Journal of Agripreneurship and Sustainable Development (JASD)
www.jasd.daee.atbu.edu.ng; Volume 5, Number 3, 2022
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

TECHNICAL EFFICIENCY OF SOLE COWPEA PRODUCTION IN ADAMAWA STATE, NIGERIA

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ABSTRACT
The study determined the technical efficiency of sole cowpea production in Northern Agricultural Zone of Adamawa State, Nigeria. Primary data were collected from 180 sole cowpea producers selected by a multi-stage random sampling procedure, using structured questionnaire. The Data was subjected to descriptive and inferential statistics. Results revealed that, males dominated (81.11%) cowpea production in the area. The average age of the respondents was 46.52 and are mostly married with average family size of 8 persons. Also 88.33% used their personal savings to finance cowpea production and about. Farm size, family labour, hired labour and agro-chemicals were significantly related with cowpea output at 1% and 5% levels. Farming experience, extension contact, family size and credit availability enhance the efficiency of the respondents. Substantial variation existed in the TE indices of farmers with mean technical efficiency (TE) of 0.80 and minimum and maximum indices of 0.43 and 0.97, respectively. Farmers in the study area were relatively efficient in the production of sole cowpea. Inputs such as agrochemicals, farm land, improved seeds, labour as well as credit should be made available to farmers timely and at subsidized rates by government and non-governmental organizations.

Keywords: Technical, Efficiency, Sole-Cowpea, Production, Adamawa.

INTRODUCTION

Cowpea is an important staple food in Nigeria and is produced largely for domestic consumption. It is a veritable source of protein and thus capable of providing solution to the protein-carbohydrate imbalance of the nutrition of Nigerians (Afolami, 2001). It is also an income earner, livestock feed, industrial raw material and capable of improving soil fertility (Quin, 1997). Production of cowpea is expanding in the country although is concentrated in the northern part (Sudan zone). Nigeria is a major producer of cowpea in the world; its production estimate in 1997 were 1.7 million tons from about four (4) million hectares and greater part of it was from the drier regions of the north (Singh *et al*., 1997). The increasing demand for the commodity has led to more of its cultivation in many parts of the country. The use of improved technologies such as agro-chemicals and seeds also have encouraged farmers into cowpea production in recent times for expected yield increase and economic gain. Thus, area of adoption for cowpea is on the increase in Nigeria.

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. Therefore, it is assumed in efficiency measurement that firms operate on the outer bound production function that is on their efficiency frontier. When firms fail to operate on the outer bound production function, they are said to be technically inefficient. For such firms, an improvement in technical efficiency may be achieved in three ways. First, through improved production techniques; next, improvement in the production technology and finally by improvement in both production technique and technology. Moreover, an economically efficient input-output combination would be on both the frontier function and the expansion path. Therefore, as stressed by Nimoh and Assuming- Brempong (2012), optimizing output results in economic efficiency (Heady, 1960; Amaza and Tashikalma, 2003; Ogundari and Ojo, 2006).

However, the Farrell's method of measuring efficiency was subsequently modified and extended by different economic studies in agriculture. For instance, Aigner and Chu (1968) and Degla (2015) both specified a parametric frontier production function in input-output space based on a Cobb-Douglas function; Schultz (1970) extended the model by expressing input-output data to allow the use of linear programming technique for estimating production function which result in efficiency indices that reflected conceptual causes of variation in efficiency. Also, Bravo-Ureta and Rieger (1990) and Degla (2015) presented a review of the stochastic frontier approach by estimating both deterministic and stochastic production functions. Other researchers which include Mijindadi (1980), Battese (1992), Oredipe (1998), Mbanasor and Obioha (2003), Nurudeen and Rasaki (2011) and Ayodeji *et al.* (2014) carried out efficiency analysis using production function estimated by the ordinary least square (OLS) technique.

In recent years, the stochastic frontier production which was first independently proposed by Aigner *et al.* (1977) and Meeusen and van den Broeck (1977) has been used in efficiency measurements with a review and improvement by various researchers in different studies such works include Ogundari and Ojo (2006) on cassava production, Nurudeen and Rasaki (2011) on cowpea production, Adegbite and Adeoye (2015) on pineapple production, Ouedraogo (2015) on rice production and Degla (2015) on cashew nuts production. A stochastic frontier production function comprises a production function of the usual regression type and a composite disturbance term equal to the sum of two error components. It is defined by:

$$Y_i = f(X_i; \beta) \exp(V_i - U_i) \qquad i = 1,2,\ldots N \qquad \ldots(1)$$

where;

Y_i is quantity of output; X_i is a vector of inputs; β is a vector of parameters; V_i is a random error which is associated with random factors outside the control of the decision unit such as weather, measurement error, etc. It is assumed to be independently and normally distributed as, $N \sim (0,\delta^2 v)$.

