



Analysis of Technical Efficiency of Groundnut-Based Cropping Systems among Farmers in Hong Local Government Area of Adamawa State, Nigeria

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ABSTRACT

The study analyzed the technical efficiency of groundnut-based cropping systems among farmers in Hong Local Government Area of Adamawa State, Nigeria. Data were collected from 120 randomly selected groundnut farmers using multi-stage sampling process. The study identified two groundnut-based cropping systems, namely; sole groundnut production which accounted for 39.2% of the cropping systems and groundnut/sorghum combination which accounted for 60.80% of the cropping systems, indicating that mixed cropping dominated groundnut based enterprise in the study area. The result of the stochastic frontier production function shows that sigma squared was 0.522 and significant at 1% level, indicating good fit and correctness of the distributional form assumed for the composite error term. The value of gamma was 0.841 and significant at 1% level, suggesting that 84% of the variability in the output of farmers was due to differences in their technical efficiency. The coefficients of farm size, hired labour, family labour and herbicides were positive and significant at varying levels indicating direct relationship with output of groundnut-based cropping systems. The analysis of the inefficiency variables revealed that formal education, cropping system, primary occupation and household size decreases technical inefficiency of the farmers. Mean technical efficiency (TE) was 0.74 indicating that farmers have the potential to increase their TE by 26% in the short run given the current state of technology. To achieve this, policies by the government and non-governmental agencies should be geared towards encouraging farmers' education on farm management practices so that they would be able to allocate production resources more efficiently especially herbicide for optimum yield.

Keywords: Groundnut, production, cropping systems, technical efficiency

INTRODUCTION

Groundnut (*Arachis hypogaea L.*) also known as earthnuts, peanuts, gobber peas, pinders, manilanuts is a member of the genus *Arachis* in the family *Leguminosae*. Other members of the family include: Cowpea, pigeon pea, melon and soybean. It is an important oilseed and food crop for millions of people in the semi-arid tropics and generates employment on the farm during cultivation and in agro-processing. The seed contain high quality edible oil (50%), easily digestible protein (25%) and carbohydrates (20%) (FAO, 1994); as such, it is an essential food product that enjoys good patronage in both the domestic and international market as a veritable source of edible oil, animal feed and also consumed as snacks. Groundnut seeds are nutritional source of vitamin E, niacin, calcium, phosphorus, magnesium, zinc, iron, riboflavin, falacin, thiamine and potassium (FAO, 2006; Nnamdi, 2010).

Groundnut production comes under different cropping systems, most commonly as mixed farming, mixed cropping or mono-cropping due largely to consideration for risk minimization, stable income and adaptability to a particular season (Sani and Haruna, 2010). In West Africa, Nigeria produces 41% of the

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total groundnut output where production of unshelled nuts was estimated at about 2.6 million metric tons annually from a land area of approximately 2.5 million hectares and a yield range of 500-3000kg/ha (Echekwu and Emeka, 2005). The yields of the pods from farmers' field are low, averaging about 800 kg/ha, less than one-third the potential yield of 3000 kg/ha (Zekeri and Tijjani, 2013). This is due to a combination of factors such as unreliable rains, little technology available to small scale farmers, poor seed varieties, and increased cultivation on marginal land (ICRISAT, 2001).

Efforts made by the Nigerian government to revitalize the production of this crop such as funding of researches, crop improvement practices and extension services have not yielded significant result as supply of groundnuts to meet both the local and international markets still lag behind the demand. One way by which farmers can achieve sustainable groundnut production is to raise the productivity of their farm by improving efficiency within the limit of the existing resources and available technology. Efficient use of input is an important part of sustainability while inefficient use can jeopardize food availability and security (Maurice *et al.*, 2013). With huge potentials of groundnut in terms of both cash and food crop, there seems to be inadequate supply to meet both domestic and international market demand despite numerous efforts by the government such as crop improvement practices and researches; hence, the need to investigate the level of productivity and efficiency. This is based on the premise that if farmers are not making efficient use of existing technology, then efforts designed to improve efficiency would be more cost-effective than introducing new technologies as a means of increasing agricultural output. To this end, the technical efficiency of groundnut-based cropping system is examined because productivity growth and efficiency of inputs in agricultural production are the core-elements of sustainable crop production of small-scale farming activities.

