Resource use efficiency of smallholder crop production in the central highlands of Ethiopia

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Abstract

Resource use efficiency in agricultural production has been a major concern in Ethiopia. In this article data from 700 households in the central highland districts were used to assess farm-level resource use efficiency and to determine factors that influence inefficiencies in the production of *teff* (*Eragrostis tef*), wheat and chickpea, the major important crops in the country. The study established that smallholder farmers are resource use inefficient. Moreover, a two-limit Tobit regression model results reveal that inefficiency in resource use is positively and significantly affected by family size, farming experience and membership to associations. It is also found that those households whose decision makers have roles in their community activities show improved resource use efficiency. Moreover, the findings show that eliminating resource use inefficiency could contribute about 31.28% of the minimum annual income required for the sustenance of an average farm household. The study established that resource use efficiency and productivity gains are likely to be significantly improved through expansion of nonfarm sectors, reform of farmer related associations and integrating community leadership in various community activities and programs. Moreover, market infrastructure development would likely increase efficiency and agricultural productivity.

JEL classification: C21, C61, Q12

Keywords: DEA; Tobit; Resource use efficiency; Smallholder production; Crops; productivity; Ethiopia

1. Introduction

Agriculture is the basis of Ethiopian economy which accounts for almost half of the country's GDP, 60% of its exports and 80% of total employment (CIA, 2007). This makes the sector to play a critical role in the country's important macroeconomic performance such as

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economic growth, employment, universal food security and per capita income. However, Ethiopian agriculture remains largely dominated by subsistence and smallholder-oriented system (Bishaw, 2009). Moreover, Ethiopian highland agriculture is characterized by high dependency on rainfall, traditional technology, high population pressure, and severe land degradation combined by the low level of productivity (Medhin and Köhlin, 2008).

The issue of increasing agricultural productivity has become the main concern to governments following considerable increase in food price over the last two years that follows decades of low food price (Conradie et al., 2009). Despite of Ethiopian government's policy to expand crop production for exports, domestic consumption and universal food security (MoFED, 2006), the productivity of *teff* is the lowest among cereal crops (Haile et al., 2004). In addition, despite its huge potential in wheat production, the country remains the net importer of the commodity (Rashid, 2010). Moreover, the competitiveness of smallholder chickpea producers in Ethiopia is restricted by low productivity and poor quality of traditional varieties (Shiferaw and Teklewold, 2007). In addition, in Ethiopia, the adoption of modern and intensive agricultural practices such as the use of chemical fertilizer and improved seeds is quite low. Moreover, inappropriate land use planning combined with overgrazing and population pressure has led Ethiopia to experience one of the highest rates of soil nutrient depletion in sub-Saharan Africa (Chanyalew et al., 2010).

Agricultural productivity depends on how factors are efficiently used in the production process. Therefore, intensification of agricultural land and expansion of technology use must be accompanied by resource use efficiency that enhances productivity of factors. Improvements in resource use efficiency hence increase in productivity will reduce encroachment of population to marginal agricultural lands. In turn, this will protect the resource base of the poor against degradation. More importantly, efficient resource use is the basis for achieving universal food security and poverty reduction strategies particularly in the rural areas. It is also crucial for policy makers to have adequate and evidence based policy options to increase efficiency and productivity to improve the livelihoods of the poor. However, most of the previous empirical efficiency studies in Ethiopia (see Khairo and Battese (2005) and Gebreegziabher et al. (2005)) have been dominated by the use of simple efficiency measures to provide required information on resource use efficiency in agriculture. The studies focus on a particular agro-ecology, or concentrated on technical efficiency otherwise they analyzed specific crop production efficiency. Such approaches may give inconsistent results and conclusions that may mislead.

This study estimates technical, allocative, and economic efficiencies of smallholder major crop producers in the central highland districts. The study covers a relatively larger population and considers important major crops to increase farm household income and achieve nutritional and food security. In addition, the study focuses on the areas where high population pressure and land degradation threatens sustainable agricultural production and food security. Moreover, the sample districts are some of the areas where cereal crops and legumes are largely produced whereby resource use efficiency and productivity improvement can have a substantial impact on the livelihoods of many farm households.