It is therefore a two-sided error term that is identical and independent of the U_i. The U_i is an asymmetric component which reflects technical inefficiency that is attributed to be the result of behavioural factors which are under the control of the decision unit. It is a non-negative random variable, half normally and independently distributed as, $|N \sim (0, \delta^2 u)|$. Thus, U_i represents the systematic effects that are not explained by the production function and are therefore attributed to the technical inefficiency of household. This inefficiency term (U_i) is one-sided and hence if $U_i = 0$, the household would be lying on the production frontier obtaining maximum production (output) given the levels of inputs whereas if $U>0$, then the household would be operating at some level of inefficiency (Apezteguia and Garate, 1997; Amaza and Tashikalma, 2003; Ogundari and Ojo, 2006; Degla, 2015).

The parametric stochastic frontier method is the most favoured for estimation of production technical efficiency. It allows for the estimation of individual firm efficiency level

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www.jasd.daee.atbu.edu.ng; Volume 5, Number 3, 2022
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

with both time variations and cross-sectional data. In estimation, the stochastic production frontier is determined by the structure of production technology, i.e., the deterministic production frontier given by f (.), and in addition by external factors to the production process, including household's specific factors. Therefore, the technical efficiency of a given farm household is defined as:

$Y_i \quad f(Xi;\beta)\ \exp\ (V_i\text{-}U_i) \quad \exp\ (\text{-}U_i)$ so that $0 \leq TE \leq 1$ ...(2)

$Y^* \quad f(Xi;\beta)\ \exp\ (U_i)$

where;

Y_i is the observed output, Y^* is the frontier output and the ratio of the two defines the technical efficiency of the individual household based on the available technology employed. Farms which are efficient operate on the production frontier, and the level by which a farm lies below its production frontier is regarded as the measure of technical efficiency which is as a result of inability to achieve maximum output from a given bundle of factors.

In estimating equation (1), the technical inefficiency factor U_i is separated from the 'white noise', (V_i) because the two are guided by different assumptions about their distribution although both constitute the components of the composite error. Given the expression in the equation, the technical efficiency score of a household is positive and cannot be greater than one. So, the reciprocal of the quantity exp ($-U_i$) which is not less than one is interpreted as a measure of technical inefficiency of production. Thus, the amount by which exp ($-U_i$) exceeds one is a measure of technical inefficiency. This is the value by which farm output can be increased at the current level of input use (Ajibefun and Aderinola, 2003; Battese *et al.*, 2000; Ogundari and Ojo, 2006; Adegbite and Adeoye, 2015).

Furthermore, in efficiency analysis the stochastic frontier model can be estimated by the maximum likelihood method where the inefficiency effects (U_i) arise by truncation (at zero) of the normal distribution. Here, the maximum likelihood estimates of the parameters of the model is obtained using parameterization. Following Battese and Coelli (1995), Battese and Corra (1977) and Adegbite and Adeoye, 2015, the overall variance (σ^2) for the model is given as:

$\sigma^2 = \delta^2_v + \delta^2_u$ ...(3)

where;

δ^2_v and δ^2_u are variances of the parameters V and U respectively. The total variation in output from the frontier which can be attributed to technical efficiency (γ) is defined by:

$\gamma = \delta^2_u / \sigma^2\ (0 \leq \gamma \leq 1)$ …(4)

This variance ratio parameter, γ use to indicate whether variation in production like inability to obtain the maximum output by a farm is because of random factors outside the farmer's control or due to differences in technical efficiency. Hence, if farmer's output differs from the efficient output mainly because of random errors, δ^2_u tends to zero and consequently γ also tend to zero; but if the difference is due to inefficient use of resources by the farmer, δ^2_v tends to zero while γ tends to one (Kalirajan, 1981; Degla, 2015). However, Battese and Coelli (1995) extended the stochastic production frontier model by suggesting that the inefficiency effects can be expressed as a liner function of explanatory variables, reflecting farm-specific characteristics. Based on this they specified the distribution form of inefficiency in the stochastic function as:

$U = f\ (Z_i;\delta)$ …(5)

where;

Z_i is the vector of farmer specific factors and δ is the vector of parameters. In estimation of the stochastic production function, the efficiency, inefficiency, and variance parameters as well as individual farm level efficiencies are done using the computer programme FRONTIER version 4.1 (Coelli, 1994).

