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Analysis of Technical and Allocative Efficiency among Small Scale Maize Producers in Arsi Negele Woreda, West Arsi Zone of Oromia, Ethiopia

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ABSTRACT: This research study is carried out to examine Technical and allocative efficiency among Maize growers in Aesi Negele Woreda, West Arsi Zone of Oromia, Ethiopia. The study is based on primary and secondary data, collected through a well designed questionnaire from a sample of 98 small holder Maize producers. The data were analyzed with the use of stochastic frontier Cobb-Douglas production function to estimate the efficiency level and identify important factors affecting the efficiency. Moreover, the allocative efficiency was estimated using APP, MPP and MVP. The maximum likelihood estimates for the model indicate that land, seed quantity and labor have positive significant effects on maize yield. However, the amount of fertilizer applied had a negative relation with maize output. Allocative efficiency analysis reveals that land, labour and seed are underutilized, while fertilizer over utilized for maize production in the study area. Finally, the study recommends training for maize growers and provision of advanced new technological options has a vital role in boosting production and productivity efficiently.

KEYWORDS: Cobb-Douglas production function, Technical efficiency, Allocative efficiency

INTRODUCTION

Agriculture is the backbone of the Ethiopian economy. This particular sector determines the growth of all other sectors and consequently the whole national economy. It constitutes over 50% of the gross domestic product (GDP), accounts for over 85% of the labour force and earns over 90% of the foreign exchange (Alemu et al., 2010). On average, crop production makes up 60% of the sector's outputs, whereas livestock accounts for 27% and other areas contribute 13% of the total agricultural value added. The sector is dominated by small-scale farmers who practice rain-fed mixed farming by employing traditional technology, adopting a low-input and low-output production system. The land tilled by the Ethiopian small-scale farmer accounts for 95% of the total area under agricultural use, and these farmers are responsible for more than 90% of the total agricultural output (Gebreselassie et al., 2010).

Despite the fact that many areas of the economy have made progress, the livelihoods of small-scale farmers are still constrained by many impeding factors. The salient constraints include: small and diminishing farm lands due to large family sizes and rapid population growth; soil infertility with decreasing yield-per-hectare ratios; on-field and post-harvest crop pests; unpredictable patterns of rain; input scarcity and outdated technologies leading to low outputs; shortage of capital; reduced market access; lack of market information; outbreaks of animal diseases and shortages of animal feed; and declining price structures (Rahmeto D, 2008).

The country is known by being the origin and centre of diversity of many cultivated crops. Among these crops, cereals took the largest share of production and consumption. Maize (Zea mays L.) originated from Latin America and its cultivation is considered to have begun by 3000 BC. It was introduced to West and East Africa in the 16th century (JAICAF 2008).

The maize crop in Ethiopia has shown tremendous growth, in both area harvested and productivity per hectare. On average, the maize area harvested expanded from 1.5 million ha to more than 2 million ha between 2001 and 2006 and 2012–2015. For the same period, the maize yield also increased substantially, from 1.86 to 2.9 tons ha−1. Because of this growth, maize production has been boosted recently, surpassing 6 million MT. During 2001–2006 and 2012–2015, maize production registered a 113% growth rate, on average, from 2.8 million MT to 6.1 million MT (United States Department of Agriculture (USDA) 2015).

Farming practices and the use of farming technology in Ethiopia are still at lower stage of development. Despite this problem, Ethiopia's agricultural sector has witnessed consistent growth since 2003: maize production has expanded at 6% per annum, and the aggregate export values across all commodities have grown at 9% per annum. Conversely, the farm productivity per hectare is very low as compared to other African countries. In terms of maize productivity per hectare, South Africa’s yields (3.77 tons/ha) are relatively higher compared to Ethiopia which is 3.06 tons/ha (FAO, 2013). These results indicate that both countries are operating below the maximum potential grain yield which ranges from 7–12 tons/ha (Abate Bekele, 2009). What is more is that, maize plays a crucial role in Ethiopia’s food security and it is the staple crop with the greatest production, i.e., 4.2 million tons in 2017/18, compared to teff which is 3.0 million tons and sorghum which is 2.7 million tons (Kibirige D, 2014). It is estimated that, by bridging this yield gap and tapping into latent demand sinks, smallholders could increase their income.

