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Full length Research

Climate Change Adaptation Practices and Technical Efficiency of Cassava Production in Ekiti State, Nigeria

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This study examined climate change adaptation strategies and technical efficiency of cassava production in Ekiti State, Nigeria. It specifically identified the socio-economic characteristics, the various causes of climate changes perceived, the different coping strategies employed to meet with climate change adversity and analyzed the determinants of technical efficiency of cassava production in the study area. Multi-stage sampling technique was used to obtain data from 180 cassava farmers that were selected from 3 Local Government Areas in Ekiti State based on their size of cassava yield. Descriptive analysis and stochastic frontier production function were used to analyze the data. The proportion and various adaptation strategies employed by the cassava farmers were; Adoption of new varieties (60.6%), changing farmland (57.9%), changing planting date (91.1%), improving farming practices (75.6%), weather monitoring (85.6%), off farm activities (72.2%), and increase land size culture (27.8%). The influence of climate change adaptation strategies on the technical efficiency of respondents revealed that technical inefficiency effects existed in cassava production in the study area as confirmed by the gamma value of 0.973 that was significant at 1 percent level. The productivity analysis showed that farm size, fertilizer, labour, planting material and farm tools were efficiently utilized, whereas, it was not in the case of agrochemical whose utilization was already in the stage three of the production region. The return to scale (RTS) of 1.152 showed that cassava production was in irrational stage of the production surface. The Technical Efficiency varied substantially between 0.149 and 0.984 with mean value of 0.866. Farmers' socio- economic variables represented by age and farming experience contributed positively to technical efficiency of the farmers. The level of education, household size and extension service however reduced technical efficiency of the farmers. Cassava production could therefore be increased by awareness creation and extensive education on climate change and possible coping strategies to be used, efforts should be geared towards increasing the technical manpower of farmers, and a land redistribution policy that will increase the farm size of farmers, since they are mainly small scale farmers, which will boost cassava production.

Keywords: Climate Change, Adaptation Practices, Cassava Production, Technical Efficiency

INTRODUCTION

In Nigeria, agriculture is the main source of food and employer of labour. The sector employs (about 60-70 percent) of the population (Mayong *et al.,* 2005). It is a significant sector of the economy and the source of raw materials used in the processing industries as well as a source of foreign exchange earnings for the country (Mohammed and Atte, 2006). Since agriculture in Nigeria is mostly rain-fed, it follows therefore that any change in climate is bound to impact its productivity in particular and other socio-economic activities in general. The impact could, however, be measured in terms of effects on crop growth, availability of soil water, soil erosion, incidence of pest and diseases, sea level rises and decreased soil fertility (Adejuwon, 2004). The issue of climate change has become more threatening not only to the sustainable development of socio-economic and agricultural activities of any nation but to the totality of human existence (Adejuwon 2004). As further explained by the United Nations Framework Convention on Climate Change, UNFCCC, the effect of climate change implies that the local climate variability which people have previously experienced and adapted to is changing and this change is observed to be occurring rapidly. Hence, the agricultural sector is considered by examining agricultural productivity. Rainfall is by far the most important element of climate change in Nigeria and water resources potential in the country (Adejumo, 2004).

Climate change is a change in the statistical distribution of weather over periods of time that range from decades to millions of years while weather is the atmospheric condition of a place at a particular period of time. It can be a change in the average weather or a change in the distribution of weather events around an average (for example, greater or fewer extreme weather events). Climate change is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods. This is in line with Odjugo (2007) that identified two factors as the causes of climate change. These are natural processes (biogeographical) and human activities (anthropogenic). Climate change is one of the most important global environmental issues of our generation. It is distinct from natural climate variability in that it exists because of human activities that have altered the composition of the Earth's atmosphere. In his study, Odjugo (2007) described the trend in Temperature and Rainfall in Nigeria. It was discovered that the temperature trend in Nigerian since 1901 shows an increasing pattern. The increase was gradual until the late 1960s and this gave way to a sharp rise in air temperatures from the early 1970s, which continued till 2005. The mean air temperature in Nigeria between 1901 and 2005 was 26.6^{o}C while the mean temperature increase for the 105 years was 1.1^{o}C; this is higher than the global mean temperature increase (Odjugo, 2010)**.**