Allocative efficiency deals with the achievement of a situation where production resources are allocated and utilize in the farm- firm based on market price. It is concerned with an economic or better use of available farm inputs based on a given or prevailing prices of the inputs to increase output levels. In measurement of farm efficiency, gains in output could be obtained even in the short run by improving allocative efficiency. Therefore, allocative, and economic efficiencies in agricultural production are important aspects of the overall farm level efficiency as well as market situations. Allocative efficiency has to do with the extent to which farmers make efficient decision by using inputs up to the level of which their marginal contribution to production value is equal to the factor cost. So, a farm is allocative efficient in a profit maximization if the marginal product of every variable input used is equal to the marginal cost of the input. Resource allocation has been emphasized as a means of achieving allocative efficiency. Also, to achieve maximum efficiency in production, resources must be allocated in such a way that there is no difference between marginal productivity of the various resources and their respective prices. And for a multi-product form, resources are said to be allocated optimally among feasible production enterprises when the marginal value product (MVP) of every input is equal to its price in all enterprises in which it is employed (Upton, 1973; Ajani and Olayemi, 2002; Mbannasor and Obioha, 2003; Nimoh and Asuming-Brempong, 2012).

However, in the measurement of allocative efficiency, Heady (1960) suggested the use of net profit from resources rather than resource prices, to obtain a single index of efficiency. But Akinwunmi (1970) stressed that so long as the pricing system accurately reflects the value system and consumer choices, the value productivity of resources can serve as an index of production efficiency despite its limitations. In recent years, allocative efficiency is determining as a ratio of the least-cost combination of variable inputs used to the variable costs for the efficient input quantities used in production. The two separate costs here are determine based on the estimated frontier production function with consideration of the observed input and output level (Kopp and Diewert, 1982; Ogundari and Ojo, 2006).

Economic (overall) efficiency on the other hand is the product of technical and allocative (price) efficiencies. It occurs when a firm chooses resources and enterprises in such a way as to attain economic optimum. The optimum implies that a given resource is most efficiently used when its marginal value product is just sufficient to offset its marginal cost (Adesina and Djato, 1997; Nimoh and Asuming-Brempong, 2012). Economic efficiency (EE) hinges more on price relationship in production as well as the ultimate performance of the process. Therefore, it can only exist if a firm achieves technical and allocative efficiency simultaneously. Hence, it is given as the product of these two efficiencies, i.e., EE = TE x AE. The achievement of EE is based on price of input and output that gives the best output level in production. Thus, economic efficiency (EE) refers to the capacity of a firm to produce a predetermined quantity of output at a minimum cost for a given level of technology.

MATERIALS AND METHODS

The Study Area

The study was carried out in the Northern Agricultural Zone of Adamawa State. The area consists of ADADP Zones I and II of the state and it comprises of Madagali, Michika, Mubi North, Mubi South, Maiha, Hong, Gombi, Song and Girei Local Government Areas (LGAs). The area lies between Longitudes $12^{o}15'$ and $13^{o}45'$E and Latitudes $9^{o}15'$ and 11^{o}N (Adebayo, 2004; Sajo and Kadams, 1999). It has a land area of 14,345.77 km^2 and a population of 1,319,600 people according to the national census figure in the year 2006, with an annual population growth rate of 2.8% (NPC, 2006). Therefore, the projected population of the study area based on the yearly increment of 2.8% is 1, 691,921 people in 2015. The area has a typical tropical savannah climate that is characterized by a dry and rainy season every year with the rainy season commencing in April and ends in October while the dry season starts in November and ends in April, and the wettest months are August and September. The mean annual rainfall ranges from 800 mm to 1050 mm and mean monthly temperature is 27.8°C, while the vegetation type is Sudan savannah characterized by scattered trees and short grasses/shrubs over the area (Adebayo, 1999a; Adebayo, 1999b).