The paper is organized as follows. In the next section we discuss the empirical modeling strategies of the paper including data envelopment analysis (DEA) technique and two-limit Tobit model. In section 3 we describe the study areas and the data used by the study. Results of efficiency scores and identifying sources of resource use inefficiency are presented in section 4. In the last section we present our conclusions and key policy implications.

2. Modeling strategy

2.1 Data Envelopment Analysis (DEA)

Based on Farrell's (1957) influential work, Charnes et al. (1978) were the first to introduce DEA approach to estimate efficiency. Since its introduction, the approach has served as the corner stone for all subsequent developments in the nonparametric approach to the measurement of technical efficiency (Hadi-Vencheh and Matin, 2011). As pointed out by several authors (see Ray, 2004; Coelli et al., 2005; Headey et al., 2010 for details), DEA strategy has several advantages. It is a nonparametric technique that does not require a prior specific functional form for the production frontier. In addition, multiple outputs and multiple inputs without necessarily being aggregated can be handled in DEA technique. Furthermore, it is possible to identify the best practice for every decision-making unit under consideration and estimate the output or cost gap of inefficient firms to be fully efficient. Regarding its potential weaknesses, however, apart from its sensitivity to extreme observations, a hypothesis testing at the first stage of DEA is not possible. Moreover, the technique attributes all deviations from the frontier (best practice) to resource use inefficiency. However, this study adopts the two-stage DEA method to estimate efficiency of multiple inputs and outputs production process.

Supposing a group of n homogenous Decision-Making Units (DMUs), in order to produce r number of outputs ($r=1,2,3,\ldots k$) s number of inputs are utilized ($s=1,2,3,\ldots m,$) by each DMU i ($i=1,2,3,\ldots n$). In order to maximize the level of weighted outputs subject to weighted inputs the following linearly expressed equation developed by Charnes, Cooper and Rhodes (CCR) approach (Charnes et al., 1978) is estimated:

$$\text{Max}_{\mu\nu}: \quad \theta = \mu_1 Y_{1i} + \mu_2 Y_{2i} + \ldots + \mu_r Y_{ri} \tag{1}$$

Subject to:

$$\nu_1 X_{1i} + \nu_2 X_{2i} + \ldots + \nu_s X_{si} = 1 \tag{2}$$

$$\mu_1 Y_{1j} + \mu_2 Y_{2j} + \ldots + \mu_r Y_{rj} \le \nu_1 X_{1j} + \nu_2 X_{2j} + \ldots + \nu_s X_{sj} \tag{3}$$

$\forall_i \ \ \mu_i, \nu_i \ge 0,$ and (i and $j = 1, 2, 3, \ldots, k$)

where θ is the technical efficiency and i represents i^{th} DMU. While Y_{ri} is the amount of output r produced by i^{th} DMU, X_{si} represents the amount of input s used by DMU i. In the expression μ_r is weight given to output r, and ν_s is weight given to input s.

However, in the maximization process, DMUs always face financial limitations or imperfect competitive markets where increased amounts of inputs do not proportionally increase the amount of outputs obtained (Coelli et al., 2005). In order to account for these effects the DEA model for variable returns to scale (VRS) was developed by Banker, Charnes and Cooper (BCC) (Banker et al., 1984).

Mathematically, the DEA method under VRS assumption for each DMU can be expressed as:

$$\begin{aligned}&\text{Maxi}_{\phi\lambda}\phi\\&\text{Subject to:}\\&x_i - X\lambda \geq 0\\&-\phi y_i + Y\lambda \geq 0\\&N1'\lambda = 1\\&\lambda \geq 0\end{aligned} \tag{4}$$

In the restriction $N1'\lambda=1$, $N1'$ is convexity constraint which is an $N\times1$ vector of ones and λ is an $N\times1$ vector of weights (constants) which defines the linear combination of the peers of the i^{th} DMU. $1/\phi$ defines a technical efficiency score which varies between zero and one. If $\phi=1$ then the DMU is on the frontier and is technically efficient and if $\phi< 1$ the DMU lies below the frontier and is technically inefficient.

