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Resource Productivity among Small Scale Maize-Cowpea Farmers in South West, Nigeria: A Translog Function Approach

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Authors' contributions

This work was carried out in collaboration between all authors. Authors TTA and JOO designed the study and supervised the work while author OO collected data, analysed, interpreted and prepared the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

This study assessed the productivity of small-scale maize-cowpea farmers in South-Western Nigeria. One hundred and eighty respondents were selected using a multistage sampling technique. Primary data were collected through the administration of a well-structured questionnaire and analysed using a combination of descriptive statistics, budgeting analysis, stochastic frontier translog cost and production function Analysis and multiple regression model. Maximum Likelihood Estimates of the Stochastic Frontier Translog Production Function results showed that the coefficients of labour, agrochemicals, farm size and seed had significant effect on the technical efficiency of maize-cowpea farmers in the study area. Most of the interaction terms among the second order coefficients significantly influenced the technical efficiency. Maximum Likelihood Estimates of the Stochastic Frontier Translog Cost showed that the price of agrochemicals, price of implements, and price of labour had significant effect on the total cost of production. The return to scale was 0.86 indicating that the maize-cowpea farmers were operating

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at positive decreasing returns to scale. The results of allocative efficiency measurement showed that the allocative efficiency varied widely across maize-cowpea production, ranging between 0.41 and 1.00 with the mean of 74% implying that, in the short run, there is possibility of increasing allocative efficiency in maize-cowpea production in the study area by 26% if the farmers would adopt the technology and production techniques currently used by the most efficient farmer. Arising from the findings of the study, some recommendations were made for increased productive efficiency and income of maize-cowpea farmers.

Keywords: Maize-cowpea; productivity; south-western; determinants; farmers.

1. INTRODUCTION

Agriculture plays important roles in the economic development of Nigeria. It is the economic mainstay of majority of households in Nigeria [1] and is a significant sector in Nigeria's economy [2]. For many years, productivity has been a key issue of agricultural development strategies because of its impact on economic and social development. It is generally believed that the surest means through which mankind can raise itself out of poverty to a condition of relative material affluence is by increasing productivity.

Maize in Nigeria is usually intercropped, with yam, cassava, guinea corn, rice, cowpea, groundnut, and soybeans. IITA 2012 estimates that approximately 60 percent of maize produced in the country is used for industrial end uses for both for human (flour, beer, malt drinks, cornflakes, starch, dextrose, syrup) and animal consumption, mainly poultry [3]. In terms of maize types, yellow maize is mostly used for feed and human consumption, while white maize for human consumption only.

Cowpea (*Vigna unguiculata L. Walp.)* is an important food legume grown in the semi-arid tropics, covering Africa, Asia, Southern Europe and Central South America [4]. It is one of the ancient crops known to man and is cultivated primarily for grain, but also as vegetable, a fodder and cover crop. Its ability to replenish soil nitrogen gives it a key position in the modern crop farming system in rotation with other crops, with the view for long term sustainable agriculture development prospect. World production of cowpea was estimated to be 2.27 million tons of which Nigeria produces about 850,000 tones [5,6]. Cowpea is of major importance to the livelihoods of millions of relatively poor people in less developed countries of the tropics [5]. The production of cowpea all year round basis in all parts of Nigeria is expected to boost production, thereby improving nutrition, contributes to food security as well as increase revenue of the producers and creates employment opportunities and enhancing the efficiency of utilization of labour.

Cowpea's high protein content, its adaptability to different types of soil and intercropping systems, its resistance to drought, and its ability to improve soil fertility and prevent erosion makes it an important economic crop in many developing regions. The sale of the stems and leaves as animal feed during the dry season also provides a vital income for farmers. In Africa humans consume the young leaves, immature pods, immature seeds, and the mature dried seeds [7]. Due to the increase in the demand for the crop, arising from the growing population in the country, Nigeria remains the largest producer and consumer of cowpea both in West Africa and in the World [3,8].

