



## TECHNICAL EFFICIENCY OF MAIZE-BASED CROPPING SYSTEMS AMONG RAIN FED FARMERS IN ADAMAWA STATE, NIGERIA

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### ABSTRACT

This study analyses the technical efficiency of maize-based cropping systems among rain fed farmers in Adamawa State, Nigeria. Primary data were collected from 310 randomly selected maize farmers in eight Local Government Areas of the State using structured questionnaire. The stochastic production frontier model was used to determine the technical efficiency of the farmers. The results revealed that majority (68.08%) of the farmers were male and with a mean age of 47 years with mean household size of 8 members and 77.42% possess varied levels of formal education. Similarly, Maize intercropped with other crops was the dominant (73.11%) cropping system and accounted for 56.78% of total area cultivated by the farmers. The findings also revealed that the farmers were technically efficient in their production, with a mean technical efficiency of 0.73. The factors such as education, farming experience and extension contact were significant variables that positively influence technical efficiency, while age negatively affects technical efficiency. Most of the farmers operated below the production frontier, hence will not be able to maximize their yield per hectare. This therefore, translates to low income and hence low revenue. More production incentives such as subsidized farm inputs should be put in place and promoted to farmers for increase efficiency.

**Keywords:** Adamawa, Cropping, Efficiency, Farmers, Maize-based, Systems, Technical.

### INTRODUCTION

Nigeria is the largest producer of maize in Africa where about 70% of the farmers are small scale farmers and produce about 90 % of total farm output (IITA, 2008; Cadini and Angelucci, 2013). In sub-Saharan Africa, maize is a staple food for an estimated 50% of the population where about 80% of it is consumed, while 20% is utilized in a variety of industrial processes for the production of starch, corn sweetener, ethanol, cereal and alkaline (Owaeye, 2017). Maize production in Nigeria has risen to commercial scale where it provides raw materials to many agro-based industries (Iken, and Amusa, 2014). In Nigeria, more than 50% of the annual maize production is used to produce animal feds and most of the farmers are involved in its cultivation, processing and marketing (Samade, 2016). The country has a total arable land of about 98.3 million hectares, of which only 40% is under cultivation (FMARD, 2001; Omorogiuwa *et al.*, 2014). Ironically, domestic food demand in the country has outstripped food supply over the years resulting in wide food deficits leading to large scale food importation (Ogundari and Ajibefun, 2006; CBN, 2016). The low productivity of maize is attributed to the bulk (90%) of the country's farms relying on subsistence agriculture which involved the use of rudimentary tools, low capitalization and low yield per hectare (Ogundari *et al.*, 2006). The achievement of food self-sufficiency therefore has been the policy thrust of successive governments in Nigeria.

In view of the growing gap between the demand for and supply of food in the country against the background of an increasing population, the efficiency with which available



resources and technology are used by farmers becomes a priority subject of investigation (Maurice *et al.*, 2014). It is no surprise therefore, that considerable effort has been devoted to the analysis of farm level efficiency in developing countries. Efficiency studies are important in that they serve as reliable guidance in formulating policies, especially when it comes to the search for the primary causes of inefficiency and improvement potentials (Ogundari *et al.*, 2011). Efficiency analysis is an issue of interest given that the overall productivity of an economic system is directly related to the efficiency of production of the components within the system.

It is concerned with the economic performance of the processes used in transforming given inputs into outputs. Technical efficiency measures the relationship between the physical quantities of inputs and output. In other word, technical efficiency determines the maximum possible output using the same input mix or different combination of resources (Ogbanje *et al.*, 2014). Formally, the level of technical efficiency is measured by the distance of firm from the optimal production frontier. A firm that sits on production frontier is said to be technically efficient. Increased productivity gain have in general decreased food cost and improve food security, particularly for vulnerable section of the society (Sani and Haruna, 2010), therefore, food crop farmers need to be more efficient in their production activities and be also responsive to market indicators, so that scarce resources are utilized efficiently to increase production as well as productivity in order to ensure continuous food supply. Even though the subject of efficiency in maize- based cropping system is important, very few studies have focused on this area. Thus the broad objective of this study was to determine the technical efficiency of maize-based farmers in Adamawa state. Nigeria.