The soils of the northern part of Adamawa State generally consist of well-drained light sandy loam soils (rich acidic soils) derived from the mountainous characteristics of the area as well as relatively high rainfall. This support the production of maize, sorghum, cowpea, rice and cassava as major food crops in the area while groundnut and sugar cane are the major cash crops. Livestock such as cattle, sheep, goat and poultry are also reared in the area (Sajo and Kadams, 1999).

Sampling and Data Collection Procedures

Primary data were used for the study and information were collected from sole cowpea producers in the northern agricultural zone of Adamawa State. A multi-stage random sampling technique was employed in selection of the respondents. First, five LGAs (5) out of the nine (9) LGAs in the area were randomly chosen. Next is the random selection of five wards from each of the chosen LGAs, then two (2) villages were selected from each of the wards. Finally, a total of 180 sole cowpea farmers were sampled from the 50 villages proportionate to their population size. Structured questionnaire was used for the data collection and was administered to the respondents with the assistance of trained ADADP staff.

Data analysis

Descriptive statistics such as means, percentages and frequency distributions were used in analysing the socio-economic characteristics of cowpea farmers in the study area. Inferential statistics involving the use of the Stochastic Frontier Production was used to determine the technical efficiency of the farmers.

The stochastic frontier production model was used to estimate technical efficiency of farmers and the factors which determine it based on the frontier model independently proposed by Aigner *et al.* (1977) which later was further improved and used by Battese and Coelli (1995) and Ajibefun and Aderinola (2003). The model assumed the production technology of farmers to be specified by a Cobb Douglas production functional form with a multiplicative disturbance term which allows for the simultaneous estimation of the random disturbance term (V_i) which is outside the control of the production unit and the inefficiency effect (U_i) which determines efficiency of the decision unit. The farm frontier production function can be written as:

$$Y_i = f(X_i;\beta) \exp(V_i - U_i) \qquad \ldots(6)$$

where;

Y_i is the quantity of agricultural output; X_i is a vector of input quantities; β is a vector of parameters; V_i is the random term (outside control) and U_i is the inefficiency effect term.

The empirical frontier model for sole cowpea production in the study area is assumed to specify the technology of farmers and is given by:

$$\ln Y_{ij} = \beta o + \beta_1 \log X_{1ij} + \beta_2 \log X_{2ij} + \beta_3 \log X_{3ij} + \beta_4 \log X_{4ij} + \beta_5 \log X_{5ij} + \beta_6 \log X_{6ij} + V_{ij} - U_{ij} \qquad \ldots(7)$$

where;

subscripts ij refers to the j^{th} observation of the i^{th} farmer;

ln = Logarithm to base e

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www.jasd.daee.atbu.edu.ng; Volume 5, Number 3, 2022
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Y = Output of cowpea in kilogrammes
X_1 = Farm size in hectares
X_2 = Quantity of seed planted in kilogrammes
X_3 = Family labour used in production (in man days)
X_4 = Hired labour used in production (in man days)
X_5 = Quantity of agrochemicals in litres
X_6 = Amount spent on ploughing (tractor and animal traction) in Naira
βs = Parameters estimated
V_i = Random errors which are $N \sim (0, \delta^2_{Vi})$
U_i = Inefficiency effects which are non-negative with half normal distribution, $|N\sim (0, \delta^2_{Ui})|$.

The inefficiency of production, U is modelled in terms of the socio-economic variables of farmers and, it is assumed that the inefficiency effects are independently distributed and U_{ij} arises by truncation (at zero) of the normal distribution where U_{ij} is defined by:

$$U_{ij} = \delta_o+\delta_1 Z_{1ij} +\delta_2 Z_{2ij} +\delta_3 Z_{3ij} +\delta_4 Z_{4ij} +\delta_5 Z_{5ij} +\delta_6 Z_{6ij} \quad \ldots(8)$$

where;
U_{ij} = Technical inefficiency of the i^{th} farmer
Z_1 = Age of farmers in years
Z_2 = Years of farming experience
Z_3 = Years of formal education
Z_4 = Extension contacts (number of meetings)
Z_5 = Household size (number of people)
Z_6 = Credit availability (1, accessed; 0, otherwise)
$\delta_{1-}\ \delta_6$ = Unknown parameters estimated

The β and δ-coefficients in equations 13 and 14, respectively, are unknown scalar parameters which are estimated. The variance parameters of the model in the estimation are expressed in terms of the following formulae:

$$\sigma^2 = \delta^2_u + \delta^2_V \quad \ldots(9)$$

$$\gamma = \delta^2_u / \sigma^2 \quad \ldots(10)$$

where;
σ^2 is the overall variance for the model, γ is the total variation of output from the frontier which can be attributed to technical efficiency and δ^2_u and δ^2_V are variances of the parameters U and V, respectively. The maximum-likelihood estimates for all the parameters in equations 13, 14, 15 and 16 as well as farm-level technical efficiencies were estimated simultaneously using the computer program FRONTIER 4.1 (Coelli, 1994).