However, the ability of Nigerian agriculture to perform its roles in development has been on the decline in the last three decades [9]. The overall agricultural situation deteriorated, creating wide gap between demand and supply for food. Revenue from the agricultural sector dwindled and the government was faced with mounting food import bills. At the same time, industries continued to import agricultural raw materials, thus putting considerable stress on Nigeria's foreign exchange earnings. It was against this background of a rudimentary economy, but abundantly-endowment with human and natural resources, that Nigerian government adopted different agricultural programmes and policies at raising the productivity and the efficiency of the agricultural sector. These programs and policies placed the smallholder farmers in central focus. This was due to the fact that the nation's agriculture had always been dominated by the smallholder farmers who represent a substantial proportion of the total farming population and produce over 90% of the total agricultural output in the country [10].

However, despite the importance of agriculture in terms of employment creation, its potential for contribution to economic growth is far from being fully exploited. Empirical studies suggest that most under developed and developing countries, Nigeria inclusive are still facing the problem of high poverty levels. This calls for improving yields of major staples, such as maize and cowpea for better food security and livelihoods of rural households. Thus, resources need to be used in the most efficient way to achieve this objective. Improved efficiency is expected to improve food security by cutting hunger halfway in 2015 [11]. Raising agricultural productivity is an important issue in African agriculture [12].

Increased production of maize and cowpea in all parts of Nigeria is expected to boost agricultural production, thereby improving nutrition, contribute to food security as well as increase revenue of the producers and create employment opportunities and enhance the efficiency of utilization of labour. In Nigeria, intercropping maize with legumes, particularly cowpea, has gone a long way to improve the already limited fertility profile of many farming plots. The increase in agricultural production is an important step for an appreciable development to be achieved in the Nigerian agricultural sector. Thus, the study of efficiency in agricultural production at the farm level needs to be carried out from the stand point of the important information which may be gained from the study. Efforts need to be made by food crop farmers in Nigeria to improve efficiency of resource – use in food production which can raise output to meet the country's food consumption needs. This study thus focused on the estimation of technical and allocative efficiencies of maize-cowpea farmers and examined the factors affecting the allocative efficiency of the farmers.

2. METHODOLOGY

The study was conducted in South Western Nigeria. The six states in South Western Nigeria are: Ogun, Osun, Ondo, Oyo, Lagos and Ekiti. It is bounded in the North and East by Kwara and Kogi states, in the West by the Republic of Benin and in the South by the Atlantic Ocean. It has a land area of 76,852 square kilometres and population of about 25.2 million [13]. All the states have an average annual rainfall and temperature of 1486 mm and 26.7°C respectively [14]. The climate of South-west Nigeria is tropical in nature and it is characterized by wet and dry seasons. The wet season is associated with the South-west monsoon wind from the Atlantic Ocean while the dry season is associated with the northeast trade wind from the Sahara desert. Primary data were used for this study. The data were collected from the respondents with the aid of well-structured questionnaire. Multi-stage sampling technique was used to select one hundred and eighty (180) respondents in the study area. In the first stage, two states noted for growing maize and cowpea were purposively selected (Oyo and Osun States).In the second stage, three LGAs were randomly selected in each State. In the third stage, three communities were randomly selected in each LGA and in the final stage ten (10) maize-cowpea farmers were purposively selected from each community to make ninety (90) maize-cowpea farmers per state. Thus, the total of one hundred and eighty respondents (180) was the sample size for the study. Data collected were analysed using a combination of stochastic frontier production function and translog cost production function Analysis. Stochastic frontier production function and translog cost production function Analyses were employed to determine the technical and allocative efficiency of the farmers in the use of major production inputs in maize-cowpea production respectively.

$$\ln Y_t = \beta_0 + \sum \beta_k \ln X_{ki} + \tfrac{1}{2} \sum \sum \beta_{kj} \ln X_{ki} \ln X_{ji} + (V_i - U_i) \quad (1)$$

Where, ln = the natural logarithm; i = ith respondent, Y_t = Output of farmer in kilograms (kg), X_{ki}= Variable inputs, X_{ji} = Fixed inputs, β_0, β_k and β_{kj} are parameters to be estimated. V_is = Assumed to be independently and identically distributed normal, random errors, having zero means and unknown variance (δ^2v). U_is = Technical efficiency, which are assumed to be independent of V_is.

