequency	Efficiency Percent	Economic Frequency	Efficiency Percent	Allocative Frequency	Efficiency Percent
≤ 0.10	26	8.7	24	8.0	8	2.7
0.11- 0.20	12	4.0	30	10.0	5	1.7
0.21- 0.30	18	6.0	34	11.3	7	2.3
0.31- 0.40	18	6.0	46	15.3	12	4.0
0.41- 0.50	80	26.7	82	27.3	9	3.0
0.51- 0.61	80	26.7	38	12.7	21	7.0
0.61- 0.70	83	27.7	29	9.7	78	26.0
0.71- 0.80	20	6.7	17	5.7	48	16.0
0.81- 0.90	-	-	-	-	58	19.3
0.91- 1.00	-	-	-	-	54	18.0
Mean	0.582		0.3939		0.6958	
Minimum	0.010		0.010		0.014	
Maximum	0.840		0.777		0.999	

Computed from Field Survey, 2015.

Discussion

The socio-economics characteristics of respondents considered in the study include; respondents age, sex, education, farming experience and household size. The result of the descriptive analysis of age shows that food crop farmers are in their economically active years. This agrees with Ambali *et al.,* (2012) and Oladapo and Shittu (2017) who found that most food crop farmers sampled in their study were in their active age. The analysis also indicates that there are more male respondents compared to female respondents. This is an indication that male farmers are more involved in food crop production. This is in agreement with the finding of Daudu *et al.,* (2015) who establish that male farmers were more involved in arable crop production activities than their female counterpart. The educational status of the food crop farmers gives them an opportunity to adopt new technologies and innovations to combat the effect of climate variability in other to increase food production efficiency. Irekhore *et al.,* (2015) in their study observed that literacy increases the ability of farmers to source for useful information in agricultural production. The large household size observed in the study area is an indication that labour supply for food crop production will not be a constraint. Osarenren and Emakoro (2015) reported that fairly large household size is an assurance against short falls in the supply of hired labour.

Most of the sampled respondents reported that they were aware of climate variability. The research conducted by Ali and Elnazir (2015),

revealed a similar observation, that public awareness is fairly high despite some limitations in the knowledge of the causes and prevention of climate change.The various adaptation strategies used by food crop farmers to mitigate the effect of climatic variability in the study area indicated that most of the respondents plant different crop varieties as a measure of adaptation strategy to combat the effect of climatic variability in the study area. This corroborates the work of Temesgen *et al.,* (2014) and Abid *et al.,* (2015) that farmers adopted planting of different crop varieties to reduce the effect of climate change.

The estimated coefficients of farm size, planting material, herbicides, labour and fertilizer were as expected. Thus, the elasticity of variable of farm size, planting material, herbicide, labour and fertilizer used in food crop production were positive. This implies that increasing any of these inputs would increase output. The estimate of the parameters of the Stochastic production frontier indicates that elasticity of output with respect to farm size is positive and approximately 0.9674 and it is statistically significant. This suggests that farm size is a positive and significant factor that influences the output of food crop farmers. An increase of one percent in farm size will result to an increase of 96.74% in food crop output depending on the farmer's ability to managing climatic variability in the study area. The coefficient of the variable of planting material was significant, thus a 1% increase in the variable of planting material will increase output by 24.17%. Also, the coefficient of the

variable of herbicide, labour and fertilizer were positive but not significant. The returns to scale computed as the sum of output elasticity for all inputs was estimated as 1.6322, indicating that food crop production is in stage 1 of the production response surface and that on average food crop production is experiencing an increasing return to scale. If farmers increased all factors of production by 1%, food crop production would increase by 1.63%, and it is expected to increase farmers profit significantly.

The coefficient of the variable of age was statistically significant at 1% alpha level, indicating that an increase in farmer's age increases the efficiency of food crop farmers. A priori expectation is that increase in age is expected to decreases efficiency, this result could be because most of the farmers sampled for the survey are still very much in their active age.

The coefficient of the variable of farming experience was positively correlated with technical inefficiency and statistically significant at 1%, indicating that an increase in farmer's experience does not increase food crop farmer's production efficiency. This is contrary to a priori expectation. However, this result could be because the experience gathered by the food crop farmers are not completely in the area of how they could manage climate change.