Despite the economic and food security importance of cereal crops, data and opinion suggest a yield gap: actual smallholder farm yields do not achieve estimated potential yields for wheat, sorghum, maize, lentils and peas. Furthermore, cereal prices in Ethiopia fall between import and export parity prices, limiting their international trading prospects. Although there are significant wheat imports, these reflect the influx of food aid and not competitive trade on the international market (Kate and Leigh, 2010).

Maize and wheat the major top crops in the study area and efforts have been made by the respective bodies by giving advice on better agronomic practices and input use to raise maize output. These technologies are all incentives known for increased production efficiency. However, according to the Agricultural development Office of the study area, the average maize productivity of smallholder farmers is 3.5 metric tons per hectare against the potential.

According to Alemayehu et al., (2011), there has been substantial growth in cereals, in terms of area cultivated, yields and production since 2000, but a yield are low by international standards and overall production is highly susceptible to weather shocks, particularly draught. This shows that smallholder farmers are technically inefficient since they are producing below potential output using the existing technology.

This showed that, evaluating the mean and plot specific efficiency of smallholder farmers and their determinants of farmer and farm characteristics will able to contribute a lot to the performance of maize productivity and profitability in Arsi Negele Woreda. Resources must be used much more efficiently with more attention paid to eliminating waste. This will lead to an increase in productivity and incomes. The success in achieving broad based economic growth will depend largely on the ability to efficiently utilize the available resources. Other observed that efficient resource use enhanced farm output, farm income and reduce annual farm cost (Umeh and Asogwa, 2005; Asogwa et al., 2007).

Owing to this reality, in order to boost productivity, the GOs and NGOs supplied appropriate inputs and technical services to farmers in Arsi Negele Woreda. Though farmers applied the production techniques given by development practitioners and realized a slight increased in production, it is not clear evidence that asserts whether they were relatively more efficient both allocatively and technically.

Accordingly, there is knowledge gap in technical and allocative efficiency of maize farmers in Arsi Negel Woreda. Thus, this study was carried out in order to establish technical and allocative efficiency and factors affecting technical and allocative efficiency of maize farmers in the study area. Results from this study will be used to enhance the services delivered for maize farmers in the Woreda to boost production and productivity.

OBJECTIVES OF THE STUDY

The overall objective of this study was to determine the technical and Allocative efficiency of maize farmers in Arsi Negel Woreda of West Arsi Zone. The Specific Objectives of this study depicted hereafter accordingly:

1) To determine the level of technical efficiency in maize growing farmers.
2) To determine the level of allocative efficiency in maize growing farmers.
3) To identify the factors affecting technical efficiency in maize production.

METHODOLOGY

Description of the Study Area

Arsi Negele district has borderlines with Southern Peoples' Regional State, Adami tulu-Jido, Shasemene & Siraro districts and Arsi zone (fig.6). Arsi Negele with 1395.87 km2 area is the 6th largest district in East Shewa zone. Arsi Negele town is the district capital. Except the southeastern part, most of the district's elevation is between 1500 and 2300 metres. Gara Duro (3095m) is the highest peak in the district. Arsi Negele has the highest number of rivers in the zone. They include Gedamso, Lephis, Huluka, Awede Jitu, Awede Gudo & Dadaba Gudo. The district id rich in natural lakes too. The major rift valley lakes of Abijata, Langano and Shalla are partly in Arsi Negele accounting for about 32% of the total area of the district. About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone. Andosol soil type covers about 52.2% of Arsi Negele, while Nitosols cover the remaining 47.8%. Coniferous forests of podocarpus variety, woodland and savanna, and broadleaf forests prevail in the district. The major wild animals of the district are Cheetah, Hyena, Porcupine, Monkey, Ape, Olive Baboon, Grant's Gazelle, Greater Flamingo, African Fish Eagle, Great White Pelican and Bush Buck. The Shalla-Abijata National park is largely in Arsi Negele district. The district had a total population of 147,114 in 1997. The urban population was 17.8% in the same year. The age groups 0-14, 15-64 and above 64 years were 50%, 48% and 2% respectively. About 51.3% of the urban and 50.7% of the rural populations was females. The average family size for the district was 5.2 (5.3 for urban & 5.1 for rural). The population density of the district was 105.4 persons per km2.