CONCEPTUAL FRAMEWORK AND EMPIRICAL REVIEWS

Efficiency of a farm refers to its performance in the utilization of resources at its disposal (Kalirajan, 2007). This performance is either compared with the normative desired level or with that of any other farm. The analysis of efficiency is generally associated with the possibility of farms producing a certain optimal level of output from a given bundle of resources or certain level of output at least cost.

Farrel (1957) defined technical efficiency as the ability of the firm to produce on the isoquant frontier. It is the ratio of the farm's actual output to its maximum frontier output for a given level of inputs and chosen technology. Bokusheva and Hockmann (2006) stated that technical efficiency is attained when the best available technology is used. It therefore implies that the frontier output varies with the level of technology employed by the farm. On the other hand, technical inefficiency arises when less than maximum output is obtained from a given bundle of factors. Technical efficient farms operate on the production frontier, and the level by which a farm lies below this production frontier is regarded as the measure of technical inefficiency (Asogwa *et al.*, 2011). It results in an equi-proportionate over-utilization of inputs.

Amaza *et al.* (2006) examined the determinants of food crop production and technical efficiency in the northern guinea savanna of Borno State, Nigeria using stochastic frontier production function. A mean technical efficiency index of 0.68 was found, an indication that technical efficiency in food crop production could be increased by 32% through better use of available resources, given the current state of technology. The Maximum Likelihood Estimate (MLE) results revealed that farm size, fertilizer and hired labour were the major factors that were associated with changes in the output of food crops; while farmer specific factors which comprised age, education, credit, extension contact and crop diversification were found to be the significant factors that account for the observed variation in efficiency among the farmers.

Udoh and Falake (2006) used the stochastic function to estimate output oriented technical inefficiency of crop mix of farmers in Odukpani Local Government area of Cross River State, Nigeria. The result revealed a mean output oriented efficiency of 0.73%, showing that there exists room for improvement by 27% with the present technology. The existence of technical inefficiency among the farmers accounted for about 27% of the variations in the output levels of the crops grown.

In their study on the profitability and economic efficiency of groundnut production in Benue State, Nigeria, Ani *et al.* (2013) used the stochastic frontier production model to determine the factors that influence groundnut farmers' technical efficiency from a sample of 270 randomly selected farmers. The result revealed a technical efficiency range of 0.004 to 0.83, with a mean of 0.0387. The analysis of the inefficiency model shows that age, annual income and household size were the major determinants of technical efficiency of the farmers in the State.

Maurice *et al.* (2015) examined the technical inefficiency in food crop production systems among small-scale farmers in selected Local Government Areas of Adamawa State, Nigeria using cross-sectional data from 360 randomly selected food crop farmers in eight local government areas spread across the four Adamawa Agricultural Development Programme (ADP) zones of the State. Eleven cropping systems were identified with mixed cropping accounting for about 53% of the cropping systems and about 54% of the total hectare allocations. The maximum likelihood estimates of the stochastic frontier production function revealed that farm size, family labour, agrochemicals, inorganic fertilizers and seed contributed significantly to food crop output. The Technical Efficiency (TE) scores ranged from 0.26-0.96 with a mean TE of 0.66, implying that there is a scope for increasing technical efficiency in food crop production by 34% in the short-run under the current technology. Education, extension contact, crop diversification and credit availability were found to decrease technical inefficiency of the farmers.

METHODOLOGY

Study area

Adamawa State is located in the North-eastern part of Nigeria and lies between Latitudes 8.00°N and 11.00°N of the equator and Longitudes 11.50°E and 13.50°E of the Greenwich meridian. The State has a population of 3,161,374 people comprising of 1,580,333 males and 1,581,041 females (NPC, 2006). As opposed to a national annual population growth rate of 3.2%, the population of the State is growing at the rate of 2.8% per annum, hence by 2015; the state is expected to have 4,067,411 inhabitants.

Hong Local Government Area is one of the 21 Local Government Areas of the State located in the central senatorial district on Latitude 10°13'N and Longitude 12°55'E (Adebayo, 1999). The Local Government has a total land area of about 2,376.66km² and a population of 169,126 (NPC, 2006). The dominant soil groups in the area are luvisols, regosols, cambisols, vertisols and lithosols derived from basement complex, while few other places are on sandstones, shales and alluvium.