The translog production function is alternatively defined as follows:

$$\ln Yi = bo + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + b_5 \ln X_5 + ½ b_6 \ln X_1^2 + ½ b_7 \ln X_2^2 + ½ b_8 \ln X^2_3 + ½ b_9 \ln X^2_4 + ½ b_{10} \ln X^2_5 + b_{11} \ln X_1 \ln X_2 + b_{12} \ln X_1 \ln X_3 + b_{13} \ln X_1 \ln X_4 + b_{14} \ln X_1 \ln X_5 + b_{15} \ln X_2 \ln X_3 + b_{16} \ln X_2 \ln X_4 + b_{17} \ln X_2 \ln X_5 + b_{18} \ln X_3 \ln X_4 + b_{19} \ln X_3 \ln X_5 + b_{20} \ln X_4 \ln X_5 + e.$$

Where; In = natural logarithm, Y_i = output (kg), X_1 = total labour used in man days, X_2 = farm size (ha), X_3 = quantity of seeds used (kilogrammes), X_4 = quantity of agro-chemicals used (litres), X_5 = quantity of fertilizer used (kilogrammes), bs = coefficients to be estimated.

e = error term (Vi – Ui)

2.1 Technical Inefficiency Model

The inefficiency model is defined to estimate the influence of some farmers' socio-economic variables on the technical efficiency of the farmers. The model is specified by (4):

$$U_i = \delta_0 + \delta_1 Z_{1i} + \delta_2 Z_{2i} + \delta_3 Z_{3i} + \delta_4 Z_{4i} + \delta_5 Z_{5i} + \delta_6 Z_{6i} + \delta_7 Z_{7_i} + \delta_8 Z_{8_i} + \delta_9 Z_{9_i} + W \quad (2)$$

Where; U_i= technical inefficiency effects, δ s = unknown scalar parameters to be estimated, z_1 = age (years), z_2 = Level of education (years spent in acquiring formal education), z_3 = farming experience (years), z_4 = household size (Number of persons feeding from the same household pot and residing together), z_5 =Cooperative membership (1 for membership, 0 for Non membership) z_6 = Credit (₦), z_7= farm distance in kilometres, z_8 = land management practices (1 for using, 0 for not using), z_9 = source of raw material e.g seeds (1 from government sources, 0 from open markets),Where i= 1, 2, 3 represents the factors which influenced efficiency of the farmers.

2.1.1 Economic efficiency

Cost efficiency was measured using Stochastic Frontier Translog Cost Function which is specified as follows:

$$LnC_i = \alpha_0 + \alpha_1 \ln P_1 + \alpha_2 \ln P_2 + \alpha 3 \ln P_3 + \alpha_4 \ln P_4 + \alpha_5 \ln P_5 + \alpha_6 \ln P_6 + ½ \alpha_7 \ln P_1^2 + ½ \alpha_8 \ln P_2^2 + ½ \alpha_9 \ln P^2_3 + ½ \alpha_{10} \ln P^2_4 + ½ \alpha_{11} \ln P^2_5 + ½ \alpha_{12} \ln P^2_6 + \alpha_{13} \ln P_1 \ln P_2 + \alpha_{14} \ln P_1 \ln P_3 + \alpha_{15} \ln P_1 \ln P_4 + \alpha_{16} \ln P_1 \ln P_5 + \alpha_{17} \ln P_1 \ln P_6 + \alpha_{18} \ln P_2 \ln P_3 + \alpha_{19} \ln P_2 \ln P_4 + \alpha_{20} \ln P_2 \ln P_5 + \alpha_{21} \ln P_2 \ln P_6 + \alpha_{22} \ln P_3 \ln P_4 + \alpha_{23} \ln P_3 \ln P_5 + \alpha_{24} \ln P_3 \ln P_6 + \alpha_{25} \ln P_4 \ln P_5 + \alpha_{26} \ln P_4 \ln P_6 + \alpha_{27} \ln P_5 \ln P_6 + V_i + U_{i.}$$

Where LnC_i= Total input cost of the i-th farm, P_1=Output in kg, P_2= Unit price of seed in naira per kg, P_3 = Price of fertilizer in naira per kg, P_4 = Price of agrochemicals in naira, P_5 = Unit price of implement in naira, P_6 = Price of labour in naira,α_0, α_1, α_2................α_{27} are parameters to be estimated. V_i= Stochastic or random error (Errors that are not under the control of farmers) $U_{i.}$= Error due to inefficiency effect in the model (Errors term under the control of farmers).