Sampling Procedure and Sample Size

Arsi Nehge woreda was purposively selected for this study. A multi-stage sampling technique was employed in this study. First based on maize crop area (ha) coverage KAs were randomly selected. From these potential kebeles, four KAs were randomly selected. Based on the number of households contained in each four sampled KAs, sample size of each KA allocated proportionally. Then from each and among these a total of 98 households was selected randomly from the sampling frame and get interviewed.

Methods of Data Collection and Type of Data

In order to analyse the level of technical efficiency, allocative efficiency and factors affecting the technical efficiency of maize producers in West Arsi zone of Arsi Negele woreda primary as well as secondary sources of data have been used.

Primary data was collected from farmers using a well structured interview schedule involving a questionnaire. The questionnaire contained socio-economic and farm level production input used that enables to catch up important data for the analysis of efficiency and factors that affects the level of efficiency of small holder maize farmers in the study area. As far as secondary sources of data concerned, the data from Agriculture department of West Arsi zone, reports, journals and other published literatures have been used.

Analytical methods

The data obtained from the field was subjected to analysis using the SPSS program (Version 20) and the program FRONTIER (Version 4.1c). The descriptive statistics presented in tables using frequencies, percentages, standard deviation, and means. The estimation of allocative efficiency and technical efficiency was using a Cobb Douglas production function and a stochastic production frontier function derived from a Cobb Douglas function. The estimation of the inefficiency of the maize farmers was using socio-economic characteristics the specific respondents of this study. The method of data analysis of allocative and technical efficiency and determinants of technical efficiency are presented hereafter accordingly.

Estimation of Technical Efficiency (T.E)

In this study, Cobb-Douglas stochastic frontier production function was assumed to be appropriate model for the analysis of the technical efficiency of the maize farmers. This study assumed that maize production is dependent on human labour, fertilizers applied, amount of seed planted, size of land allocated manure applied, herbicide applied and insecticide applied. Therefore, technical efficiency was estimated following physical production relationships derived from the Cobb – Douglas production function of Equation. Thus, the specific model estimated as defined by (Seyoum et al., 1998) is given by:

$$(1).\ \ln Y_i = b_o + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4 + E_j$$

Where:-

In = represents natural logarithm, the subscript i represents i-th sample farmer,

Y = Amount of maize produced per farm household (kg)

X_1 = Land allocated to maize production (ha) by a given household

X_2= Amount of seed planted (kg) by a given household.

X_2= Amount of labour used (MD) by a given household
X_4 = value of fertilizers (DAP and Urea) applied in maize by a household
(2) $E_j = V_j - U_j$ is the composed error tem and V_j is two sided error term, while U_j is the one sided error term.

Accordingly, individual farmer level technical efficiency was predicted from estimated stochastic production frontiers. The measure of production efficiency relative to the production frontier was the ratio of the observed output to the corresponding maximum output given the available technology and it is defined as:

$$(3)\ TE = \frac{Y_i}{Y_i^*} = \exp(U_i)$$

Where: - Y_i is the observed output represents the actual output and Yi^* is the minimum output and represents the frontier output. TE takes the value with in interval (0,1) and 1 indicates fully efficient farmer.