RESULTS AND DISCUSSION

The socio-economic characteristics of the respondents examined were age, gender, marital status, extension contact, land acquisition and family size. This is illustrated in Table 1. Most of the respondents (59.4%) fell within the age of 31 and 50 years, implying that the respondents are in their productive age. Having a considerable number of farmers who are in their active age is of great advantage, because studies have shown that they are probably stronger and are willing to take risk, hence may easily adopt high yielding technology that are essential for greater productivity. The average age of the respondents is 46.52 years. Result of the gender indicate that majority (about 81%) of the respondents are male while 18.89% are female. This could mean that there are more male folks in cowpea production in the study area than female folks. This result is similar with the report of Ayodeji *et al.* (2014) that cowpea production is male-gender biased.

The marital status of the respondents indicates that majority (89.44%) are married, 6.11% are widowed while about 4% are single. This means that, married folks are the majority in cowpea production. This may be to cater for the livelihood of their families. The family size of the farmers indicated that the average family size of the respondents is eights (8) persons per household as shown on the table. This is similarly to the result of Ajibefun and Aderinola (2003) who reported a mean family size of eight (8) persons in their work on food crop farmers in Ekiti and Osun States, respectively. The finding however reveals that majority (72.22%) of the respondents attended one form of tertiary education or the other. This implies these farmers would easily accept changes through new ideas. However, a high percentage (about 28%) had no formal education. Distribution of the farming experience of the respondents shows about 81 % had farming experience between 6 years and over 20 years. This shows majority are experienced cowpea farmers and most likely, they might know the practices involved for increased output in production. The mean years of experience of the farmers are about 11 years. This finding is in consonance with the report of Adebayo and Anyanwu (2012) where they discovered that most of the respondents (male and female) have experience because they have been farming for more than 10 years. The result of farm size shows that majority (68.89%) of the respondents had farm sizes of 1-2 hectare while 17.22% of them had 3-4 hectares' farm size. The finding revealed that majority (68.89%) of the cowpea farmers in the area are small scale farmers since they have farm size of 1-2 hectares. furthermore, 40.56% of the farmers had contact with agricultural extension services through the agents while majority (59.44%) did not have contact. This could mean that these farmers were unable to benefit from agriculture extension-productive package. The result is in consonance with the findings of Idiong *et al.* (2006) who revealed in their study that majority (57.1%) of swamp rice farmers in Cross River State did not have contact with extension whereas 42.9% of the farmers had contact. Distribution of respondents based on cooperatives indicates that 33.33% are members of cooperative organizations, while majority (66.67%) are non-members. This means that cooperative membership is important in enhancing farmers' knowledge on improved technologies through information sharing. It enables accessibility and subsidized procurement of inputs.

Table 1: Socio-economic characteristics of the respondents

Variables	Percentages
Age (years)	
21-30	4.44
31-40	25.00
41-50	34.45
51 and above	36.11
Total	100
Mean = 46.52	
Gender	
Male	81.11
Female	18.89
Total	100
Marital status	
Married	89.44
Widowed	6.11
Single	3.89
Divorced	0.56
Total	100
Family size	
1-5	44.44
6-10	41.11
11-15	8.89
16-20	2.78
More than 20	2.78
Total	100
Mean = 8	
Educational level	
No formal education	27.78
Primary school	21.11
Secondary school	31.11
Tertiary education	20.00
Total	100
Years of experience	
1-5	19.44
6-10	31.11
11-15	21.67
16-20	12.78
Over 20	15.00
Total	100
Mean = 11.12	

Source: Field survey, 2011

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www.jasd.daee.atbu.edu.ng; Volume 5, Number 3, 2022
ISSN (Print): 2651-6144; ISSN (Online): 2651-6365