## **MATERIALS AND METHODS**

### **The Study Area**

Adamawa State is located at the North Eastern part of Nigeria and created in 1991 from the defunct Gongola State. It lies between Latitude  $7^{\circ}$  and  $11^{\circ}$ N of the Equator and between Longitude  $11^{\circ}$  and  $14^{\circ}$ E of the Greenwich Meridian. It shares boundary with Taraba State in the South and West, Gombe State in the North West and Borno State in the North. Adamawa State has an international boundary with Cameroun Republic along its eastern border. The State covers a land area of about  $38,741\text{Km}^2$  and is divided into 21 Local Government Areas with projected population of 3,675,000 (NPC website, 2015). The State has a tropical climate marked by dry and rainy seasons. The rainy season commences in April and ends in late October. The wettest months are August and September. Mean monthly temperature in the State ranges from  $26.7^{\circ}\text{C}$  in the south to  $27.8^{\circ}\text{C}$  in the north eastern part of the State. The mean annual rainfall ranges from 700mm in the north eastern part of the State to 1600mm in the southern part (Adebayo, 1999a). On the other hand the north eastern strip and the southern part have over 1,000mm (Adebayo, 1999b).

### **Sampling Procedure and Data collection**

Multi-stage random sampling technique was employed in the selection of respondents used for the study. In the first stage, two Local Government Areas were randomly selected from each ADP zone. These were Michika and Mubi North LGAs in zone I, while, Gombi and Girei LGAs in Zone II, and Ganye and Mayo Belwa LGAs in Zone III the finally, Guyuk and Demsa LGAs in zone IV. In the second stage, two wards were randomly selected from each of the selected Local Government Area given a total of 16 wards. Thirdly, one village was randomly selected from each ward giving a total of 16 villages. Consequently, a total of 310 farmers were selected and data sourced from them by administering pre tested structured questionnaires.



### Method of Analysis and Model Specification

The specification of the stochastic frontier production function model used for the analysis in explicitly form is thus:

$$\ln Y_{ij} = \beta_0 + \beta_1 \ln X_{1ij} + \beta_2 \ln X_{2ij} + \beta_3 \ln X_{3ij} + \beta_4 \ln X_{4ij} + \beta_5 \ln X_{5ij} + \beta_6 \ln X_{6ij} + V_{ij} - U_{ij} \dots (1)$$

where;

$L_n$  = Logarithm to base e

$Y_i$  = Output of food crops (grain equivalent weight)

$X_1$  = Farm size (ha)

$X_2$  = Family labour (in mandays)

$X_3$  = Hired labour (in mandays)

$X_4$  = Agrochemical (Litres/ha)

$X_5$  = Inorganic fertilizer (kg/ha)

$X_6$  = Seeds (kg/ha)

It is assumed that the technical inefficiency effects are independently distributed and  $U_i$  arises by truncation (at zero) of the normal distribution with mean,  $\mu_{ij}$  and variance  $\delta^2$ , where  $\mu_{ij}$  is defined by:

$$\mu_{ij} = \mu_0 + \mu_1 Z_{1ij} + \mu_2 Z_{2ij} + \mu_3 Z_{3ij} + \mu_4 Z_{4ij} + \mu_5 Z_{5ij} + \mu_6 Z_{6ij} + \mu_7 Z_{7ij} \dots (2)$$

where;

$\mu_i$  = Inefficiency effect

$Z_1$  = Age of farmer (years)

$Z_2$  = Farming experience (years)

$Z_3$  = Educational level of farmers (years)

$Z_4$  = Household size

$Z_5$  = Extension contact (number of meetings)

$Z_6$  = Crop diversification (1 indicate sole cropping and 0 otherwise)

## RESULTS AND DISCUSSION

### Maize-based Cropping Systems

The objective of any cropping system is efficient allocation of all resources (Panda, 2007). The distribution of cropping system of maize –based farmers as presented in Table 1 revealed seven (7) cropping systems. Sole cropping accounted for 23.87%, with 35.11% of the total hectare allocation, while mixed cropping accounted for 76.13%, with 64.89% of the total hectare allocation. On the area under cultivation, the average area under sole maize was estimated at 3.61ha and is higher than areas under maize combined with other crops. The distribution reveals that mixed cropping is the common cropping system among the farmers in the area and is due largely to consideration for risk minimization, stable income and adaptability to a particular season (Sani and Haruna, 2010; Maurice *et al.*, 2015).