Estimation of Allocative Efficiency (A.E)

Allocative efficiency reflects the ability of a firm to use inputs in optimal proportions, given their respective prices. A production process is said to be allocative efficient if it equates the marginal rate of substitution between each pair of inputs with the input price ratio. The requirement for the fulfilment of allocative efficiency is for the marginal physical product (MPP) of all productive resources to be known (Ellis, 1988).

Allocative efficiency was estimated to achieve the second objective of this study. In this study, Cobb-Douglas stochastic frontier cost function was assumed to be appropriate model for the analysis of the analysis of the allocative efficiency of the maize farmers. This study assumes that maize production is dependent on human labour, fertilizers applied, amount of seed planted and size of land allocated. Therefore, allocative efficiency is estimated following physical production relationships derived from the Cobb – Douglas production function of Equation (1). Thus, the specific model estimated was given by

$$(4).\ Y = AX_1^{\alpha_i}\, v\, X_2^{\alpha_2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots X_n^{\alpha_n}$$

Where:-

Y = Amount of maize produced per farm household (kg)
x_1 = Land allocated to maize production (ha) by a given household
x_2= Amount of seed planted (kg) by a given household
x_3= Amount of labour used (MD) by a given household
x_4 = value of fertilizers (DAP and Urea) applied in maize by a household
A = Constant
V = Random error term
From (4) the linear production function can be re-written as:

$$(5).\ \mathrm{LnY} = \mathrm{LnA} + \sum_{i=1}^{4} + \beta\, i + \mathrm{LnXi}$$

Where A, α and βi are parameters to be estimated. According to Chukwuji (2006), allocative efficiency analysis is done by estimating a Cobb-Douglas function using OLS. It is followed by computing the value of marginal product (VMP_i) for each factor of production, which then is compared with the marginal input cost (MIC_i). Results from (5) give the beta estimates (β_i) and using the estimated coefficient, the marginal product of the i^{th} factor X was calculated as

$$(6).\ \mathrm{MPi} = \frac{\partial y}{\partial xi} = \beta \frac{y}{xi}$$

$$(7).\ \mathrm{AP} = \frac{y}{xi}$$

Where:-

Y is the geometrical mean of maize output;
X_i is the geometrical mean of input i and
β i is the OLS estimated coefficient of input i.
The value of marginal product of input i (VMPi) can be obtained by multiplying marginal physical product (MPi) by the price of output (Py). Thus,

$$(8).\ VMPi = MP\, i \ {*}P\, y$$

Finally, the allocative efficiency could be calculated as;

$$(9).\ (A.E) = \frac{\mathrm{VMPi}}{\mathrm{Pi}}$$

Where Pi = Marginal cost of the i^{th} input.

Allocative efficiency was determined by comparing the value of marginal product of input i (VMP i) with the marginal factor cost (MFCi). Since farmers are price takers in the input market, the marginal cost of input i approximates the price of the factor i, P xi (Grazhdaninova and Lerman, 2004). Hence, if VMPi > Pxi, the input is underused and farm profit can be raised by increasing the use of this input. Conversely, if VMPi < Pxi, the input is overused and to raise farm profits its use should be reduced. The point of allocative efficiency (maximum profit) is reached when VMPi = Pxi (Chavas et al., 2005).

The estimation process is based on the allocative efficiency rule which states that the slope of the production function (MPP) should equal the inverse ratio of input price to output price at the point of profit maximization (Ellis, 1988).

ESTIMATION OF FACTORS AFFECTING TECHNICAL EFFICIENCY

The other Objective of the study attained by determining factors that affect the level of technical inefficiency by establishing the relationship between farm/farmer characteristics and the computed technical efficiency indices. It will be done in one step maximum likelihood estimation approach with a stochastic frontier production function. In which the inefficiency effects will be expressed as an explicit function of a vector of socio-economic variables. In the first stage, the inefficiencies are assumed to be independently and identically distributed in order to estimate their values. However, in the second stage, the estimated inefficiencies are assumed to be a function of a number of firm specific factors, and hence are not identically distributed unless all the coefficients of the factors are simultaneously equal to zero (Coelli, Rao and Battese, 1998).