Climate change can lead to desertification, more intense storms, melting of the polar ice caps, and rising sea levels, changing the physical face of the Earth and the pattern of our everyday lives. While the possible consequences of climate change are alarming, there are many ways for every individual to take part in preventing these consequences from reaching their most dangerous potential. Agriculture however is extremely vulnerable to climate change. Higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the likelihood of short-run crop failures and long-run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. A number of empirical studies (Oyekale, et al., 2007; Apata et al., 2009; Ajetomobi and Abiodun, 2010 and Salimonu et al., 2010) have been carried out in recent times in Nigeria to explore the effects of climate change on agricultural production. Low outputs from farms in southwestern Nigeria, as a result of low rainfall and increased temperature were also detected in the study of Apata *et al*. (2009). Farmers in the study area were also abandoning mono-cropping for mixed farming in order to cope with losses in the earlier years. An in-depth analysis carried out by Ajetomobi and Abiodun (2010) in Nigeria recently also revealed that Climate change has negative impacts on cowpea productivity in Nigeria over the years reviewed.

Cassava (*Manihot esculenta)* is a native from South America that is extensively cultivated as an annual crop in the tropical and subtropical regions for its edible starchy tuber as root. Cassava has the ability to grow on marginal lands and it is one of the most important staple food crops in Tropical Africa with its efficient production of food energy, year round availability which makes it eminently suitable for farming and food system in Nigeria. Therefore, cassava is an important factor in food security, rural – urban drift and reducing unemployment among others (Okpukpara, 2006). The discovery and exploitation of petroleum led to the decline in the importance attached to cassava production and other important agricultural produce. However, Ekiti state being one of the cassava producing states in Nigeria is highly sensitive to variation in climatic factors most especially rainfall, temperature and sunshine duration. This study is aimed at unraveling various causes of climate change perceived, different coping strategies employed to meet with the adversity of climate change and analyze the determinants of technical efficiency of cassava production. This will open a new dimension to farmers and policy makers on how to increase cassava production by determining the extent to which it is possible to raise efficiency of cassava farmers with the existing resource base and available technology in order to address food production problem in Nigeria. This paper is organized as follows: section 1 is introduction and objectives, materials and method used in section 2. Results are presented in section 3 while section 4 describes discussion. In section 5, conclusion and policy implication from the result are drawn.

MATERIALS AND METHOD

The Study Area

The research work was based on farm level on cassava producers in Ekiti State, Nigeria. Ekiti State is in Southwestern part of Nigeria. It has indicating land surface with characteristics landscape that consists of old plants broken by top sided slopes. Temperature in the state ranges between 21 and 28 degree Celsius with high humidity. Tropical forest exists in the south while guinea savannah occupies the northern part. The major occupation of the people in the study area is farming while their major food crops are yam, cassava and maize.

Data Collection and Sampling Technique

The data, mainly from primary sources, were collected from 180 cassava farmers selected using multistage sampling techniques from three Local Government Areas. The three LGAs; Emure, Ikole and Moba were purposively selected at the first stage. The second stage involved a simple random selection of 60 farmers from each of the three LGAs, making 180 respondents. Data were collected with the aid of well-structured questionnaire. The input data include: Farm size (hectares), Labour (man/day), Fertilizer (kg), Agrochemical (litres), Planting material (kg) and Depreciation. Data were also collected on the socio-economic variables; such as: Sex (Male = 1, Female = 0), Age (years), Educational level (years), Farm size (hectares), Farming experience (years), Household size (numbers), Membership of cooperative (yes =1, otherwise = 0), Access to extension service (yes =1, otherwise = 0), Access to loan (yes =1, otherwise = 0), Engaged in non-farming activities (yes =1, otherwise = 0).