Table 1: Distribution of Farmers by Maize-based Cropping Systems

Cropping systems	Farmer		Hectarage allocation		Average farm size (ha)
	No.	%	No	%	
Sole maize	74	23.87	267.5	35.11	3.61
Maize/sorghum	11	5.54	31.0	4.07	2.82
Maize/cowpea	168	54.19	384.5	50.47	2.29
Maize/cowpea/sorghum	28	9.03	63.4	8.32	2.26
Maize/groundnut	10	3.22	9.0	1.18	0.9
Maize/cowpea/groundnut	10	3.22	2.0	0.26	0.2
Maize/rice	9	2.90	4.5	0.59	0.5
Total	310	100	761.9	100	

Source: Field Survey, 2016

Stochastic Frontier Production Function Analysis for Maize-based Farmers

The maximum likelihood estimates (MLE) of the stochastic production function in explaining the influence of production inputs on the output of maize-based farmers in the state and also in determining the effect of farmers' specific characteristics on the technical inefficiency is presented in Table 2. The result shows that the coefficients of farm size (β1), hired labour (β3) and agrochemicals (β4) are all positive and statistically significant at varied acceptable levels. This implies that a one % increase in the use of these production inputs will bring about increase in the total output of maize-based production by the respective values of the coefficients. The elasticity of the explanatory variables shows decreasing returns to scale (< 1), indicating that the input allocation by these farmers is in stage II of the production function. The sigma squared (0.499) is statistically significant at 5% level. This indicates a good fit and correctness of the distributional form assumed for composite error term. The variance ratio defined as gamma is 0.89 and statistically significant at 1% level, implying that 89% of the variation in the output of the farmers was due to differences in their technical efficiencies. In other word, the existence of technical inefficiency among the farmers accounted for 89% of the variation in the output level of the farmers.

Similarly, farm size is positive which conform to a priori expectation and significant at 1% level. This implies that a 1% increase in hectare used in maize-based production ceteris paribus will bring about increase in the total output by 0.153% and vice versa. This result agrees with Girei (2014) who identified land as a critical factor in agricultural production. The coefficient of hired labour is positive and statistically significant at 1% level, implying that a 1% increase in man-days of hired labour used in production will bring about increase in maize-based output by 0.215%. According to Audu et al. (2009), given the ageing trend of our farmers and high rate of rural-urban migration, the high cost of labour is undesirable. Furthermore, agrochemicals which include herbicides and pesticides have an elasticity coefficient of 0.126 and statistically significant at 5% level. This means that a 1% increase in the quantity of agrochemicals used in maize-based crop production would increase output by 0.126%. The use of agrochemicals help farmers to save time and money that would have been spent on weeding and manual control of pest and diseases. This result agrees with the findings of Maurice et al. (2015)) who reported that the use of herbicides reduces cost of weeding and also reduces stress and fatigue associated with food crop production. By implication it helps farmers to cultivate large hectares of land which will result in an increase in maize-based output. This agrees with



the findings of Okoze *et al.* (2012) who asserted that the use of herbicide reduces drudgery and enable farmers increase their farm size.

Table 2: Stochastic Production Frontier Analysis for Maize-based farmers

Variable	Parameter	Coefficient	t-ratio
Constant	$\beta_0$	4.035	48.2859***
Farm size ( $x_1$ )	$\beta_1$	0.153	2.7605***
Family labour ( $x_2$ )	$\beta_2$	0.0541	0.5349
Hired labour ( $x_3$ )	$\beta_3$	0.215	2.6626***
Agrochemicals ( $x_4$ )	$\beta_4$	0.126	2.2372**
Inorganic fertilizer( $x_5$ )	$\beta_5$	0.0153	0.0849
Seeds ( $x_6$ )	$\beta_6$	-0.0412	-0.8948
<b>Inefficiency effects</b>			
Age( $z_1$ )	$Z_1$	-6.647	-1.4328
Farming experience( $z_2$ )	$Z_2$	-0.228	-2.4935**
Education( $z_3$ )	$Z_3$	-0.164	-2.8678***
Household size( $z_4$ )	$Z_4$	0.129	1.5705
Extension contact( $z_5$ )	$Z_5$	-0.144	-2.3128**
Crop diversification( $x_6$ )	$Z_6$	-0.776	-2.2108**
<b>Diagnostic statistics</b>			
Sigma-squared	$\delta^2$	0.499	2.0665**
Gamma	$\Upsilon$	0.888	5.3932***