FRONTIER software employed for this study uses the ideas of Kumbhakar et al., 1991 and Reifschneider and Stevenson (1991) and estimates all of the parameters in one step to overcome this inconsistency. The inefficiency effects are defined as a function of the firm specific factors (as in the two-stage approach) but they are then incorporated directly into the MLE. This is something that should be taken into consideration when programming in some of the general statistical packages (Sean Pascoe et al., 2002).

Thus, the inefficiency model U_i was defined as:

$$(6).\ U_i = \delta + \delta 1Z_1 + \delta 1Z_2 + \delta 1Z_3 + \delta 1Z_4 + \delta 1Z_5 + \delta 1Z_6 + \delta 1Z_7 + \delta 1Z_8 + \delta 1Z_9 + \delta 1Z_{10} + \delta 1Z_{11} + \delta 1Z_{12} + \delta 1Z_{13} + \delta 1Z_{14}$$

Where: Z is a vector of explanatory variables that include:

Z_1 = Maize seed used; A dummy variable having the value of 1 if the farmer not seed recycled maize seed and 0 otherwise.

Z_2= Gender of house hold head; dummy variable having a value of 1 for female and 0 otherwise

Z_3= Age of household head (in years).

Z_4= Level of education of farmer (years spend in school).

Z_5= Farming experience; years of active farming.

Z_6=Variety of maize planted; A dummy variable having the value of 1 if the farmer has used improved maize seed (purchased hybrid) and 0 otherwise.

Z_7= Medium Soil fertility; A dummy variable having the value of 1 if the farm fertility is poor and 0 otherwise.

Z_8=Good Soil fertility; A dummy variable having the value of 1 if the farm fertility is good and 0 otherwise.

Z_9 = access to off-farm income; A dummy variable having the value of 1 if the household head had access of off-farm income and 0 otherwise.

Z_{10}= Credit received; A dummy variable having the value of 1 if the farmer has access to credit and 0 otherwise.

Z_{11}= Extension visits; A dummy variable having the value of 1 if the farmer had extension visit and 0 otherwise.

Z_{12}= Proximity to market; the distance of plot from the nearest market in kilo meter (km).

Z_{13}=Membership in local organization; A dummy variable having the value of 1 if the household head is the member of local organization and 0 otherwise.

Z_{14} = Family size; total number of household members.

δ i = is a (Mx1) vector of unknown parameter to be estimated.

RESULT AND DISCUSSIONS

Cobb-Douglas Production Function Model Results

The study uses the Cobb-Douglas production function in order to determine the technical efficiency of maize production by small-scale farmers in Arsi Negele Woreda of West Arsi zone that relates production to those variables for better understanding of the functional relationships.

The stochastic production frontier estimations were done using maximum likelihood methods using the statistical software FRONTIER Version 4.1. The dependent variable of the estimated model was maize output in the main cropping season of 2016/17 and the independent variables include; land area cover under maize production in hectare, amount of seeds planted in kilograms, labour used for maize production in man days and amount of fertilizer used in kilograms.

The results indicated that out of 4 variables/inputs used in the Cobb-Douglas, three of variables were found significant and only 1 of the variable was not significant. This implies that there is an input to output relationship. The preceding Paragraphs below presented the OLS Cobb-Douglas model results.

Table 1. OLS Estimates of Maize Production using Cobb-Douglas production Function.

Variables	Parameters	coefficient	Standard error	t-ratio
Constant	β_0	4.696766	0.86034274	5.4591802***
Ln (land)	β_1	0.40468495	0.16823458	2.4054802***
Ln (seed)	β_2	0.35026737	0.16608288	2.1089914**
Ln (Labour)	β_3	0.27669427	0.11216424	2.4668671***
Ln (fertilizer)	β_4	0.00061134	0.08610433	0.007099

*, **, *** Significant at 10%, 5% and 1% respectively.