The inefficiency variables included in the regression estimate shows that increase in multiple planting dates increases the technical efficiency of food crop farmer in the study

area. Important evidence presented in the result indicates that the coefficient of the variable of crop diversification was negative and significant at 1%, showing that diversification into different crops increases farmer's production efficiency. The coefficient of the variable of land fragmentation also showed a negative correlation with technical inefficiency and was statistically significant at 1%. This implies that further increase in the number of food crop land owned by the farmers has the tendency of increasing the efficiency of food crop farmers in the study area.

It was also evident that, the coefficient of the variable of different varieties of crop planted was negative and statistically significant at 1%. The implication is that, increase in the varieties of the different number of crops planted reduces the inefficiency of food crop farmers in the study area.

The estimated coefficient of the parameters of the cost function reveals that all the explanatory variables conform with the a-priori expectations as the variable of the estimated coefficient were all positive. This implies that the significant variables in the regression analysis have an effect on the total cost of production. Therefore, a unit increase in the use of each input variable will result into an increase that is equal to the value of each coefficient of the input variables used in the analysis.

Conclusion

The descriptive analysis shows that food crop farmers in the study area are economically active. The result of the various adaptation strategies used by food crop farmers to mitigate the effect of climatic variability indicates that most of the respondents adapt the planting of different crop varieties as a measure of adaptation strategy to combat the effect of climatic variability in the study area. The empirical result of the stochastic frontier production function estimate showed that farm output increases with farm size and planting materials.

The result of the cost function shows that the coefficient of the variables of multiple planting dates, changes in farm size, varieties of different crop produce, years of climatic variability awareness and social capital negatively correlated with cost inefficiency and were statistically significant.

The study recommends that food crop farmers should be informed, using various channels, (radio, market days and village meetings) on the importance of climatic variability. Farmers should also be encouraged to intensify the use of different climate adaptation strategies, such as multiple planting dates, changes in farm size, number of different crops produced and increase in social capital as a measure of adaptation strategies in other to mitigate the possible effect of climatic variability in the study area.

References

Abid, M., Scheffram, J., Schneider, U.A., and Ashfag, M. (2015). Farmers' perceptions of and adaptation strategies to Climate Change and their determinants: The case of Punjab Province, Pakistan. *Earth System Dynamic* 6: 225 -243

Adams, R.M., Hurd, B.H., Lenhart, S. and Leary, N. (1998). Effects of global change on agriculture: an interpretative review. *Climate Research*, 11: 19-30

Aigner, D.J., Lovell, C.A.K., and Schimidt, P. (1977). Formulation and estimation of Stochastic
Frontier Function models. *Journal of Econometrics* 6:21-37

Ali, S.A.B., and Elnazir, R. (2015). Climate Change Awareness and Perception amongst the Inhabitants of Muscat Governorate, Oman. *American Journal of Climate Change*, 4: 330-336

Ambali1, O.I., Adegbite, D.A., Ayinde, I.A., and Awotide, D.O. (2012). Analysis of Production Efficiency of Food Crop Farmers in Ogun State, Nigeria. *ARPN Journal of Agricultural and Biological Science* 7(9) 680-688.

Bryan, E., Ringler, C., Okoba, B., Roncoli, C., Silvestri, S., and Herrero, M (2013). Adapting agriculture to climate change in Kenya: Household strategies and

determinants. *Journal of Environmental Management* 114: 26–35.

Bradshaw, B., Dolan, H and Smit, B. (2004). Farm-Level Adaptation to Climatic Variability

and Change: Crop Diversification in the Canadian Prairies. *Climatic Change* 67: 119–141.

Coelli, T., and Battese, G. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics* 40(2): 103 – 128.

Coelli, T.J., Prasado Rao, D.S., and Battese, G.E. (1998). An Introduction to Efficiency and Productivity Analysis. *Kluwer Academic Publishers*. Boston/Dordrecht.