Source: Field Survey, 2016

The inefficiency parameters were specified as those relating to farmers specific socio-economic and other characteristics which include age, farming experience, education, household size, and extension contact and crop diversification. A negative coefficient indicates that the variable has positive effect on efficiency and vice versa. The coefficient of farming experience variable is estimated to be negative and statistically significant at 5% level. This implies that farmers with more experience tend to be more efficient in maize-based production than those who are not experienced. This is because experience increases expertise and managerial skills of the farmers. Thus, farmers with more years of farming experience are expected to be more efficient, presumably due to their ability to acquire technical knowledge through learning on the job. This result agrees with the findings of Oladimeji and Abdulsalam (2014) who established that increase in farming experience decreases inefficiency among farmers.

The estimated coefficient of education variable is negative and statistically significant at 1% level, implying that farmers with formal schooling tend to be more efficient in maize-based production than illiterate farmers, presumably due to their enhanced ability to acquire technical knowledge which makes them move closer to the frontier output. Also, educated farmers respond easily to the use of improved technology, such as improved seeds, agrochemicals, fertilizer application among others which moves them closer to the frontier output. Also, the coefficient of extension variable is estimated to be negative and statistically significant at 5% level. This indicates that increase in extension services to farmers tend to increase technical efficiency in maize-based production in the study area. Extension visit help the farmers to learn new technology about agricultural production. A similar result was also reported by Girei (2014) who obtained a significant and positive relationship extension contact



and technical efficiency. Crop diversification variable in the model is negative and statistically significant at 5% level. As farmers practice diversification (maize intercropping), the more efficient they become. That is crop diversification is associated with higher relative efficiency. A similar and comparable result was obtained by Maurice (2012) who established that crop diversification contributed to technical efficiency.

**Technical Efficiency Indices of Maize-based Farmers**

The technical efficiency index of the respondents is presented in Table 3. It shows that the technical efficiency of the sampled farmers is less than 1.0, indicating that all the farmers were producing below the maximum efficiency frontier. The farmers’ technical efficiency reveals a wide efficiency differential between the best technically efficient farmer (0.94) and the least technically efficient farmer (0.11). The mean technical efficiency is 0.73 indicating that in the short run, there is a scope for increasing technical efficiency among maize-based crop farmer in the study area by 27 %. Also, the least efficient farmer needs about 83% efficiency improvements to attain the level of the most efficient farmer in the State.

**Table 3:** Distribution of Technical Efficiency Indices among the Farmers

Efficiency index	Frequency	Percentage
0.10-0.19	7	2.26
0.20-0.29	10	3.23
0.30-0.39	16	5.16
0.40-0.49	21	6.77
0.50-0.59	14	4.52
0.60-0.69	29	9.35
0.70-0.79	56	18.06
0.80-0.89	141	45.48
0.90-1.00	16	5.16
Mean	0.73	
Minimum	0.11	
Maximum	0.94	

Source: Field Survey, 2016

The result of Table 3 also shows that majority (82.5%) of the farmers produce above 0.49 efficiency index, while 50.64% of the farmers produce above estimated average technical efficiency of 0.73. Most of the sampled farmers operated below the production frontier, hence will not be able to maximize their yield per hectare. This will translate to low income and hence low revenue. A similar result was obtained by Egbodion (2012) in a study on comparative technical efficiency among arable crop based and permanent crop enterprise combination in Edo State, Nigeria where a mean technical efficiency of 0.68 (68%) was obtained.

**CONCLUSION AND RECOMMENDATIONS**

Most of the farmers operated below the production frontier, hence will not be able to maximize their yield per hectare. This therefore, translates to low income and hence low revenue. The stochastic production function results further shows that the coefficient of farm size, hired labour and agrochemicals were positive and significantly affect maize-based output of the farmers. This indicates that there is a scope for increasing technical efficiency in the short-run by 27 % through efficient utilization of existing inputs under the current state of technology. It is also important to note that farmers literacy level is high, indicating a departure



from the age-long non-formal and illiteracy status of Nigerian farmers. However, the farmers were mostly small-scaled, cultivating not more than 3 hectares of farm land. In addition, male farmers dominated maize-based cropping system in the study area.