The estimated OlS results obtained from the study revealed that except fertilizer all of the coefficients of factors of production involved in maize production of Arsi Negele woreda maize farmers were statistically significant at 1 and 5% level of significance.

Table 2. Maximum likelihood Estimates for Parameters of Stochastic Frontier Production Function and Inefficiency Model for Maize Farmers of Arsi Negele Woreda.

Variables	Parameters	Coefficients	Standard - error	t-ratio
General model				
Constant	β_0	6.12753	0.90170853	6.7954664***
Ln (land)	β_1	0.47036065	0.15826012	2.9720731***
Ln (seed)	β_2	0.39906517	0.14947669	2.6697485***
Ln (Labour)	β_3	0.24388172	0.11912205	2.0473264**
Ln (fertilizer)	β_4	-0.33365419	0.10483207	-3.182749***
Inefficiency model				
Seed not recycled	δ_1	-0.36170905	0.34976414	-1.0341513
Sex	δ_2	-0.058715336	0.36897052	-0.15913286
Age	δ_3	-0.001244687	0.010733726	-0.11596033
Education	δ_4	0.046925393	0.046616187	1.006633
Maize Farming experience	δ_5	-0.041358367	0.01809079	-2.2861559**
Improved Seed used	δ_6	0.18537848	0.30516152	0.60747661
Medium soil	δ_7	0.013202027	0.39223172	0.033658743
Fertile soil	δ_8	0.27524065	0.44329783	0.6208933
Off-farm income	δ_9	-0.27998086	0.24514396	-1.1421079
Access of Credit	δ_{10}	1.0398431	0.4935447	2.1068873**
Extension contact	δ_{11}	0.00061933	0.007097953	0.087254687
Proximity to market	δ_{12}	0.028511016	0.045985745	0.61999683
Cooperative membership	δ_{13}	0.28024142	0.20797238	1.3474934
Family size	δ_{14}	-0.010024106	0.032416499	-0.30922852
Variance Parameters				
sigma-squared	δ^2	0.21797453	0.0407636	5.3472837***
gamma	γ	0.50950826	0.12198271	4.1768891***

log likelihood function		-39.937749		
LR test		23.063917		

***, **, *** Significant at 10%, 5% and 1% respectively.**

From the Cobb-Douglas stochastic frontier production function output presented in the above Table 2, the estimate of the variance ratio (γ) is highly significant at 1% significance level. The value is 0.5095. This implies that about 50.95% of the variation in maize output is attributable to technical efficiency differences among production units. The value of γ suggests that there is a difference in technical efficiency among the production units considered in this study.

By implication about 40.95 % of the variation in output among producers is due to random factors such as unfavorable weather, effect of pest and diseases, errors in data collection and aggregation and the like. The γ parameter is very important because it shows the relative magnitude of the inefficiency variance associated with the frontier model which assumes that there is no room for inefficiency in the model. The sigma squared (δ^2) on the other hand is 0.2179 and it is highly statistically significant l% level. Since the figure statistically different from zero, it indicates a good fit and correctness of the distributional form assumed for the composite error term.

RETURN TO SCALE

Return to scale was calculated by adding up the coefficient for elasticity of each variable, the sum of b`s is used as an indicator of return to scale. For constant return to scale, the sum of the technical coefficients β must be equal to one (1), for increasing return to scale, they must also be greater than one, and for decreasing return to scale they must be less than one (1). The results as shown in Table 2, the sum of b`s is less than one (1), simply indicating that a decreasing return to scale. Thus the production of maize in the study area is not profitable.

However, among the input variables of each individual coefficient, the elasticity for the land (0.47) was highest. This means that, maize land was the most essential input in maize production. The second most important elasticity was 0.40 for amount of seed used in maize production. While the fertilizer amount used had a negative relation with respect to a given out put in the study area.

