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Climate Change and Technical Efficiency of Yam Farmers in Ekiti State, Nigeria

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Abstract
Yam holds important position as a food and industrial crop in the Nigerian economy. Thus, the ability to meet the future demand may hinge upon proper assessment of the effects of climate change on productivity and economic efficiency of yam farmers in the country. The study was carried out in Ekiti State. Multi-stage sampling technique was employed to select respondents for the study. One hundred and twenty (120) respondents were sampled for this study. Information from 107 respondents were found suitable for analysis. Data collected were subjected to descriptive, budgetary and stochastic frontier analyses. Results indicated that most of the farmers were males (88%) with more than half (55%) above 50 years of age. Majority of the farmers (93%) had formal education. Delay in rain onset (90%) was prevalent with mixed cropping (89%) and mulching (88%) as the most coping strategies used to reduce its effect. The gross margin and profit were ? 71,820.00 and ? 69,520.00 respectively. Cost ratio (2.47) and percentage profit (147.04%) shows that yam farming was profitable in the study area. Farm size and labour are positive and significant ($p < 0.01$) variables in the production function estimated. Household size, education and adoption index had negation relation in the model and contributed to technical efficiency in the system. It was concluded that yam production was highly profitable in the area. Farmers were advised to reduce labour costs and thus increase profit margin. Farmers should be encouraged to be educated as this will help them to employ more copping strategies against climate change, consequently enhancing efficiency in the system.

Keywords: Climate change, Technical efficiency, Yam farmers, Ekiti State, Nigeria

Introduction
Agriculture is one of the sectors mostly affected by the ongoing climate change. The wide range of literature on this subject demonstrates that damages caused by climate change is relevant to both cropping and livestock activities (Salvo *et al.,* 2013). In fact, climate change affects different agricultural dimensions, causing losses in productivity, profitability and employment. Climate change clearly threatens food security (Sanchez, 2000; Siwar *et al.,* 2013), due to the instability of crop production, and induced changes in markets, food prices and supply chain infrastructure (Salvo *et al.*, 2013). Climate change can be considered as one of the most serious threats to sustainable development, with adverse impacts particularly on human health, food security, economic activity, water resources and other natural resources, and scientists agree that increased anthropogenic greenhouse gas concentrations in the atmosphere are the causes (Huq *et al.,* 2006; Adebayo *et al.,* 2012; Adeloye and Sotomi, 2013). Climate is the average weather of a place over a period of time or is defined as the prevalent pattern of weather observed over a prolonged period of time.

Climate change is often synonymously used with climate variability and yet the two are different. The term climate change refers to an overall alteration of mean climate conditions, whereas the term climate variability refers to fluctuations about the mean. A changing climate is likely to bring about changes to patterns of climate variability. Climate change refer to the long term significant change in the "average weather" that a given region experiences, while climate variations in the mean state and other statistics of climate on all temporal and spatial scales beyond that of individual weather events (Oluwasusi and Tijani, 2013). Climate change impact varies among regions and between different generations, income groups and occupations, men and women as well as young and old people which have social and economic impact on human livelihood (Adeloye and Sotomi, 2013). These impacts of climate changes are manifested in increase extreme weather conditions such as, irregular rainfall pattern, increase in temperature, sea level rising, delay rainfall onset, early rainfall retreat, drought, flood, prolonged dry season, and increase in ground water salinity. These have led to water scarcity, soil infertility, insect pest invasion, longer growing season, redistribution of crops, decline in animal production and crop yield (Adeloye and Sotomi, 2013).

Yams (Dioscorea sp.) are annual or perennial tuber-bearing and climbing plants. The genus Dioscorea has over 600 species but only a few are cultivated for food and others for medical uses. The major edible species of African origin are white guinea yam (Dioscorea rotundata Poir), yellow guinea yam (Dioscorea cayenesis Lam) and trifoliate or bitter yam (Dioscorea dumetorum Kunth) (Mignoun et al., 2003). In Nigeria the common species grown are white yam (Dioscorea rutundata) and water yam (Dioscorea alata) (Brand-Miller et al., 2003; Osunde, 2008).
Nigeria is so far the world's largest producer of yams, accounting for over 70 to 76 percent of the world production. Statistically in 2004, the global yam production was about 47 million metric tons, which about 95 percent of the metric tons was produced in Africa. Nigeria alone accounted for about 70 percent of the world production (FAO, 2006). With growing demand, yam has assumed great importance in Nigeria. The nation produces about 31.5 million metric tons of yams annually.