CONCEPTUAL FRAMEWORK/MODEL SPECIFICATION

Stochastic Frontier Production Function

This was used in this study can be illustrated with a farm using inputs (X_1, X2, ... Xn) to produce output Yi. Efficient transformation of inputs into output is characterized by the production function f(Xi), which shows the maximum output obtainable from various input vectors. The stochastic frontier production function assumes the presence of technical inefficiency of production. Hence, the function is defined as:

$$Yi = f(Xi, \beta) \exp(Vi-Ui)$$

Where Vi is a random error associated with random factors not under the control of farmers.

The model is such that the possible production Yi is bounded above by the stochastic quantity, f(Xi, β) exp (Vi). The random error (Vi) is assumed to be normally distributed N ~ (0, σ_v^2) random variable that is independent of Ui. The U is a non-negative one-sided truncation at zero with the normal distribution. It measures the technical inefficiency relative to the frontier production function, which is attributed to controllable factors (technical inefficiency). It is half normal, identically and independently distributed with zero mean and constant variance. The variances of the random errors (σ_v^2) and that of the technical inefficiency effects (σ_u^2) and overall model variance (σ^2) is related thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$, and the ratio $\gamma = \sigma_u^2 / \sigma^2$ is called gamma. Gamma measures the total variation of output from the frontier, which can be attributed to technical inefficiency.

Technical efficiency

This is defined in terms of the ratio of the observed output (Y_i) to the corresponding frontier output (Y_i^*). The Y_i^* is maximum output achievable given the available technology and assuming 100% efficiency. It is denoted as:

$$Y_i^* = f(X_i b) + V, \text{ that is, } Y_i / Y_i^*$$

Also, the TE can be estimated by using the expectation of U_i conditioned on the random variable. (V-U) as shown by Battese and Coelli (1988), that is

$$TE = \frac{f(X_i\beta) + V - U}{f(X_i\beta) + V}$$

and that , $0 \le TE \le 1$

The Technical Efficiency of the cassava farmers was expressed following the adoption of Battese and Coelli (1995) with the explicit Cobb-Douglas functional form specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + \beta_6 \ln X_6 + V_i - U_i$$

Where Yi = cassava output (kg), X_1 = Farm size (hectares), X_2 = Labour (man/day), X_3 = Fertilizer (N), X_4 = Agrochemical (N), X_5 = Planting material (kg), X_6 = Depreciation.

Inefficiency Model

The inefficiency model (U_i) is defined as:

$$Ui = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6$$

Where Z_1 = Off-farm activities (number), Z_2 = Level of education (years), Z_3 = Increasing land size culture (hectares), Z_4 = Changing planting date (Yes = 1, No = 0), Z_5 = Improving farm practices (Yes = 1, No = 0), Z_6 = Weather monitoring (Yes = 1, No = 0). These coping strategies variables were included in the model to indicate their possible influence on the technical efficiencies of the farmers. The β's and δ's are scalar parameters to be estimated. The variances of the random errors, σ_v^2 and that of technical inefficiency effects σ_u^2 and overall variance of the model σ^2 are related thus: $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and the ratio $\gamma = \sigma_u^2 / \sigma^2$, gamma, measures the total variation of output from the frontier which can be attributed to technical inefficiency (Battese and Corra), 1993.

RESULTS AND DISCUSSIONS

Socio-Economic Characteristics of Cassava Farmers

The analysis of the socio-economic characteristics of the respondents is presented in Table 1. The study revealed that the respondents were mostly male with

Table 1: Analysis of socio-economic characteristics of the respondents.