Estimation of Technical Efficiency

The technical efficiency level of each production unit covered by the study has been computed a. The result indicates a difference in efficiency levels among production units. The table 3 below shows the distribution efficiency estimates of Maize producers in the study area using Jondrow et al., (1982) conditional expectation predictor.

Table3. Frequency distribution of Technical Efficiency estimates

Category of Technical Efficiency (%)	No. in Sample	Relative efficiency	Percentage
20 - 29	1		1.02
30 - 39	1		1.02
40 – 49	4		4.08
50 – 59	4		4.08
60 – 69	9		9.18
70 – 79	18		18.37
80 – 89	33		33.67
90 - 100	28		28.57
Total	98		100.00
mean		79.68	
min		22	
max		96	

Source: own survey data, 2017.

Technical efficiency was obtained using the estimated parameters from the log linear Cobb Douglas stochastic production frontier. The study showed that technical efficiency ranges between 22% - 96%. The lowest level of efficiency is 22 % which is far below the efficient frontier by 96%. Hence, such lowest production units, the lowest level, are technically inefficient. The highest level of efficiency is 98% which is only 2 % away from the frontier. Such production units can be classified as being technically efficient since in reality production units hardly operate at 100% level of efficiency. The mean technical efficiency of the pooled sample is 79.68%.

The 79.68% mean technical efficiency implies that on the average 20.62% more output would have been produced with the same level of inputs if producers were to produce on the most efficient frontier following best practices. A greater proportion of the production units (33.67%) are concentrated in the efficiency class of 80 – 89 %. The next highest concentration of producers in the efficiency class 90 – 100 % which contains 28.57 % of the pooled sampled households and the least concentration of producers in the efficiency class of 20 – 29% which contains 1.02% pooled sampled maize producers of the study area.

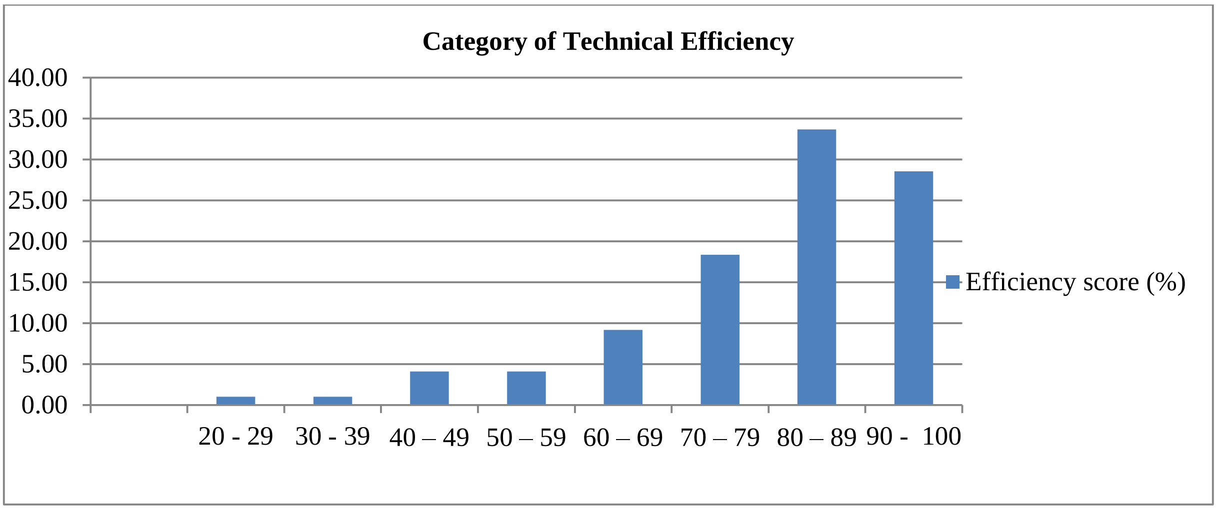

Figure1. The graphical representation of the distribution of efficiency indices among Maize farmers.