CBN (2003) and FAO (2002) reported that Nigeria accounts for 71% (26 million ton) of the total world production of yam harvested from 2,760.00 hectares. On the basis of quantity of root and tuber crops produced in Nigeria, yam ranks second only after cassava (NBS, 2007). Although, there has been a decline in yam production relative to cassava and rice in Africa, yam is such a preferred staple food that, bearing in mind that as population increases, demand will remain and the absolute production will rather increase (Srivastava and Gaiser, 2008).

Efficiency is a very important factor of productivity growth especially in developing agrarian economies, where resources are meager and opportunities for developing and adopting better technologies are dwindling. Such economies can benefit from efficiency studies which show that it is possible to raise productivity by improving efficiency without increasing the resource base or developing new technologies. Raising productivity and output of small farmers would not only increase their incomes and food security, but also stimulate the rest of the economy and contribute to broad-based food security and poverty alleviation (Lipton, 2005). Thus, the ability to meet the future demand may hinge upon proper assessment of the effects of climate change on efficiency of yam farmers in Ekiti State. The main objectives of the study are to examine climate change variables affecting the farmers and determine the technical efficiency of yam farmer in Ekiti state. Specifically, the study estimates the costs and returns to yam production and determines the factors that affect the technical efficiency of yam production in the study area.

Methodology

The study was carried out in Ekiti State. Multi-stage sampling technique was employed. The first stage was a purposive selection of four (4) Local Government Areas (Irepodun, Ilawe, Ise and Emure LGA) based on the yam farmers prominence in those areas. The second stage involved purposive selection of three (3) villages from each of the four local government areas. The third and final stage involved a random selection of ten (10) respondents from each of the villages. A total of one hundred and twenty (120) yam farmers were interviewed with the use of structured questionnaires. Information from 107 respondents were found suitable for analysis. Data obtained were analyzed using descriptive statistics, budgetary technique and stochastic frontier analysis.

Budgetary technique is expressed as:

$GM = TR - TVC$……………………….(1)

$\Pi = GM - TFC$…...……………………(2)

Where, GM = Gross Margin, Π = profit, TR = Total Revenue, TVC = Total Variable Cost, TFC = Total Fixed Cost.

Stochastic Production Frontier Model

According to Lawson (2004) the parametric frontier approach to efficiency measurement involving the specification and estimation of a parametric representation of the technology (frontier production, cost or profit function) has been applied extensively in many industries, including agriculture. Forsund et al. (1980) and Schmidt (1986) each provide a valuable overview of the modeling and estimation of parametric frontier functions and their relationship to efficiency measurement. In addition, Battese (1992) provides a survey of empirical applications of the parametric frontier production approach to technical efficiency measurement in the agricultural sector. The specification of explicit Cobb-Douglas production function for yam farmers in the study area is therefore given as:

$LnQ = \alpha + \alpha_1 LnX_{1i} + \alpha_2 LnX_{2i} + \alpha_3 LnX_{3i} + \alpha_4 LnX_{4i} + \alpha_5 LnX_{5i} + (v_i + \mu_i)$ …….. (3)

Where, Q = Total output (kg/hectare);

X_1 = Farm size (hectare);

X_2 = Labour used (man-day)/hectare;

X_3 = Quantity of fertilizer (kg/ha);

X_4 = Quantity of herbicides (kg/ha); and

X_5 = Coping strategies. The choice of the Cobb-Douglas is based on the fact that the methodology of the function is self-dual in the case of production function (Lawson, 2004). The efficiency model (μ_i) is expressed thus:

$\mu_i = \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5$ ….....… (4)

Where, Z_1 = farming experience, Z_2 = household size, Z_3 = educational level, Z_4 = age and Z_5 = adoption index, (which was computed using responses on likert scale) respectively. The estimates for all parameters of the stochastic production frontier model and inefficiency model are simultaneously obtained using the program – Frontier software.