Similarly, to estimate economic efficiency scores (EE), a cost minimizing DEA is specified as:

$$\begin{aligned}&\text{Min}_{\lambda,X_i^*} W_i' X_i^*\\&\text{Subject to:}\\&-y_i + Y\lambda \geq 0\\&X_i^* - X\lambda \geq 0\\&N1'\lambda = 1\\&\lambda \geq 0\end{aligned} \tag{5}$$

where, W_i' is a transpose vector of input prices for the i^{th} DMU and X_i^* is the cost-minimizing vector of input quantities for the i^{th} farm given the input prices W_i and total output level y_i. Economic efficiency is the ratio of potential minimum cost of production ($W_i'X_i^*$) to the actual cost of production ($W_i'X_i$) as:

$$EE= W_i'X_i^*/ W_i'X_i \tag{6}$$

Allocative efficiency can be estimated as the ratio of economic to technical efficiency as $AE=EE/TE$. In this study, for the DEA technique, the output variables are outputs of chickpea, *teff* and wheat (kilogram). The input data consist of total area of land ploughed (hectare), total labor used (man/days), total amount of fertilizers used (kilogram), amount of field chemicals applied (liter) and the amount of seed used for each crop (kilogram). The costs associated with each input are also included in the DEA to estimate economic efficiency. Efficiency scores are estimated using the computer program, DEAP Version 2.1 described in Coelli (1996).

2.2 The Two-limit Tobit Model

Smallholder farmers are assumed to operate under the same policy and institutional environments and face exogenous variables denoted as Z_i. In addition, it is also assumed that these conditions determine farmers' decision to choose set of input vector *x* and produce output vector *y*. Accordingly, in the production process a given farmer is considered to be relatively full efficient if it operates along the boundary of the frontier (Y^*) which also defines the level of technology in the system. The boundary of the frontier represents a locus of output points constructed by best practice farms. In this case the output of efficient firms (Y_i) to the potential output along the frontier is equal ($Y^*=Y_i$). Relative efficiency measures, computed as the ratio of actual (realized) to the potential (frontier) output level(Y^*/Y_i), of these farms will be unity($Y^*/Y_i=1$). On the other hand, firms which are relatively inefficient compared to the best practice (frontier) operate at points in the interior of frontier and score less than unity ($Y^*/Y_i<1$). Furthermore, the efficiency scores of the most inefficient farms in the system are found closer to zero ($Y^*/Y_i>0$). Therefore, while the scores are bounded between zero and unity with the upper limit set at one, the distribution is censored at both tails ($0 < Y^*/Y_i \leq 1$).

Thus, following Coelli et al. (2002) and Bravo-Ureta et al. (2007), the study adopts the two-limit Tobit model. The model is estimated as follows (Amemiya, 1985):

$$U_i^* = \beta_0 + \sum_{j=1}^{k} \beta_j Z_{ij} + \mu_i,$$

$$U_i = \begin{cases} 1, & if \quad U_i^* \geq 1 \\ U^*, & if \quad 0 < U_i^* < 1 \\ 0, & if \quad U_i^* \leq 0 \end{cases} \qquad (7)$$

where: i refers to the i^{th} DMU, U_i is inefficiency scores of the i^{th} DMU. U_i^* is the latent inefficiency, β_j are parameters to be estimated and μ_i is an error term that is independently and normally distributed with mean zero and common variance of δ^2 ($\mu_i \sim NI(0, \delta^2)$). Z_{ij} are host of socio economic, institutional and demographic variables.

3. Methodology

3.1 Description of the Study areas

The study is conducted in three districts, namely Minjar-Shenkora, Gimbichu and Lume-Ejere which are found in the central highlands of Ethiopia. They have a total population of 345,177 persons. The combined total area is about 379,754.25 hectares, of which 138,459.82 hectares (36.46%) is arable land. The districts are characterized by moderate to sub-humid temperature with mean of 17ºC, 23ºC and 25ºC for Gimbichu, Lume-Ejere and Minjar-Shenkora districts, respectively. The districts have altitudes of 900-2700, 1604-2364, and 1040-2380 meters above sea level for Gimbichu, Lume-Ejere, and Minjar-Shenkora, respectively. They also get annual rainfalls of ranging 800mm-1000mm, 800mm-1000mm and 500mm-1200mm for Minjar-Shenkora, Gimbichu and Lume-Ejere districts, respectively.