Table 1: Socio-economic characteristics of the respondents **Cont'd.**

Variables	Percentages
Farm size	
Less than 1	9.45
1-2	68.89
3-4	17.22
5-6	2.22
7 and above	2.22
Total	100
Mean = 2.102	
Extension contacts	
Had contact	40.56
No contact	59.44
Total	100
Cooperative membership	
Member	33.33
Not Member	66.67
Total	100

Source: Field survey, 2011

Maximum Likelihood Estimates of Parameters of the Stochastic Frontier Production Function for Sole Cowpea Farmers

Results of the maximum likelihood (MLE) estimates of the parameters of the stochastic frontier production function for cowpea farmers are given in Table 2. From the table, the sigma squared (σ^2) is estimated as 0.345 and is statistically significant and different from zero at 1% level. This indicates a good fit and correctness of the distributional assumption specified for the composite error term. The variance ratio defined by gamma (Υ) is 0.849 showing that the systematic influences that are unexplained by the production function are the dominant sources of random errors. This means that about 85% of the variation in output of sole cowpea production is as a result of existence of technical inefficiency among the farmers. The analysis confirms the presence of one-sided error component in the model specified. Also, it shows that the effect of technical inefficiency is significant and, that the ordinary least square (OLS) regression model would not be adequate to represent the dada and/or explain the inefficiency in sole cowpea production studied. Hence, the diagnostic statistics justify the application of the stochastic frontier production model as sufficient estimating technique in this respect.

The estimated coefficients of the independent variables are also the direct elasticities of the variables (b_i). Four of the production factors in the function are statistically significant at different levels, these are farm size, family labour, hired labour and agro-chemicals. The coefficient of farm size is 0.719 and has a positive sign; this means that a one-percent increase in farm size cultivated to sole cowpea would increase output by 0.719%. This finding reveals the importance of farm land in agricultural production which is a determinant of output particularly in cultivated agriculture. This agrees with the result of Adebayo e*t al.* (2012) where increase in farm size was found to positively and significantly influence farm output among farmers. Also, the highest elasticity of farm size (0.719) means that farm land is the most critical input among the production factors.

The elasticity of agro-chemical is significant (0.068) and positive, indicating that, 1% change in agro-chemical quantity would result to 0.068% change in output of sole cowpea. This reveals the relevance of agro-chemicals in cowpea production particularly in the control of pests/diseases among farmers in recent times. The result is in consonance with the work of Maurice (2012) in which he reported that, agrochemical was significant and contribute positively to output in food crop production among farmers in the study area. Moreover, Nurudeen and Rasaki (2011) had reported that, pesticide quantity was a significant factor (0.350) in cowpea production and has positive effect on farmers' output in the study area. This is so as stressed by the authors since pesticide use controls pest and diseases in cowpea farming with expected positive effect on yield. The elasticity of family and hired labour is both negative but significant at 5%. The significance level indicates how important labour input is in agricultural production. However, the negative sign suggest inefficiency in the use of labour resource in production by the farmers. Similarly, Ojo and Imoudu (2000) found in their study that labour input was significant at 5% in oil palm farms but has a negative coefficient in the non-settlement farms production. However, the sum of elasticities of the production factors is 0.71, indicating a decreasing return to scale in sole cowpea production.

The result of the inefficiency model shows the analysis of farmer – specific variables which include age, farming experience, education, extension contact, family size and credit availability. These are basically farmer's socio-economic attributes and are determined (as sources of inefficiencies) by the estimated parameters (δs). However, the interpretation is in opposite direction, that is, if the coefficient of a parameter is positive for instance, it means the variable has negative impact on technical efficiency of the farmers in production. The coefficient of farming experience is statistically significant at 10% and carries a negative sign. This implies that more years of experience enhance farmers' efficiency in production because they would know the right management practices for higher output. This is in similarity with the findings of Giroh (2012) who found that farming experience (-0.875) increases the technical efficiency of rubber farmers in production. Also, Amos *et al.* (2004) submitted that farming experience contributed positively to technical efficiency of farmers, with an estimated significant coefficient of (-0.0224).