Mean annual rainfall ranges from 700mm to 1000mm (Adebayo, 1999). The temperature characteristic in the area is typical of the West African Savannah climate characterized by high temperature almost throughout the year due to high solar radiation which is relatively evenly distributed throughout the year. Maximum temperature can reach 40°C particularly in April, while minimum temperature can be as low as 18°C between December and January. Mean monthly temperature ranges from 26.7°C to 27.8°C.

Major economic activity in the area is agriculture. Food crops grown include; maize, sorghum and cassava, while cash crops such as groundnuts, cowpea, cotton and sugar cane are produced in large quantities. Some Livestock reared in the area are cattle, sheep, pigs and goats. The dominant ethnic group

in the area is Kilba, while Margi, Higgi, Bura, Fulani and Hausa are the other minority ethnic groups. The Local Government has seven (7) districts namely; Pella, Gaya, Uba, Dugwaba, Kulinyi, Hildi and Hong.

Sampling Method

Multi-stage random sampling procedure was used in selecting respondents for the study. In the first stage, four (4) out of the seven (7) districts in the Local Government Area were randomly selected, namely; Pella, Gaya, Hildi and Dugwaba. From each sampled district, three (3) villages were randomly selected making a total of twelve (12) sampled villages. The sampling frame for this study consists of 672 groundnut farmers in the 12 villages. Simple random sampling technique was used in selecting 120 groundnut farmers in proportion to the size of groundnut farmers in the selected villages.

Analytical Technique

Stochastic frontier production model was employed to analyze data using the variant of the stochastic production analysis as adapted by Coelli and Battese (1996) and Omonoma *et al.* (2010). It is assumed that the farm frontier production function can be written as: $Y = f(X_i; \beta)$(1)

Where Y is the quantity of groundnut output, X_i is the vector of input quantities and β is a vector of parameters to be estimated.

The empirical model of the stochastic production function frontier applied in the analysis of efficiency of groundnut-based production is specified as:

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

Where:

Y = Total output (kg-grain-equivalent weight)

X_1 = Farm size (Ha)

X_2 = Quantity of seed (Kg)

X_3 = Hired labour (man days)

X_4 = Family labour (man days)

X_5 = Fertilizer (Kg)

X_6 = Herbicides (litres)

Subscript i and j refers to the i^{th} groundnut-sorghum produce and the j^{th} input used, respectively and $v_{ij} - u_{ij}$ are the composed error term (Aigner *et al.*, 1977; Meeusen and Vanden Broeck, 1977). The two component V and U are assumed to be independent of each other, where V the symmetric (two-sided) component, normally distributed random error ($V \sim NCO, \delta^2 V$) which capture variation in output due to factors outside the control of the farmer like input/prices and U is the one-side efficiency component with a half-normal distribution ($U \sim NCO, \delta U$) is non-negative random variable called technical inefficiency effect. 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, u_{ij} and variance δ^2 , where u_{ij} is defined by:

$$U_{ij} = \partial_0 + \partial_1 Z_{1ij} + \partial_2 Z_{2ij} + \partial_3 Z_{3ij} + \partial_4 Z_{4ij} + \partial_5 Z_{5ij} + \partial_6 Z_{7ij} + \partial_7 Z_{7ij} + \partial_8 Z_{8ij} \dots\dots\dots (3)$$

Where:

U_{ij} = Technical inefficiency of the i^{th} farmer

Z_1 = Years of farming experience

Z_2 = Years of formal education

Z_3 = Extension contact (dummy where 1= have extension contact, 0= no extension contact)

Z_4 = Cropping system (dummy, where 1=sole groundnut, 0= groundnut mixtures)

Z_5 = Primary occupation (dummy, where 1= farming, 0= otherwise)

Z_6 = Household size (No.)

Z_7 = Land tenure system (where, 1= inheritance, 0= otherwise)

Z_8 = Access to credit (access to credit=1, 0=otherwise)

The maximum likelihood estimates of β and γ coefficient were estimated simultaneously using the computer program FRONTIER 4.1.