The study areas represent some of the major cereals and legumes growing areas in the country. The agricultural production system is mixed crop-livestock agricultural system whereby a smallholder farmer practices crops and livestock production under the same management. *Teff*, chickpea and wheat are important and major crops in terms of quantity and area grown in the study areas.

3.2 Data source

The data used for this study originates from a baseline survey conducted by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and Ethiopian Institute of Agricultural Research (EIAR) in 2008. A Multi-stage sampling procedure was used to select districts, *kebeles*[2] and farm households. In the first stage, three districts namely Minjar-Shenkora, Gimbichu and Lume-Ejere were purposively selected from the major legume producing areas based on the intensity of chickpea production, agro-ecology and accessibility. Then, eight *kebeles* from each of Gimbichu and Lume-Ejere districts and ten *kebeles* from Minjar-Shenkora district were randomly selected. Finally, 700 farm households were randomly selected from the districts for the study.

4. Empirical results

4.1 Efficiency scores

The descriptive statistics of variables used for estimation of efficiency scores using DEA are presented in Table 1. The results for output variables show that an average household produces 1,347.90 kg of chickpea, 1,170.80 kg of *teff* and 1,296.00 kg of wheat. In the production process, on average, 245.82 kg of DAP and 144.78 kg of urea are used while the mean cost of these inputs are estimated to be ETB 926.00 and 500.90 for DAP and urea fertilizers, respectively. The mean size of land used for the three crops production is 1.96 hectare and its average cost is computed as ETB 5,086.21. In addition, about 0.62 liters of field chemical

[2] *It is usually named as peasant association and is the lowest administrative unit in the country.*

is used during production of the three major crops and its average cost is ETB 48.87. Moreover, the mean quantities of seed used are 97.37 kg, 81.89 kg and 84.71 kg for production of chickpea, *teff* and wheat, respectively. The associated average costs of chickpea, *teff* and wheat seeds are ETB 438.95, 174.84 and 351.55, respectively. Furthermore, the mean level of labor (both family and hired) use for production of the three crops in man/days is about 871.21 and its average cost is estimated to be ETB 17,424.12.

Table 1: Descriptive Statistics of variables used for DEA (N=700)

DEA Variable	Description of Variables	Unit of Measurement	Mean[a]
	Output Variables		
Y_1	Output of Chickpea	kilogram	1,347.89 (1689.13)
Y_2	Output of *Teff*	kilogram	1,170.84 (1331.71)
Y_3	Output of Wheat	kilogram	1,296.05 (1906.40)
	Input variables		
X_1	Plot Size	Hectare	1.96 (1.31)
X_2	Labor (Family and Hired)	Man/days	871.21 (535.60)
X_3	Quantity of Field chemical	Liter	0.61 (1.24)
X_4	Quantity of Chickpea seed	kilogram	97.37 (147.93)
X_5	Quantity of *Teff* seed	kilogram	81.89 (112.12)
X_6	Quantity of wheat seed	kilogram	84.71 (108.88)
X_7	Quantity of DAP fertilizer	kilogram	245.82 (211.26)
X_8	Quantity of urea fertilizer	kilogram	144.78 (146.56)
	Input Costs		
C_1	Cost of Land used	ETB	5,086.21 (3413.64)
C_2	Cost of Labor used	ETB	17,424.12 (10711.58)
C_3	Cost of field chemical applied	ETB	48.86 (99.72)
C_4	Cost of chickpea seed	ETB	438.95 (666.89)
C_5	Cost of *teff* seed	ETB	174.83 (239.38)
C_6	Cost of wheat seed	ETB	351.55 (451.84)
C_7	Total Cost of DAP fertilizer	ETB	926.03 (832.71)
C_8	Total Cost of urea fertilizer	ETB	500.84 (507.66)