Farm- level economic efficiency (EE) was obtained by the relationship:

$$EE = \frac{1}{CE} \quad [15]$$

Where

EE = Economic Efficiency

CE = Cost Efficiency

2.1.2 Allocative efficiency

This is measured as follows;

$$AE = \frac{EE}{TE}$$

Where

AE = Allocative Efficiency

EE = Economic Efficiency; and

TE = Technical Efficiency.

2.1.3 Determinants of allocative efficiency

Allocative Efficiency scores were then regressed against the set of farm specific factors to obtain the determinants for allocative efficiency as done by [16]

$$AE = b_0 + b_1 M_1 + b_2 M_2 + b_3 M_3 + b_4 M_4 + b_5 M_5 + b_6 M_6 + b_7 M_7 + b_8 M_8 + b_9 M_9 + b_{10} M_{10}$$

Where

AE = Allocative efficiency of the i-th farmer; M_1= Farmers age in years, M_2 = Household size, M_3 = Educational status (Educated =1 and Not Educated = 0), M_4= Gender (1= Male, 0 = Female), M_5 = Farmer's farming experience (Years), M_6 = Quantity of Agrochemicals (Litres), M_7 = quantity of fertilizer used (kg), M_8 = Farm size (Ha), M_9 = Membership of farmers associations/cooperative societies (a dummy variable: 1= member, 0 = otherwise), M_{10} = Number of extension contacts made by the farmer in the year; and b_0, b_1, b_2.........b_{10} **=** Regression parameters to be estimated.

3. RESULTS AND DISCUSSION

The Maximum Likelihood (ML) estimates of the stochastic frontier translog cost and parameters for maize-cowpea are presented in Table 1. The significant value of the sigma square (δ^2) indicates the goodness of fit and the correctness of the specified assumption of the composite error terms distribution [17]. From the table, output, price of agrochemicals, price of implements, price of labour were significant at 1% and 5%. This implies that increasing the prices of these inputs except price of labour, would increase the total cost of production, while the price of labour would decrease the total cost. The huge value of these coefficients indicates the importance of these variables in the cost structure of the farmers. The study is consistent with the result of [18]. Most of the interaction terms among the second order coefficients were statistically significant at 1% and 5% level of significance, indicating the suitability of the translog function [17]. Among the second order terms, the coefficients of the square term for price of implements, price of labour and interaction of price of seed and price of fertilizer were positive and significant at 1% and 5% level of significance, implying a direct relationship with total cost of maize-cowpea production. However, the coefficients of the square term for price of fertilizer and interactions of price of fertilizer and price of agrochemicals were negative but significant at 1% level of significance, showing indirect relationship with the total cost of maize-cowpea production.