Based on the findings, the following recommendations have been put forward:

- i). There should be deliberate effort by the government and non-governmental agencies to educate farmers on the utilization of basic agricultural technology through strengthening the extension system.
- ii). More production incentives such as subsidized farm inputs should be put in place and promoted to farmers.

## REFERENCES

- Adebayo, A. A. (1999a). *Climate I and II*. In: Adebayo, A. A. and Tukur, A. L (eds.), *Adamawa State in Map*. Department of Geography, Federal University of Technology, Yola. Paraclete publishers, Yola Pp.20-26.
- Adebayo, A. A. (1999b). *Introduction*. In Adamawa State in maps, Adebayo A. A. and Tukur A. L. (eds). First edition, Paraclete publishers Yola, Nigeria.
- Audu, S. I. (2009). Gender roles in Agricultural Production in the Middle Belt Region of Nigeria. *American- Eurasian Journal of Sustainable Agriculture* 3(4): 626-629.
- Cadini, P. and Agelucci, F. (2013). *Analysis of incentive and Disincentive for maize in Nigeria*, pp. 15-39
- Egbodion, J. and Ada-Okunbowa, C. I. (2012). A comparative analysis of Technical Efficiency Study among Arable crop base and permanent crop base Enterprise combination in Edo State, Nigeria. *Australian Journal of Basic and Applied Sciences*, 6(13): 74-79
- FMARD (2001). *Nigeria Rural Development Sector Strategic Main Report*, Federal Ministry of Agriculture and Rural Development, Abuja.
- Girei, A. A. (2014). *Economic Appraisal of National Fadama II Facility in Alleviating Poverty and enhancing Food Crop Production in Adamawa State, Nigeria*. Unpublished doctoral thesis, Department of Agricultural Economic and Extension, Modibbo Adama University of Technology, Yola, pp. 49-53
- Sani, M. H. and Haruna, U. (2010). Farm planning model for sustainable vegetable crop production in the eastern part of Kogi State, Nigeria. *Nigeria Journal of Agronomy*, 9(1): 17-22.
- IITA (2008). *Increasing Maize Production in West Africa*. <http://www.iita.org/cms/details/contactus.aspx>
- Iken, J. E. and Amusa, N. A. (2014). *Maize research and production in Nigeria*. Institute of Agricultural Research and Training (IAR&T), Obafemi Awolowo University, PMB 5029, Moor plantation, Ibadan, Nigeria. Pp 302-307.
- Maurice, D. C. (2012). *Optimal farm plan and resource allocation in food crop production in Adamawa State, Nigeria*. Unpublished doctoral thesis, Department of agricultural Economics & Extension, Modibbo Adama University of Technology, Yola.
- Maurice, D. C., Joseph, M. and Garba, A. (2015). Analysis of Technical Inefficiency in Food Crop Production Systems Among Small-Scale Farmers in Some Selected Local Government Areas of Adamawa State, Nigeria. *ATBU, Journal of Science, Technology and Education (JOSTE)*, 3(1): 1-14.
- Ogbanje, E. C., Tsue, P. T. and Ogebe F. O. (2014). Technical Efficiency of Fadama II Grain farmers in Taraba State, Nigeria. *African Journal of Agricultural Research*, 9(34): 596-2603.



- Ogundari, K., Ojo, S. O. and Ajibefun, I. A. (2006). Economic of Scale and Cost Efficiency in Small Scale Maize Production: Empirical Evidence from Nigeria. *Journal of Social Science*, **13**(2), 131-136.
- Ogundari. K. and Brummer. B. (2011). A technical efficiency of Nigerian Agriculture: A meta-regression analysis. *Outlook on Agriculture*, **40**(2): 171-180.
- Okoze, B. C., Onyenweaka, C. E. and Agwu, A. E. (2012) Technical Efficiency of Small Holder Cocoyam Farmers in Anambra State, Nigeria: Implication for Agricultural Extension Policy. *Journal of Agricultural Extension*, **12**(1): 107-116.
- Oladimeji, Y. U. and Abdulsalam, Z. (2014). An Economic Analysis of Dry Season Irrigated Farming In Asa River, Kwara State, Nigeria: Implication for Poverty Reduction. *Journal of Sustainable Development in Africa*, **16**(7): 1-15.
- Owoeye, R. S. (2017). Adoption of improved Technology in maze-based cropping systems on income of farmers in Ondo State, Nigeria. *American Journal of Theoretical and Applied Business*, **3**(2): 18-22.