RESULTS AND DISCUSSION

Groundnut-based cropping systems

Cropping systems are the yearly sequence and spatial arrangement of crops on a farm during a given period of time with the objective of obtaining maximum return from each crop without compromising the soil fertility (Panda, 2007). The objective of any cropping system is efficient allocation of all production resources, maintaining stability in production and obtaining higher net returns. The distribution of the cropping systems is presented in Table 1. The distribution shows that two groundnut-based cropping systems abound in the area, namely; sole groundnut and groundnut/sorghum enterprises. Majority (61%) of the farmers intercropped sorghum with groundnut while only about 39% cultivate sole groundnut. The reasons why majority of farmers in the area practiced groundnut/sorghum combination could be attributed to the desire to increase yield and income, better utilization of scarce resources, risk minimization in the event of failure of one crop and greater scope for self-sufficiency in meeting the needs of animals for feeds and fodders.

Table 1: Distribution of respondents by cropping systems

Cropping system	Frequency	Percentages
Sole groundnut	47	39.17
Groundnut/sorghum	73	60.83

Source: Field Survey, 2012

Technical efficiency

The maximum-likelihood estimates (MLE) of the parameters of the stochastic frontier production function are presented in Table 2. The production estimates indicated the relative importance of factor inputs in groundnut-based cropping system. From the results, all the coefficients of the explanatory variables have the expected positive sign, indicating that more output would be obtained from the use of additional quantities of these inputs *ceteris paribus*.

The value of sigma squared (δ^2) is 0.522 and significantly different from zero, indicating goodness of fit and correctness of the distributional form assumed for the composite error term. The variance ratio defined by gamma (γ) is estimated at 0.84 and significantly different from zero indicating that systematic influences that are unexplained by the production function were the dominant sources of random error. In other words, the existence of technical inefficiency among the farmers accounted for 84% variation in the output levels of these farmers. This confirms that in the specified model, there is the presence of one sided error component.

The coefficient of farm size was estimated at 0.14 and statistically significant at 1% level, implying that a 1% increase in the hectares of land put into groundnut-based cropping systems will bring about increase in output by 0.14%. This is attributed to the relative importance of land in crop production and corroborates the findings of Wakili (2012) who obtained a significant relationship between farm size and output. The coefficients of both family and hired labour were positive and statistically significant at 5% and 10%, respectively. This suggests that a 1% increase in man-days of family and hired labour would induce an increase in output by 0.07% and 0.09%. This is in conformity with previous work by Ani *et al.* (2013) who found a positive and significant relationship between family and hired labour with farm output.

Herbicide has a positive coefficient and statistically different from zero at 5%, indicating that a 1% increase in the litres of herbicides applied on groundnut-based farms would bring about a 0.14% increase in output. The use of herbicides besides reducing the expenditure on weeding also reduces the drudgery and fatigue associated with food crop production and help farmers who are not constrained by land to increase their scale of production.

The inefficiency parameters were specified as those relating to farmers' specific socio-economic characteristics and were examined by using the estimated δ coefficients. A negative δ coefficient indicates that the parameter has a positive effect on efficiency and vice versa. The result of the inefficiency model showed that all the variables used in the model except extension contact and land tenure system have the expected negative sign. The coefficient of extension contact, land tenure system and access to credit were however not significant.

Table 2: Maximum-likelihood estimates of parameters of the stochastic frontier production function for groundnut-based farmers

Variables	Parameter	Coefficient	Std. Error	t-ratio
Constant	β_0	0.3031	0.0846	3.5846***
Farm size (ha)	β_1	0.1438	0.0544	2.6427***
Quantity of seed(kg)	β_2	0.0953	0.0813	1.1736
Hired labour (Man days)	β_3	0.0867	0.0473	1.8327*
Family labour (man days)	β_4	0.0744	0.0368	2.0239**
Fertilizer (kg)	β_5	0.1027	0.1189	0.8637
Herbicides(ltr)	β_6	0.1436	0.06572	2.1853**
Inefficiency model				
Constant	δ_0	-0.5655	0.5463	-1.0352
Farming experience	δ_1	-0.0203	0.0145	-1.4027
Formal education	δ_2	-0.0673	0.0331	-2.0332**
Extension contact	δ_3	0.1023	0.0712	1.4364
Cropping system	δ_4	-0.0735	0.0221	-3.3253***
Primary occupation	δ_5	-0.0546	0.0275	-1.9847**
Household size	δ_6	-0.2643	0.1138	-2.3216**
Land tenure system	δ_7	0.0660	0.0383	1.7241
Access to credit	δ_8	-0.0610	0.0375	-1.6257
Variance parameters				
Sigma squared	δ^2	0.5223	1.2426	7.2616***
Gamma	γ	0.8413	0.0209	40.2274***
Log likelihood function	Llf	167.4848		