Table 1. Maximum likelihood estimates of the stochastic translog cost function

Variables (parameters)	Coefficients	Std. errors	T-values
Constant (α_0)	22.5862	1.2345	18.2947
LNOUTPUT (α_1)	0.1141***	0.0221	5.1525
LNFSEED (α_2)	-0.0881	1.0796	-0.0816
LNFERT (α_3)	-0.0249	0.0730	-0.3410
LNAGROCHEM (α_4)	0.8437***	0.2688	3.1387
LNIMPLEMT (α_5)	2.0157**	0.9385	2.1477
LNLAB (α_6)	-0.0644***	0.0155	-4.1487
(0.5 LNOUTPUT)^2 (α_7)	0.5733	0.6981	0.8212
(0.5 LNFSEED)^2 (α_8)	-0.1844	0.7471	-0.2468
(0.5 LNFERT)^2 (α_9)	-0.0210**	0.0100	-2.0892
(0.5LNAGROCHEM)^2 (α_{10})	0.0954	0.2360	0.4041
(0.5 LNIMPLMT)^2 (α_{11})	2.0151**	0.9475	2.1266
(0.5 LNLAB)^2 (α_{12})	0.0201***	0.0049	4.0849
LNOUTPUT*LNSEED (α_{13})	0.0110	0.0384	0.2860
LNOUTPUT*LNFERT (α_{14})	0.2935	0.3837	0.7648
LNOUTPT*LNAGROCH (α_{15})	-0.0828	0.5270	-0.1571
LNOUTPT*LNIMPLMT (α_{16})	-0.7271	0.8240	-0.8823
LNOUTPT*LNLAB (α_{17})	-0.0770	0.2941	-0.2618
LNFSEED*LNFERT (α_{18})	0.2277***	0.0721	3.1548
LNSEED*LNAGROCHM (α_{19})	0.0575	0.4262	0.1349
LNFSEED*LNIMPLMNT (α_{20})	-0.4774	0.5612	-0.8506
LNSEED*LNLAB (α_{21})	-0.0973	0.7661	0.1270
LNFERT*LNAGROCHE (α_{22})	-0.0514**	0.0245	2.09929
LNFERT*LNIMPLEMNT (α_{23})	0.1799	0.8526	0.2110
LNFERT*LNLAB (α_{24})	0.0770	0.1994	0.3861
LNAGRCHEM*LNIMPM (α_{25})	0.0351	0.3205	0.1095
LNAGROCHEM*LNLAB (α_{26})	-0.0880	0.3602	0.2443
LNIMPLEMT *LNLAB (α_{27})	-0.0347	0.2296	0.1511
Log-likelihood function	-524.1596		
Total Variance (δ^2)	0.2468**	0.1126	2.1910
Variance Ratio (γ)	0.8958***	0.2828	3.1672
LR Test	52.2315		

Significant at 10% level; ** Significant at 5% level; * Significant at 1% level*
Source: Computed from field survey data, 2015

3.1 Estimates of the Stochastic Translog Production Function

The Maximum Likelihood (ML) estimates of the stochastic frontier translog production function and parameters for maize-cowpea are presented in Table 2. The high and significant values of sigma square (δ^2) indicate the goodness of fit and correctness of the specified assumption of the composite error terms distribution [19]. The variance ratio (γ) of 0.8462 shows that 84.62% of the variability in the outputs of maize-cowpea farmers that are unexplained by the function is due to technical inefficiency. The first order coefficients are those of single factor of production; the second order coefficients are those of squared variables; while the third are the interactive variables. Among the first order coefficients, the results revealed that, the coefficients of labour and agrochemicals had significant positive effect (significant at 1% and 5% respectively) on the technical efficiency of maize-cowpea farmers in the study area. This implies that, increase in these variables would result to increase in technical efficiency of maize-cowpea farmers in the study area. On the other hand, the results revealed that the coefficients of farm size and seed had negative effect (1% and 5% respectively) on the technical efficiency of maize-cowpea farmers in the study area. This implies that increase in these variables would lead to reduction in technical efficiency of maize-cowpea farmers. This could be that these inputs were not optimally used in the production of maize-cowpea.

Among the second order coefficients, the results revealed that only the coefficient of fertilizer at 5% level of probability had significant positive effect on the technical efficiency while the coefficients of farm size and seed had significant negative effect (1% and 5% respectively) on the technical efficiency of maize-cowpea farmers. The results revealed that, continuous increase in these variables would reduce significantly the technical efficiency of maize-cowpea farmers in the study area. This indicates that, the utilization of most of the specified factors of production occurred in stage II or optimal stage in the classical production surface. Therefore, increase in the use of these inputs might push the production process to stage III, where diminishing marginal return, sets in. In addition, technical efficiency has a mixed relationship with

Table 2. Maximum likelihood estimates of the stochastic translog production function