Variable	Frequency	Percentage
Sex		
Female	32	17.8
Male	148	82.2
Marital status		
Married	133	73
Single	21	11.7
Widow/Divorced	26	14.4
Age		
20-29	6	3.3
30-39	10	5.6
40-49	52	28.9
50-59	50	27.8
60 and above	62	34.4
Occupation		
Farming	80	44.4
Civil Service	31	17.2
Artisan	32	17.7
Trading	17	9.4
Contractors	20	11.1
Household size		
1-4	52	28.9
5-8	124	68.8
9-12	4	2.3
Farming experience		
>10	30	16.7
10-15	34	18.9
16-20	19	10.5
21 and above	97	53.9
Educational level		
No formal education	40	22.2
Primary	76	42.2
Secondary	48	26.7
Tertiary	16	8.9
Extension Contacts		
Visit	46	25.6
No visit	134	74.4
Membership of Cooperative Society		
Member	68	37.8
Non-member	112	62.2
Farm size (hectares)		
0.01-0.40	95	52.8
0.41-0.80	73	40.5
0.81-1.20	6	3.4
1.21-1.60	5	2.8
1.61-2.00	1	0.6

Source: Field survey, 2015

majority of them married and relatively old people with about 59.4 percent having ages more than or equal to 50 years but with large household size. This has negative implication for farming activities since young people in the study area were not actively involved in farming thereby making the productivity level of cassava to drop. It was also revealed that the major occupation of the respondents was farming and they were well experienced but with relatively low education since about 35.8 percent had secondary education and above. This

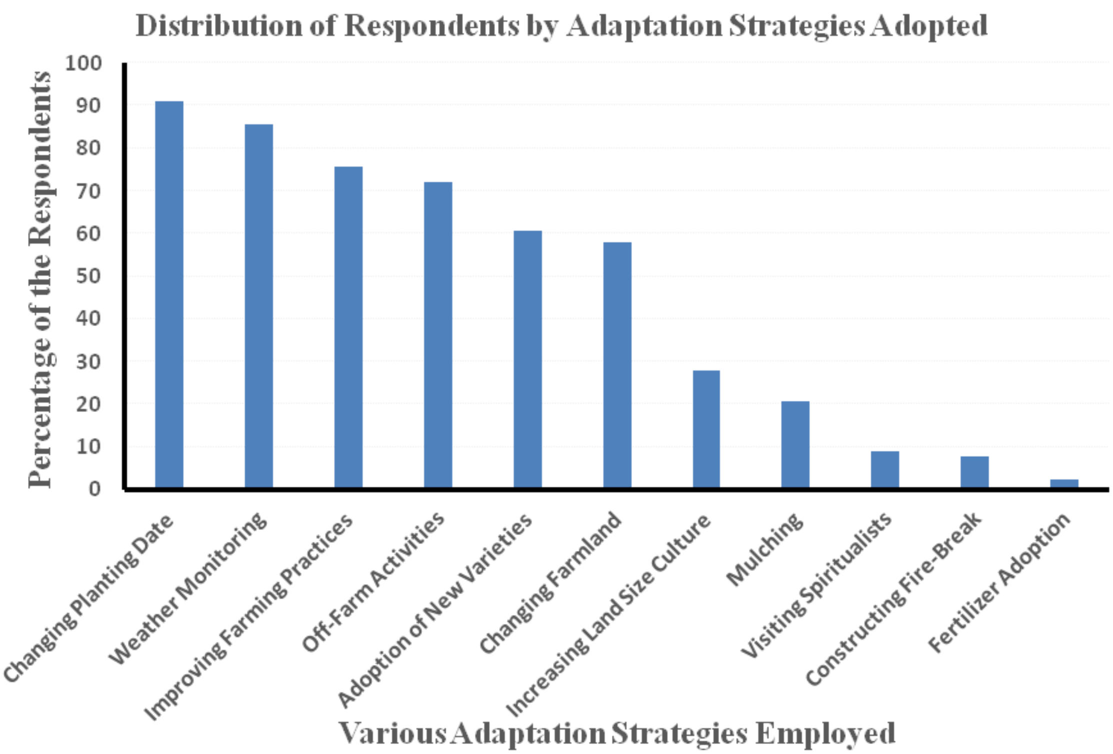

Figure 1: Distribution of Respondents by Adaptation Strategies Adopted.
Multiple responses

(**Source:** Field Survey, 2015).

low education would pose threat to efficient utilization of productive resources among the farmers. About 62.2 percent of the respondents belonged to cooperative societies but with about 72.8 percent having no access to loan, making expansion of farm size difficult for the zealous farmers. Only 25.6 percent had access to extension services, implying that farmers are rarely informed about the recent innovations in cassava production.