Allocative Efficiency Estimates

The predicted allocative analysis of smallholder maize farmers of Arsi Negele woreda presented hereafter accordingly.

Table 4. Mean values

Variable	Unit	Mean values
Output	Kg	1102.55
Land	Ha	0.49
Fertilizer	Kg	12.55
Seed	Kg	84.87
Labour	MD	39.43

Source: own survey data, 2017.

The OLS results presented in the above table was used alongside with the mean values of the variables included in the model to estimate the allocative efficiencies.

Table 5. Allocative efficiency of sample farmers

Variable	β_i	Geometric mean	APP	MPP	Output unit prices (P_Y)	MVP_i	UFC (P_i)	Allocative efficiency scores (Z)
land (ha)	0.404	0.44	2230.13	900.97	9.50	8559.25	8000.00	1.07
seed (Kg)	0.350	11.36	87.85	30.75	9.50	292.09	44.80	6.52
fertilizer (Kg)	0.001	69.09	12.99	0.01	9.50	0.07	24.50	0.00
Labour (MD)	0.277	37.59	27.96325	7.75	9.50	73.59	54.00	1.36

Source: own survey data, 2017.

Where:- MPP= APP*input elasticity **(β_i)**

(MPP and APP = Marginal and Average Physical Product)

MVP=MPP*output price (Py) (MVP = Marginal Value Product),

Alloctive Efficiency (A.E) = MVP/Pi

If A.E = 1 then the input is optimally/efficiently used and if A.E < or > 1 then input is Inefficiently used.

From the above table 5, it was seen that none of the marginal value of products of inputs are equal to one. This inequality indicates that the farmers in the study area have failed to show their efficiency in using the resources. Hence, more profit can be attained by increasing investment in those inputs (Duloy, 1959). In the case of fertilizer, the ratio is positive but less than one, implies that too much use of this resource have gone beyond the economic optima. Hence, fertilizer is over utilized in the production process. This implies an inefficient utilization of the factors of production. Labour is paid less than their MVP in the production process. This is because the allocative efficiency ratio for this factor is less than unity.

CONCLUSIONS AND RECOMMENDATIONS

In general the study concludes that farmers are technically and allocativelly inefficient since they are under and over-utilizing resources at farm level and that farmers` technical and allocative efficiency can be determined through the influence of certain socio-economic factors. Given the empirical findings, the proposed recommendations are depicted below.

Result of the frontier production function indicates that all conventional input variables were found to be requisite in the production of maize crop production that an increase in one of inputs will enhance production keeping everything constant. Generally, all significant input variables were found to affect output positively, as expected. However, the fertilizer used had an inverse relation with respect to the given level of output. Hence, the use of fertilizer amount should be minimized accordingly.

In case of land, labour and seed the ratio of MVP and UFC were greater than one and positive. It reveals that the maize farmers did not avail themselves of the opportunity of using the optimal amounts of those inputs. So, there are ample opportunities for farmers of the study area to increase the output per hectare by rational and increased use of these inputs.

An important conclusion stemming from this study is that, there exists a considerable room to reduce the level of technical inefficiency of maize crop production in the study area. To increase the growers' efficiency, the study recommends government and concerned departments to design capacity building programme for agricultural development project by training and giving them skills on how to allocate resources efficiently, farmers also need to have access to enough arable land. Since land was the first important input in the study area, which has a positive relationship and having a major stake in boosting maize yield among the inputs used in maize production.

More effort should be intensified on the part of extension agent in educating the farmers so as to boost their efficiencies in maize production. These extension gents should have to get on job trainings based on the gap analysis made to build their capacity. They are being used to inform the farmers in the rural areas about the improvement of farm practices and that enables to supply new technological findings for the maize farmers. Hence, there should have strong participatory planning, monitoring and evaluation of development activities being implemented in the study area.

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