The variable of extension contact has a coefficient of -0.196, meaning that it affects efficiency positively. Also, the coefficient is significant at 1% level, which means that if extension agents are available and farmers can easily meet them it will give the farmers opportunity to get knowledge from the agents to improve their production or at least, to solve their problems. The result is in conformity with the finding submitted by Nsikak *et al.* (2004) where they found extension service (-0.1237) to significantly increase level of technical efficiency in urban farms. Family size is revealed to be significant and increases technical efficiency of the farmers (-0.368). This can indicate the relevance of household size in farming through "free" labour availability especially in large family sizes with productive age group. Given the estimated coefficient of credit availability (-0.114) which is also significant at 5%, it clearly shows that increase in the availability of credit to the farmers would lead to increase in their technical efficiency. This is because when farmers have funds available, they will use it to boost production through proper farm financing in the procurement of inputs and carrying out farm activities such as payment of services. The finding buttressed the report of Maurice (2012) where credit availability (-1.132) to farmers was found to significantly increase the efficiency of food crop farmers in the area.

Table 2: Maximum Likelihood Estimates of Parameters of the Stochastic Frontier Production Function for Sole Cowpea Farmers

Variable	Parameter	Coefficient	Standard – error	T-ratio
Production factors				
Constant	β_0	3.042***	0.097	31.258
Farm size (X_1)	β_1	0.719***	0.096	7.464
Seed (X_2)	β_2	-0.027	0.067	-0.411
Family labour (X_3)	β_3	-0.030**	0.015	-2.037
Hired labour (X_4)	β_4	-0.027**	0.013	-2.148
Agro-chemicals (X_5)	β_5	0.068***	0.023	2.959
Ploughing cost (X_6)	β_6	0.007	0.012	0.567
Inefficiency model				
Age (Z_1)	δ_1	-0.078	0.164	-0.479
Farming experience (Z_2)	δ_2	-0.215*	0.124	-1.731
Education (Z_3)	δ_3	-0.025	0.021	-1.155
Extension contact (Z_4)	δ_4	-0.196***	0.059	-3.316
Family size (Z_5)	δ_5	-0.368***	0.127	-2.905
Credit availability (Z_6)	δ_6	-0.114**	0.054	-2.091
Variance parameters				
Sigma-squared	σ^2	0.345***	0.080	4.322
Gamma	Υ	0.849***	0.016	5.373
Log likelihood	LLF	-46.562		

Note: ***Significant at 1% level; **Significant at 5% level; *Significant at 10% level
Source: Computer Output (Frontier 4.1)

Technical efficiency distribution

Table 3 shows the distribution of the technical efficiencies of respondents which is derived from the analysis of the stochastic frontier production function. The result indicates that the technical efficiency (TE) of the cowpea farmers is generally below one, this means the farmers are generally operating below their production efficiency frontier. Also, it indicates a rather wide variation of technical efficiency index across the studied farms with a large spread. Most (40%) of the farms have technical efficiency index within 0.90-1.00 interval with the highest value of 0.97 for the best farm and 0.43 for the worst farm. The mean technical efficiency is 0.80 which implies there is still capacity of improving technical efficiency by 20% among the farmers given their production technology in the study area. This will go a long way in raising cowpea output among the producers. Moreover, on average the sampled farmers couldn't obtain output level above 80% in their cowpea production.

Table 3: Distribution of Technical Efficiency Level of Sole Cowpea Farmers

Efficiency index	Frequency	Percentage
0.40-0.49	6	3.33
0.50-0.59	23	12.78
0.60-0.69	22	12.22
0.70-0.79	25	13.89
0.80-0.89	32	17.78
0.90-1.00	72	40.00
Total	180	100
Mean = 0.80		
Minimum = 0.43		
Maximum = 0.97		

Source: Computer Print Out

CONCLUSION AND RECOMMENDATIONS

Sole cowpea production in the study area is under small scale cultivation, dominated by male gender and are experienced in cowpea farming. Farm size, family labour, hired labour and agrochemicals are determinants of cowpea output, while experience, contact with extension service, credit availability, education, family size and age positively affect technical and allocative efficiencies of cowpea farmers. There exist potential for improving technical efficiencies by 20%, among the farmers. The variance ratio gamma (ϒ) is 0.849 which means that about 85% of the variation in output of sole cowpea production is as a result of existence of technical inefficiency among the farmers.

Inputs such as agrochemicals, farm land, improved seeds, labour as well as credit should be made available to farmers timely and at subsidized rates by government and non-governmental organizations. This will improve production of sole cowpea in the study area.
Farmers should be educated through formal education process or extension education to improve their efficiency levels. Farmers should form cooperative societies to enable them access farm credit and production inputs.

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