Daudu, A.K., Matanmi, B.M., Oladipo, F.O., Aliyu, A.S., and Olatinwo, L.K. (2015). Effect of Gender on Farmers' Level of involvement in Arable Crop Production Activities in Kwara State, Nigeria. *Journal of Production Agriculture and Technology* 11(2). 10-19.

David, S., Thomas, G., Twyman C., Osbahr H., and Hewitson, B. (2007). Adaptation to Climate Change and Variability: Farmer Responses to Intra-Seasonal Precipitation trends in South Africa. *Climatic Change* 83: 301-322.

Deressa, T. T. (2007). Measuring the economic impact of climate change on Ethiopian agriculture: Ricardian approach, *World Bank Policy Research Paper No. 4342*. World Bank, Washington, D.C.

Deressa, T.T., Hassan, R.M., Ringler, C., Alemu, T., and Yesuf, M. (2009). Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia, *Global Environmental Change* 19: 248–255.

Saleemul H., Hannah R., Mama K., Atiq R., Youba S., and Florence C. (2004): Mainstreaming Adaptation to Climate Change in Least Developed Countries (LDCS), Climate Policy 4(1): 25-43, DOI: 10.1080/14693062.2004.9685508

Ishaya, S., and Abaje, I.B. (2008). Indigenous People's Perception of Climate Change and Adaptation Strategies in Jema's local government area of Kaduna State, Nigeria. *Journal of Geography and Regional Planning* 1 (18):138-143.

IPCC WGII, (2007). Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report Climate Change 2007: Climate Change Impacts, Adaptation and Vulnerability. Summary for Policymakers.

Irekhore, O.T., Bello, K.O., Adeyeye, O.A., Adegunle, A.A., and Bailey, N.A. (2015). Assessment of Management Practices among pig Farmers in Ogun State, Nigeria. *Journal of Agricultural Economics, Extension and Science* 2(2&3): 28 -37.

Kurukulasuriya, P., and Mendelsohn, R. (2006). Endogenous irrigation: the impact of climate change on farmers in Africa. CEEPA Discussion Paper No.18. Centre for Environmental Economics and Policy in Africa. Pretoria, South Africa: University of Pretoria.

Kandlinkar, M., and Risbey, J. (2000). Agricultural impacts of climate change: if adaptation is the answer, what is the question?. *Climatic Change* 45: 529-539.

Mertz, O., Mbow, C., Reenberg, A., and Diouf, A. (2009). Farmers' Perceptions of Climate Change and Agricultural Adaptation Strategies in rural Sahel. *Environmental Management* 43 (5): 804-16.

Mahmud, Y., Di Falco, S., Temesgen, D., Ringler, C., and Gunnar, K. (2008). The Impact of Climate Change and Adaptation on Food Production in Ethiopia, *IFPRI Discussion Paper* 00828: Environment and Production Technology Division.

Nhemachena, C., and Hassan, R. (2007). Micro level analysis of farmers' Adaptation to Climate Change in Southern Africa. IFPRI Discussion Paper No.00714. *International Food Research Policy*. Washington DC.

NPC, (2006). Nigeria population census report. National Population Commission, Abuja, Nigeria

Ogundari, K., and Ojo, S.O. (2007). Economic Efficiency of Small-Scale Food Crop Production in Nigeria: A Stochastic Frontier Approach. *Journal of Social Sciences* 14(2): 123-130.

Oladapo, A., and Shittu, A.M. (2017). Effect of Credit Use on Agricultural Output of Rural Household in Akoko North -West Local Government Area of Ondo State. *International Journal of Agriculture and Environmental Research* 3(5): 3770 -3778

Osarenren, C.O., and Emokaro, C.O. (2015). Profitability of Cocoa Production Under Different Management Systems in Edo State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment.* 11(1): 38-43

Pew Center on Global Climate Change (PCGCC), (2004). Coping with global climate change: The role of adaptation in the United States. PCGCC: Arlington

Temesgen, D., Yehualashet, H., and Rajan, D.S. (2014). Climate change Adaptation of Smallholder Farmers in South Eastern Ethiopia. *Journal of Agricultural Extension and Rural Development* 6(11): 354 – 366