Results and Discussion

Majority of the farmers were male (88%). Fifty five percent of the farmers are 50 years of age and below while 45% are older than fifty years. Thus, more than half of the yam growers are in their productive farming age. Ninety three (93%) percent of the yam farmer had formal education. Implying high literacy level of the farmers in the study area. Average farming household size of yam farmers in the study area is five persons with an average farm size of 1.1 hectares. Majority of the farmer interviewed (94%) have more than 10 years experiences in yam cultivation. Thus they are expected to be well grounded in the best practices of the enterprise. Among the various climatic factors affecting yam farmers which were observed by the farmers in the study area were, delay in rain onset (90%), annual rainfall ends early (74%), unpredictable rainfall onset (86%), heavy rainfall (80%), high temperature (66), heavy downpour within a short period (61), and irregular relative humidity. The percentages correspond to the response of number farmers that observed the particular climatic factor. The results also show that majority of the farmers adopted mixed cropping (89%), mulching (88%), use of shades (68), multiple planting dates (51) and cover cropping (62%) as coping strategies to reduce effect of the observed climate while few of the respondent adopted change of fertilizer used (13%), change of chemicals used (30%) and use of irrigation system as climate change coping strategies in the study area.

Table 1: Observed climatic variables by respondents

Variables	SA (%)	A (%)	UD (%)	D (%)	SD (%)
Delay in rain onset	43.0	46.7	1.9	6.5	1.9
Annual rainfall ends early	15.9	53.3	6.5	21.5	2.8
Annual rainfall starts early	14.0	58.9	11.2	12.1	3.7
Annual rainfall ends late	10.3	47.7	20.6	17.8	3.7
Irregular rainfall pattern	14.0	47.7	29.0	3.7	5.6
Unpredictable onset of rainfall	19.6	60.7	11.2	6.5	1.9
Heavy rainfall	30.8	43.9	9.3	10.3	5.6
Heavy temperature	20.6	41.1	16.8	15.0	6.5
Low temperature	15.0	38.3	24.3	15.9	6.5
Shift/unpredictable harmattan	11.2	34.6	26.2	19.6	8.4
Heavy downfall within a short period	17.8	39.3	27.1	15.0	0.9
Dry spell during dry season	9.3	37.4	29.9	14.0	9.3
Higher temperature during dry season	18.7	35.5	16.8	15.0	14.0
Lower temperature during rainy season	12.1	39.3	15.0	18.7	15.0
Irregular length of cold period	13.1	21.5	26.2	25.2	14.0
Irregular length of hot period	19.6	27.1	32.7	14.0	6.5
Irregular increase and decrease in relative humidity	23.4	36.4	23.4	6.5	10.3

Source: Field survey, 2018

Cost and returns

The budgetary analysis (Table 1) showed that the TVC (? 44,980) formed the bulk 95.1% of the TC (? 47,280) while TFC (? 2,300) (depreciation) was just 4.9%. This implies that farmers who want to be cost efficient have to reduce TVC especially the cost labour that is more than three quarter (79.4%) of the total cost. TFC is small (4.9%) probably because of few fixed implements such as hoes and cutlasses used in the area. This is typical of core rural communities in Southwestern Nigeria where most farmers are used to crude implement such as hoes and cutlasses. The total profit of ? 69,520 per hectare and percentage profit of 147% shows that yam farming is a highly profitable enterprise in the area. The cost ratio showed that a farmer that invested ? 1 realized ? 2.47 as revenue or gained ? 1.47 on each naira expended.

The stochastic production frontier estimates

The maximum likelihood estimate of the Cobb-Douglas production function is presented in table 2. The sigma-squared of 0.298E+07 and gamma value of 0.108 which are significantly different from zero suggest that the model is a good fit. The coefficient of various variables in the model and their interpretation are as follows:

$LnQ = 1358.961 + 190.483X_1 + 0.412X_2 + 8.631X_3$

The significant variables in the general model are farm size ($p < 0.01$), and labour (man-day) ($p < 0.01$). The coefficient of farm size (190.483) is positive. This implies that increasing the farm size by one hectare will bring about increase in the output of yam farmers in the area by 190%. Also, coefficient of labour use (0.412) has positive relationship with output. This implies that increasing the number of man-day labour will increase the output by 0.412%. The positive effect of labour use could be as a result of high family size, which could be available for farm labour in the area.