Variables (parameters)	Coefficients	Std. errors	T-values
Constant (β_0)	15.2845	4.6634	3.2775
LNLAB (β_1)	4.4235***	0.8063	5.4863
LNFSIZE (β_2)	-3.3894***	1.0568	-3.2072
LNSEED (β_3)	-2.1944**	1.0617	-2.0669
LNAGROCHEM (β_4)	1.7074**	0.8222	2.0765
LNFERT (β_5)	1.6344	0.8891	1.8382
$(0.5\ \text{LNLAB})^2$ (β_6)	-0.4013	0.2448	-1.6396
$(0.5\ \text{LNFSIZE})^2$ (β_7)	-1.4651***	0.2323	-6.3067
$(0.5\ \text{LNSEED})^2$ (β_8)	-0.4205**	0.1955	-2.1513
$(0.5\text{LNAGROCHEM})^2$ (β_9)	0.1882	0.1591	1.1827
$(0.5\ \text{LNFERT})^2$ (β_{10})	0.4686**	0.2290	2.0465
LNLAB*LNFSIZE (β_{11})	0.6103***	0.0756	8.0678
LNLAB*LNSEED (β_{12})	-0.1276**	0.0624	-2.0455
LNLAB*LNAGROCHEM (β_{13})	-0.3332	0.3023	-1.1021
LNLAB*LNFERT (β_{14})	0.1635**	0.0743	2.1996
LNFSIZE*LNSEED (β_{15})	-0.1720**	0.0786	-2.1880
LNFSIZE*LNAGROCHEM (β_{16})	-0.1685**	0.0818	-2.0602
LNFSIZE*LNFERT (β_{17})	0.1002	0.0852	1.1766
LNSEED*LNAGROCHEM (β_{18})	0.1502**	0.0738	2.0366
LNFSEED*LNFERT (β_{19})	-0.1101	0.0587	-1.8736
LNAGROCHEM*LNFERT (β_{20})	0.1969**	0.0911	2.1617
Log-likelihood function	32.1865		
Total Variance (δ^2)	0.1725***	0.0276	6.2593
Variance Ratio (γ)	0.8462***	0.0413	20.4942
LR Test	21.0723		

Significant at 10% level; ** Significant at 5% level; * Significant at 1% level*
Source: Computed from field survey data, 2015

the third order coefficients (i.e. interactive coefficients) in the model. However, most interactive coefficients were significant (i.e. more than 50% at 1% and 5% level of significance), implying that, some specified variables combined to cause significant change in the technical efficiency of maize-cowpea farmers.

3.2 Estimation of Factors Affecting Allocative Efficiency

Table 3 shows the results of the determinants of allocative efficiency in maize-cowpea production. Results showed that the included explanatory variables explained 71% of the variation in the value of allocative efficiency. The coefficients of age and farm size were negative but significant at 1% and 5% level of probability in influencing allocative efficiency in maize-cowpea production. This shows that these variables would bring about reduction in the allocative efficiency of maize-cowpea farmers as they are increased. The implication of the inverse relationship between allocative efficiency and age could be as a result of old age which incapacitated the farmers; and being less willing to adopt new practices and modern inputs. This confirmed the results of previous studies conducted by [20]. Inverse relationship between farm size and allocative efficiency could be attributed to the belief that farmers with small farm size are allocatively efficient than those with large farm size. This is in conformity with the outcome of the findings of [21] who stated that smaller farm sizes lead to decrease in level of allocative efficiency. The coefficients of education, membership of association and extension contact had positive relationship with allocative efficiency and significant at 1% and 5% level of probability. This implies that, increase in these variables would lead to increase in the allocative efficiency of maize-cowpea farmers, confirming the *a priori* expectation that the level of education, membership of association and extension contact are directly proportional to the level of allocative efficiency.

3.3 Estimates of Allocative Efficiency

The summary of the calculated allocative efficiency of maize-cowpea is presented in Table 4. The allocative efficiency ranged between 0.474 and 0.948. The mean allocative efficiency was 0.74. The results indicate that average maize-cowpea farmer in the study area would enjoy cost saving of about 26% (1-0.74) if the farmer attains the level of the most efficient maize-cowpea farmer among the respondents. The most allocatively inefficient maize-cowpea farmer will have an efficiency gain of 53% (1-0.47) in maize-cowpea production if the farmer is to attain the efficiency level of most allocatively efficient farmer in the study area.