Different Adaptation Strategies Employed by the Cassava Farmers

This result in Figure 1 was reported in multiple responses form because, virtually, all the farmers sampled in the study area adopted more than one adaptation practices. Therefore, the most commonly employed climate change practice was changing planting date (91.1 percent). This was closely followed by weather monitoring (85.6 percent), 75.6 percent of the respondents adopted improving farming practices. About 72.2 percent of the respondents indicated off-farm activities while 60.6 percent embraced new variety as their adaptation strategy. Also, 53.9% adopted changing farmland, while 27.8 percent, 20.6 percent, 8.9 percent, 7.8 percent and 2.2 percent of the respondents adopted increasing land size culture, mulching, visiting spiritualists, constructing fire- break and fertilizer adoption respectively. This result suggests that respondents employed one form of adaptation strategy or the other in order to reduce effects of climate change on cassava production

Statistics of Variables of the Stochastic Frontier Production Function for Cassava Production

Table 2 presents the summary statistics of variables of the stochastic frontier production function for cassava production. The mean output of cassava harvested by farmers was 18, 480kg with a relatively small variability as shown by the standard deviation of 11.5kg. This was an indication that the farmers operated on similar levels of farm sizes. The average amount of money spent on farm tools and average number of the planting materials (cassava stems) planted by the farmers were ₦3, 700 and 1, 040.83kg with standard deviation of 607.791 and 748.303 respectively, indicating that productivity would be very low. The average number of farm size cultivated by the farmers was 0.6 hectare of land, and standard deviation of 0.230 indicated little or no mechanized activities. The labour used in cassava production had an average number of 412 man-days and standard

Table 2: Statistics of Variables of the Stochastic Frontier Production Function for Cassava Production

Variables	Minimum	Maximum	Mean	Std. Deviation
Output (kg)	4, 000	80, 000	18, 480	11.573
Farm Size (hectares)	0.3	1.8	0.6	0.230
Agrochemical (₦)	1, 650	18, 150	13, 513	3.745
Fertilizer (₦)	0	14, 000	2, 700	111.074
Labour (man-days)	183	708	412	33.519
Planting Materials (kg)	300	8000	1040.83	748.303
Farm Tool (₦)	580	3700	1450.33	607.791

Source: Field survey, 2015

Table 3: Estimates of Stochastic Frontier Production Function of Cassava Production

Variable	Coefficient	Standard Error
Constant	0.907	0.272
Farm size	0.937***	0.110
Agrochemical	-0.272	0.412
Fertilizer	0.132	0.402
Labour	0.227	0.183
Planting Material	0.194**	0.082
Farm Tool	0.052	0.037
Inefficiency factors		
Constant	0.402	0.397
Off-Farm Activities	0.365***	0.149
Educational Level	-0.709***	0.286
Increasing Farm Size	-0.903	0.304
Changing Planting Dates	0.215	0.198
Improving Farm Practices	-0.756	0.328
Weather Monitoring	0.612	0.427
Technical efficiency summary		
Mean TE	0.866	
Minimum TE	0.149	
Maximum TE	0.986	
Variance Parameters		
Sigma Squared	0.159	0.103
Gamma	0.973**	0.398
Log likelihood function	98.816	

*** $P < 0.01$; ** $P < 0.05$

Source: Field survey, 2015

deviation of 183.5 man-days. ₦2, 700 and ₦13,513 were the average amounts of money spent on fertilizer and agrochemical by the farmers with standard deviation of 111.074kg and 3.745 respectively