$\mu = -7.075 - 209.990Z_1 - 42.116Z_2 + 35.766Z_3 - 4.234Z_4$

The result of inefficiency model revealed that, household size (-209.990), education

Table 2: Coping strategies employed by respondents

Variables	Frequency	Percentage
Practising mixed cropping	95	88.8
Change use of fertilizer	14	13.1
Change use of chemicals	32	29.9
Use of irrigation system	35	32.7
Mulching	94	87.9
Use of shades	73	68.2
Multiple planting dates	55	51.4
Cover cropping	66	61.7
Observation	N	107

Source: Field survey, 2018

Table 3: Budgetary analysis

S/N	Description	Value (₦)
	VARIABLE COSTS	
I	Cost of labour	37,560.00
II	Cost of fertilizer	2,750.00
III	Cost of Transportation	4,670.00
IV	Total Variable Cost (TVC)	44,980.00
	FIXED COSTS	
V	Depreciation (implement cost such as hoes and cutlasses)	2,300.00
VI	Total Cost (TC)	47,280.00
VII	Total Revenue (TR)	116,800.00
VIII	Gross Margin (GM) (TR-TVC)	71,820.00
IX	Profit (TR-TC)	69,520.00
X	Cost Ratio (TR/TC)	2.47
XI	Percent Profit (Profit/Total Cost)*100	147.04

Source: Data analysis, 2018

(-42.116) and adoption index (-4.234), had negative relationship in the model, which indicate that they contributed to technical efficiency in yam production in the area. This could be due to earlier result that showed that majority of the respondents adopted one or more coping strategy in reducing the effect of climate change in the area. Household size is negative and contributes to efficiency in yam production. This means that as the yam farmer's household size increasing, his efficiency improves. This might be due to availability of family labour that will reduce the cost of hired labour which increases the variable cost of production as revealed in the cost and returns, thereby reducing the cost of labour and consequently improves his production efficiency as this will enable them to produce at low cost in the area of study. On the other hand, age had a positive relationship in the model and contributes to inefficiency in the system. This implies that, the older the farmers become, the less efficient they are in the system. That is, farmer's efficiency reduces as they become older. To this effect, the youth should be encouraged to take up farming as a profession which will enhance efficiency in the system. They should also be encouraged to be educated as this will enhance their efficiency in the system.

Summary and Conclusion

This study aimed at examining the effect of climate change on the efficiency of yam production in Etiti State. Primary data were collected from 120 yam farmers in four Local Government Area of the state. But 107 respondent's data were used for this study due to inappropriateness of 13 respondent's data. The data were subjected to descriptive, budgetary and stochastic production frontier analysis. It was

Table 4: The maximum likelihood estimates of parameters of the Cobb Douglas frontier function

Variable	Estimate	T-ratio
General model		
Constant	1358.961***	107.392
Farm size	190.483***	17.475
Labour used (man-day)/ha	0.412***	3.422
Quantity of fertilizer (kg/ha)	8.631	0.383
Inefficiency model		
Constant	-7.075	-1.588
Household size	-209.990	-1.644
Education	-42.116*	-1.653
Age	35.766***	2.689
Adoption index	-4.234	-1.531
Variance parameters		
Sigma-squared	0.298E+07***	0.298E+07
Gamma	0.108**	2.466
Log likelihood	-9845.295	
LR test	4.706	

Source: Data analysis, 2018

discovered that men (88%) dominated yam farming and majority (93%) of them have formal education. Average farm size of the farmers is 1.1 hectares. They had over ten years of experience in yam production.

The most common climatic factor influencing their activities are: delay in rain onset (90%), annual rainfall ends early (74%), unpredictable rainfall onset (86%), heavy rainfall (80%), high temperature (66), heavy downpour within a short period (61), and irregular relative humidity. Mixed cropping, mulching, use of shade, multiple planting dates and cover cropping were the various coping strategies employed to reduce the effect of climate change in the area. With profit of ? 69,520 and percentage profit of 147%, the enterprise is considered to highly profitable. Farmers who invested ? 1 realized revenue of ? 2.47. Farm size and labour (man-day) are variables that had positive and significant ($p < 0.1$) relationship in the production function estimated.