[a] *Values in the parentheses are standard deviations.*

Source**:** Authors' calculation based on ICRISAT 2008 survey data, 2011

Table 2 presents aggregate efficiency distribution of farmers. It is shown that about 56.43 percent of farmers are technically efficient whereas 99 percent of farmers are both allocativelly and economically inefficient. The mean technical, allocative and economic efficiency scores are 0.79, 0.43 and 0.31, respectively. Using the results from one sample *t*-test, it is concluded that smallholder farmers are not technically, allocativelly and economically efficient. This shows that there is a significant margin of increase in output and reduction in cost of production. Furthermore, ANOVA and Kruskal Wallis tests show that there is significant variation in resource use efficiency across the three districts which call for further studies for district specific strategies to improve efficiency.

Table 2: Distribution of technical (TE), allocative (AE) and economic (EE) efficiency scores (N=700)

Efficiency Categories	TE		AE		EE	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
E≤0.1	0	0	2	0.28	5	0.71
0.1< E≤ 0.2	4	0.57	54	7.70	114	16.28
0.2< E ≤ 0.3	32	4.57	151	21.57	276	39.43
0.3< E ≤ 0.4	51	7.28	149	21.14	168	24.00
0.4< E ≤ 0.5	58	8.28	127	18.14	86	12.28
0.5< E ≤ 0.6	57	8.14	72	10.28	30	4.28
0.6< E ≤ 0.7	45	6.43	74	10.56	10	2.85
0.7< E ≤ 0.8	27	3.85	44	6.28	2	0.28
0.8< E ≤0.9	22	3.14	13	1.85	1	0.14
0.9< E≤1.0	404	57.70	14	2.00	8	1.14
Efficient Farmers	395	56.43	7	1	7	1
Inefficient Farmers	305	43.57	693	99	693	99
Mean Scores	0.79 (0.27)		0.43(0.19)		0.31(0.14)	
Minimum Scores	0.14		0.06		0.04	
Maximum Scores	1		1		1	

E stands for Efficiency, and figures in parentheses are standard deviations.

Source: Authors' calculation based on ICRISAT 2008 survey data, 2011

The mean score of technical efficiency implies that if resources were efficiently utilized, the average farmer could increase current output by 21% using existing resources and level of technology. This means that the average output of chickpea, *teff* and wheat could be increased by 21% from current level of output. The monetary value of the additional output (using real prices) due to improved technical efficiency is estimated to be ETB 4,342.77, equivalent to USD 368.66 per household per annum. The result for mean allocative efficiency score also suggests that smallholder farmers could reduce costs by 57% if producers used the right inputs and outputs mix relative to input costs and output prices.

The mean economic efficiency indicates that there is a significant level of cost inefficiency in the production process. That is an average producer could reduce current average cost of production by 69% to achieve the potential minimum cost level without reducing output levels. The result suggests that the current mean cost of production of the sample farmers (ETB

24,951.40) could be reduced by ETB 17,216.47, equivalent to USD 1461.50. This implies that reduction in cost of production through eliminating resource use inefficiency could add about 31.28% of the minimum annual income required for the sustenance of an average farm household (USD 4,672 per annum for a household with family size of 6.4 persons and 2$ per day per person). Moreover, reduction in cost of production and increase in gross margin of output will help farmers to participate in high value crop production.

The study is also found that about 37 percent of farmers operate under decreasing returns to scale, showing that farmers are using inputs above the recommended rate. Therefore, it is established that the use of inputs above the recommended level seems to be the predominant source of scale inefficiency.

4.2 Sources of resource use inefficiency

This section devotes to investigate why there is efficiency variation across farmers. To understand some of the causes of these variations, technical and economic inefficiency scores estimated using DEA were separately regressed on selected demographic, socio economic and institutional variables. The descriptive statistics of variables used in the analysis of resource use inefficiency is presented using Table 3.