The Factors Determining Technical Efficiency of Cassava Producers

The influence of climate change adaptation strategies on the technical efficiency of respondents was also shown on Table 3. The parameter estimates from the inefficiency model included in the stochastic production frontier estimation revealed that the estimated coefficient for off-farm activities was positive and significantly related with technical inefficiency. This relationship implies that as off farm activities increase, the level of technical inefficiency tended to increase (i.e. decrease technical efficiency). Contrarily, an inverse and statistically significant relationship was found between educational level and technical inefficiency. This implies that further educational level may lead to higher technical efficiency perhaps because the level of education influences efficiency in agricultural production in terms of quality and quantity as well as speed at which farmers adopt new technologies and rationalize inputs to

Table 4: Elasticities of production and returns to scale

Variables	Elasticity of Production
Farm size	0.937
Agrochemical	-0.020
Fertilizer	0.007
Labour	0.036
Planting material	0.132
Farm tool	0.052
Return to Scale	1.152

Source: Computed from Survey Data, 2015

Table 5: Frequency Distribution of Technical Efficiency Indices

Technical Efficiency Range	Frequency	Percentage
≤0.4	8	4.45
0.41-0.60	16	8.89
0.61-0.80	35	19.44
0.80-1.00	121	67.22
Total	**180**	**100**

Source: Computed from Survey Data, 2015

enhance output. There was a negative relationship between improving farm practices and technical inefficiency, implying that the more the farmers adopt improved farming practices the more the technical efficiency. This was made possible because the farmers would get adaptable to the improved practices thereby increasing productivity. The estimated coefficient of changing planting dates for respondents was found to be positive and statistically insignificant; indicating that changing planting dates in the study area might not have positive results on productivity, and this could be termed as waste of efforts. It was also revealed from the result that there was a negative relationship between increasing farm size and technical inefficiency, implying that the more the size of the farm, the higher the technical efficiency.

Returns to Scale Analysis

This is a measure of resource productivity as presented in Table 4. The RTS parameter (1.152) was obtained from the summation of the coefficients of the estimated inputs (elasticities) which indicates that cassava production in the study area was in the Stage I of the production surface and thus the production is inefficient because most of the productive resources were underutilized (Doll and Orazem, 1978). The RTS reported in this study was in conformity with the research work of Ogundari and Ojo (2005) on determinants of technical efficiency of mixed-crop food production in Nigeria. Ajibefun, (2002) also arrived on a similar situation in a study 'analysis of policy issues in technical efficiency of small scale farmers' and lastly, it was in line with the study carried out by Ojo and Ehinmowo,(2010) on economic analysis of kola –nut production in Nigeria.

Technical Efficiency Analysis

This ranged between 0.149 and 0.986 with mean technical efficiency of 0.866. The decile range distribution of the TE in Table 5 showed that about 67.22% of the cassava farmers had technical efficiencies of 0.8 and above, implying that the sampled farmers were relatively highly technically efficient because it was evident that more than half of the farmers obtained optimal output from a given set of inputs with a reduced level of resources wastage.

CONCLUSION

Cassava production is in stage 1 or increasing returns to scale of the production region and thus the production is inefficient in the study area. The study concluded that the determinants of adoption of coping strategies to climate change were educational level, primary occupation, household size, farm size, farming experience, and extension services delivery. Also, the productivity analysis shows while farm size, fertilizer, labour, planting material and farm tools were efficiently utilized it was not in the case of agrochemical whose utilization was already in the stage three of the production region. Cassava production could therefore be increased by awareness creation and extensive education on climate change and possible coping strategies method to be used, effort should be geared towards increasing the technical manpower of farmers, a land redistribution policy that will increase the farm size of farmers since they are mainly small scale farmers will boost cassava production. Planting materials supply at subsidized rate to farmers in the area should be encouraged.

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