Household size, education and adoption index are the farm specific variables that affect efficiency of yam production in the system. Age of the respondents had a positive relationship and contributed to technical inefficiency in the system. In conclusion, yam has the potential for achieving twin objectives of poverty alleviation and food security for the producers in the core rural communities of Ekiti state because, it is highly profitable and leaves farmers with high returns on their investments. Farmers have to cut down the variable costs in other for them to increase their profit. Since the bulk of the variable cost is incurred on labour, attempts at reducing this cost will lead to greater gross margins and hence the profitability of the enterprise. Farmers should be encourage to go school as this will enhance the high literacy level, consequently helping them to adopt more copping strategies in other to reduce the effect of climate change and also increase their efficiency in the system.

References

Adebayo A. A., Onu J. I., Adebayo E. F. and Anyanwu S. O. (2012): Farmers Awareness, Vulnerability and Adaptation to Climate Change in Adamawa State, Nigeria. *British Journal of Arts and Social Science,* 9(2), 104-115

Adeloye K. A., Sotomi, A. O. (2013): Youth Farmers' coping strategies with Climate Change in Osun, State, Nigeria. *J. Biol. Agric.* Health Care, 3(14), 61-66.

Battese G.E., (1992): "Frontier production functions and technical efficiency: a survey of - empirical applications in agricultural economics." *Agricultural Economics,* 7, 185-208.

Brand-Miller, J., Burani, J., & Foster-Powel, K. (2003): The new Glucose Revolution Pocket Guide to the top 100 low G.L food. *Claredon press*, London.

CBN (2003): Annual Report and statement of Account Various Issues. Central Bank of Nigeria (CBN) Abuja.

FAO (2002): Root Statistics, Proceeding of the Expert Consultation of Root Crop.

Food and Agricultural Organization (FAO) (2006): Food and Agricultural Organization Database, available at *www.fao.org*, accessed on 20-11-2011.

Forsund F., Lovell C.A.K. & Schmidt P., (1980): "A survey of frontier production functions and of their relationship to efficiency measurement." *Journal of Econometrics*, 13, 5-25.

Huq S., Reid H., Murray L.A. (2006): Climate change and development links. Gatekeeper Series. 123. Institute for Environment Develop-ment.

Lawson L.G., (2004): Relationships of efficiency to reproductive disorders in Danish milk production: A stochastic frontier analysis," *Journal of Dairy Science,* 87, 212-224.

Lipton M., (2005): "The family farm in a globalizing world: the role of crop science in alleviating poverty." IFPRI 2020 Discussion Paper 40, International Food Policy Research Institute, Washington D.C., 40 pp.Mignoun, H. O., Abana, M. M., and Asiegbu, R. (2003): Harnessing Modern Biotechnology for Tropical Tuber crops improvement. *G.U. publication*, Abuja, Nigeria.

NBS (2007). National Bureau of Statistics Annual Agricultural Survey Report: 1994/95-2005/06.

Oluwasusi, J. O. and Tijani, S. A (2013): Farmers Adaptation strategies to the Effect of Climate Variation on Yam Production: A Case Study in Ekiti State, Nigeria. Agro-search (2013), 13(2), 20-31

Osunde Z.D. (2008): Minimizing Postharvest Losses in Yam (Discoreaspp): Treatments and techniques. https://docs.google.com accessed on June 2012.

Salvo M. D., Begalli D. and Signorello G. (2013): Measuring the effect of climate change on agriculture: A literature review of analytical models. *Journal of*

Development and Agricultural Economics, 5(12), 499-509

Sanchez P.A. (2000): Linking climate change research with food security and poverty reduction in the tropics Agriculture. *Economics of Environment,* 82(1–3), 371–383.

Schmidt P., (1986): "Frontier production functions." *Econometric Review*, 4, 289-328.Siwar C., Ahmed F., Begum R.A. (2013): Climate change, agriculture and food security issues: Malaysian perspective. *Journal of Food Agriculture and Environment*, 11(2), 1118–1123.

Srivastava, A.K., Gaiser, T., (2008): Biomass production and partitioning pattern of Yam (Dioscorea rotundata). *Agricultural Journal*, 3, 334–337.