Table 3: Descriptive statistics of variables for two-limit Tobit model (N=700)

Variables	Description		Mean	Std. D
	Continuous Variables			
age	Age of the household heads (year)		47.18	12.54
hheadeduc	Education level household heads (year)		1.74	2.69
familysize	Family size (number of persons)		6.40	2.29
plotdist	Average Plot distance from residence (Kilometer)		1.67	2.05
farmexpr	Experience of growing chickpea (year)		20.34	12.39
wlkdsmnm	Walking distance to the nearest main market (Kilometer)		9.94	9.83
contextag	Contacts with extension agents (days/year)		20.56	28.36
cultrany	Cultivated land Size (hectare)		2.08	1.43
	Dummy Variables	*Response*	*Freq.*	*Percent*
gender	Sex of the household head	Male (1)	650	92.85
		Female (0)	50	7.15
rolecommu	Role of the household head in the community	Yes (1)	180	25.70
		No (0)	520	74.30
membership	Membership of household in associations	Yes (1)	612	87.43
		No (0)	88	12.57
creditacc	Access to Credit at market interest rate	Yes (1)	465	66.43
		No (0)	235	33.57

Source: Authors' calculation based on ICRISAT 2008 survey data, 2011

Age of household heads is on average 47 years while the mean level of household heads' education is 1.74 years. The result shows that about 7.15% of households are female headed. While walking distance to the main market has a mean of 9.94 km, the average plot distance from residence has a mean value of 1.67 km. Family size has a mean of 6.4 persons per household. About 25.7% of household heads have a role in their respective community activities. On the other hand, 87.43% of farm households are members in farmers associations, clubs or cooperatives. In addition, results indicate that about 66.43% of farmers got access to credit at market interest rate. It is also shown that the total size of land allocated to the three crops in the long rainy season is on average 2.08 hectares. Moreover, the mean household head's chickpea growing experience is 20.34 years. In addition, the number of farmers' contacts with extension agents has a mean value of 20.56 days per year.

Tobit regression model results for sources of technical and economic inefficiencies are presented in Table 4. The results show that age of household head contributes significantly and negatively to technical inefficiency ($P < 0.05$). This implies that as age of the decision maker increases, technical inefficiency will decrease. This may be perhaps due to the fact that farmers learn from their experience about the allocation of inputs.

The variable family size contributes positively and significantly to resource use inefficiency ($P < 0.01$) suggesting that larger family size is likely to cause farm households to be resource use inefficient. The average family size in the study areas is larger than even the national average. A farm household with large family size needs more resource to satisfy its energy and food requirements. Therefore, to meet these needs resources will be exploited more extensively that leads to the expansion of marginal lands and environmental degradation hence decline in productivity. Inefficiency in resource use in the rural areas could be reduced through absorbing the excess labor force to nonfarm sectors without negatively affecting farm output and productivity (Lien et al., 2010). The finding is consistent with that of Binam et al. (2003) and Coelli et al. (2002) where larger families are found more inefficiency.

In addition, chickpea farming experience has a significant and positive effect on resource use inefficiency. This implies that, perhaps, farmers who are more experienced in chickpea farming are more conservative to adopt new technology rather they prefer to remain with traditional production system. Thus, their resource use efficiency and productivity are negatively affected. Moreover, this result also implies that farmers are less likely to be market oriented under current production system where productivity and efficiency are compromised.

Moreover, the effect of walking distance to the nearest main market on technical inefficiency was statistically significant and affects technical inefficiency positively ($P < 0.05$). This implies that farmers far from markets are more technically inefficient compared to their counterparts reside nearby markets. This might be due to the fact that as farmers locate far from market there is limited access to input and output markets and market information. Moreover, distance to market leads to higher transaction cost which reduces the benefits accrue to the farmer. More importantly, longer distance from market discourages farmers from participating in market oriented production. Thus, development of market and road infrastructure could reduce resource use inefficiency and increase productivity of farmers through facilitating market participation and integration.