3.4 Elasticity of Production and Return-to-Scale Analysis

The input elasticities of production and returns-to-scale (RTS) values are presented in Table 5. The production elasticity measures the proportional change in output resulting from a proportional change in the i-th input level, with all other input levels held constant [22]. The RTS is the summation of the estimated coefficient of variables used for the estimation of the Stochastic Translog Frontier Production Function. The RTS of 0.86 indicates that the RTS is less than unity, but greater than zero and it implies that maize-cowpea in the study area was in positive decreasing return to scale of the

Table 3. Determinants of allocative efficiency in maize-cowpea and maize production

Variables	Coefficients	Std. errors	T-values
Constant	2.0451	0.3703	5.5220
Age	-0.0072***	0.0011	-6.5162
Household size	-0.0227	0.4119	-0.0551
Education	0.0054**	0.0022	2.3627
Gender	0.0560	0.2901	0.1930
Experience	0.0348	0.1002	0.3472
Quantity of agrochemicals	0.0081	0.2154	0.0376
Quantity of fertilizer	0.0673	0.0929	0.7241
Farm size	-0.0309**	0.0142	-2.1740
Membership of association	0.4361***	0.1433	3.0416
Extension visits	0.0042**	0.0020	2.0190

Source: Computed from Field Survey Data, 2015

*** Significant at 5% level; *** Significant at 1% level;* R^2 *= 0.710; Adjusted* R^2*=0.668* production function. Therefore, maize-cowpea in the study area was at the stage of efficient production (stage II).i.e. that most of the farmers were in the stage II of the production process. In order to increase efficiency in this stage, the use of the inputs could be continued until the productivity of such input would reach its optimal level.

Table 4. Distribution of allocative efficiency estimates

Efficiency level	Frequency	Percentage
0.41-0.50	29	16.1
0.51-0.60	34	18.9
0.61-0.70	16	8.9
0.71-0.80	52	28.9
0.81-0.90	22	12.2
0.91-1.00	27	15.0
Total	180	100.0
Mean value	0.748	
Minimum value	0.474	
Maximum value	0.948	

Source: Computed from field survey data, 2015

Table 5. Elasticity of production and return-to-scale of the respondents

Variables	
LNLAB	4.4235
LNFSIZE	-3.3894
LNSEED	-2.1944
LNAGROCHEM	1.7074
LNFERT	1.6344
$(0.5\ LNLAB)^2$	-0.4013
$(0.5\ LNFSIZE)^2$	-1.4651
$(0.5\ LNSEED)^2$	-0.4205
$(0.5LNAGROCHEM)^2$	0.1882
$(0.5\ LNFERT)^2$	0.4686
LNLAB*LNFSIZE	0.6103
LNLAB*LNSEED	-0.1276
LNLAB*LNAGROCHEM	-0.3332
LNLAB*LNFERT	0.1635
LNFSIZE*LNSEED	-0.1720
LNFSIZE*LNAGROCHEM	-0.1685
LNFSIZE*LNFERT	0.1002
LNSEED*LNAGROCHEM	0.1502
LNFSEED*LNFERT	-0.1101
LNAGROCHEM*LNFERT	0.1969
RTS	0.8611

Source: Computed from field survey data, 2015

4. CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it can be concluded that maize-cowpea farmers in the study area have not attained their best in terms of production. This has been confirmed by the presence of technical and allocative inefficiency effects in their operations. The mean allocative efficiency of maize-cowpea was 0.74, suggesting that opportunities still exist for increasing productivity and income of maize-cowpeain the study area by increasing the efficiency with which resources are used at the farm level.From this estimation, maximum allocative efficiency is not yet achieved suggesting a need for more effort at improving efficiency ofmaize-cowpea farmers.

Based on the findings of this study, the following recommendations are made:

i. Farmers should be encouraged through enlightenment programs to belong to farmers' association. This will enable the farmers to benefit from both the government and non-governmental agricultural intervention programmes.
ii. Extension agents should be supported by both government and non-governmental organisations to visit the farmers regularly and orientate farmers about the use of input combinations that can therefore increase the farm level efficiency so as to produce better output and be technically and cost efficient.
iii. Government and non-governmental organisations should help expose farmers to formal education such as adult literacy classes and training programmes as this would help reduce the level of inefficiency in resource use.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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