Source: Field survey, 2012, ***Significant at 1%, ** Significant at 5%, *Significant at 10%

The coefficient of farming experience was negative, implying that technical efficiency among farmers increases with more years of experience in farming and vice versa. This corroborates the finding of Fassasi (2007) who reported that increase in farming experience reduces technical inefficiency. Formal education had a negative coefficient and significantly different from zero at 5% implying that as farmers acquire more years of formal schooling, their technical efficiency increases. This agrees with the findings of Amaza *et al.* (2006) and Uaiene and Arndt (2009) who asserted that more years of formal education is imperative for better understanding and adoption of new technology by farmers which would move them closer to the frontier. Cropping system variable has a negative coefficient and statistically significant at 1% level, indicating that as sole crops are grown, technical inefficiency increases. This implies that mixed

cropping is associated with higher relative efficiency. The cost of production under mixed cropping is expected not to vary significantly from those under sole cropping but total yield under mixed cropping is expected to be higher with efficient allocation of resources (Maurice, 2012). Crop mixtures are employed by farmers primarily as risk-minimizing precautions and stability of income.

The coefficient of primary occupation was negative and significant at 5% implying that technical efficiency increases among farmers whose primary occupation is farming. This could be attributed to the attention the farm receives in terms of supervision and input supply as compared with farmers whose primary occupation is not farming. Household size had a negative coefficient and significantly different from zero 5%. This implies that as the number of persons (adults) in farming households' increases, technical efficiency increases. Farmers with larger household size have the potential for higher farm output in that labour needed for important farm operations such as weeding are expected to be readily available.

The distribution of farmers' technical efficiency indices derived from the analysis of the stochastic production function is presented in Table 3. The technical efficiency of the respondents was less than 1 (less than 100%) indicating that all of them were producing below the efficiency frontier. Majority of the farmers (57.5%) had technical efficiency of 0.70 and above, while only 9.17% had technical efficiency of less than 0.50. The mean technical efficiency is estimated at 0.74 with 0.31 as the minimum and 0.97 as the maximum. This implies that on the average, farmers in the study area were 74% technically efficient from a given mix of production inputs. There is a scope for 43% increase in the technical efficiency of the average farmer from the best practice (technically most efficient) farmer in the short run given the current state of technology. The efficiency differential between the technically most-efficient farmer and the technically least-efficient farmer is 66% indicating a wide gap. This result is similar to the ones obtained by Shamsudeen *et al.* (2011) and Maurice *et al.* (2015) who obtained mean technical efficiencies of 0.70 and of 0.66, respectively.

Table 3: Distribution of technical efficiency indices of groundnut-based farmers

Efficiency indices	Frequency	Percentage (%)
0.30-0.39	04	3.33
0.40-0.49	07	5.83
0.50-0.59	11	9.17
0.60-0.69	29	24.17
0.70-0.79	27	22.50
0.80 - 0.89	25	20.83
0.90 - 1.00	17	14.17
Total	120	100.00
Mean	0.74	
Minimum	0.31	
Maximum	0.97	

Source: Field survey, 2012

CONCLUSION

The study estimated the technical efficiency of groundnut-based farmers in Hong Local Government Area of Adamawa State using the stochastic frontier production model. The distribution of technical efficiency indices revealed that on the average, the farmers were moderately technically efficient in their groundnut-based output given the resources at their disposal and the existing technology. There is however the scope for increasing technical efficiency of the farmers by 26% (1.00 – 0.74) in the short-run through efficient utilization of existing inputs given the current state of technology.

RECOMMENDATIONS

- Based on the findings of this research, the following recommendations are proffered. Policies by the government and non-governmental agencies should be geared towards encouraging farmers' education on farm management practices so that they would be able to allocate production resources more efficiently especially herbicide for optimum yield.
- Cost of agricultural inputs especially herbicides should be further subsidized since agricultural sector is the largest single employer of labour in the country.
- Farm mechanization be provided and be made affordable and accessible to farmers, so that they can increase the area under groundnut production for higher yield. This will reduce the over-dependence on primitive tools and its associated limitations in agricultural production.

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