Table 4: Results of two-limit Tobit model for sources of resource use inefficiency

Independent variables	Technical Inefficiency			Economic Inefficiency		
	β_i	Std. Err.	*t*-value	β_i	Std. Err.	*t*-value
Sex of the household head	0.1016	0.0886	1.15	-0.0063	0.0204	-0.31
Age of the household head	-0.0070***	0.0025	-2.72	-0.0002	0.0006	-0.26
Education level of the household head	-0.0041	0.0085	-0.49	-0.0014	0.0021	-0.69
Family size	0.035***	0.0103	3.36	0.0098***	0.0025	3.95
Plot distance from residence	-0.0011	0.0101	-0.10	-0.0038	0.0025	-1.52
Chickpea farming experience	0.0093***	0.0025	3.76	0.0012**	0.0006	2.05
Walking distance to the nearest main market	0.0042**	0.0021	1.97	0.0006	0.0005	1.19
Membership of household	-0.0398	0.0661	-0.60	0.0330**	0.0158	2.10
Role of household head in the community	0 .0564	0.0492	1.15	-0.0236*	0.0121	-1.95
Contacts with extension agents	-0.0009	0.0008	-1.14	-0.0002	0.0002	-1.22
Credit Access	0.129***	0.0465	2.79	-0.0085	0.0109	-0.78
Total land cultivated	0.049***	0.0165	2.97	-0.0037	0.0042	-0.88
Constant	-0.4010***	0.1529	-2.62	0.6132***	0.0353	17.39
Log Likelihood	-462.87	0.000		391.507	0.000	
Sample (N)	700			700		
LR Chi-square(χ^2)(12)	72.02***			41.44***		

***, ** and * denote significance at 1%, 5% and 10% level, respectively.

Source: Authors' calculation based on ICRISAT 2008 survey data, 2011

Membership of households in a farmers' association contributes positively and significantly to economic inefficiency ($P < 0.05$). This suggests that farmers who belong to associations are found to be economically inefficient. This situation can happen if membership in the associations and participations, if any, is nominal and decision making process do not take in to account the needs of the members. Particularly, if agricultural information and technology transfer through associations do not address the needs of the poor farmer and the marginal including women, their efficiency and productivity will not improve. Similar results were found by Binam et al. (2003) in a study of Coffee Farmers in Cote d'Ivoire but it is in contrary with the findings by Nyagaka et al. (2010) in a study of smallholder Irish Potato farmers in Kenya.

It is also found that households whose heads have a role in their community activities significantly improves their level of economic efficiency ($P<0.1$). This implies that when decision makers hold responsibility in their community activities they are at the forefront of changes. They are considered as role models for the rest of farmers or change agents and are more willing to adopt new ideas and innovations. This indicates that resource use efficiency seem to be improved through integrating community leadership in various community activities and programs.

Credit access contributes positively and significantly to technical inefficiency ($P < 0.01$). This implies that farmers with access to credit in the study areas are more technically inefficient than their counterparts who have no access. This might happen due to various possible reasons. First, if credit system is not responding to the needs of farmers in terms of amount, time and repayment procedure, the service might rather bring inefficiency than reducing it. Second, the level of loan diversion problem and inappropriate use of funds by farmers may also cause the service to be ineffective in reducing inefficiency. Third, absence of competitive credit systems can also tighten the alternatives regarding collateral requirements, time of repayment and interest rate determination and conditions regarding on failure to repay the loan. Similar results were also reported by Seyoum et al. (1998). However, a study by Nyagaka et al. (2010) concluded that access to credit increases resource use efficiency.

In addition, total area cultivated during long rainy season has a positive and significant effect on technical inefficiency ($P < 0.01$). The results imply that as farm size increases technical inefficiency will also significantly increase. Perhaps, timely and appropriate agricultural operation on larger land size with traditional technology may not be effective which leads to higher level of inefficiency. Moreover, larger plot size in the study areas implies larger fragmentation of plots which are widely scattered, making it difficult for farmers to work on all their fields at the same time. Larger plot size may also mean expansion of agricultural lands to marginal areas which makes efficient crop production difficult. As a result, efficiency and productivity can be negatively affected when plot size is large given the current level of technology.

5. Conclusions

The study established that there is a significant amount of resource use inefficiency in chickpea, *teff* and wheat production in the sample districts of central highlands. It is also found that producers could increase their output by 21% with current level of resources and could reduce cost of production by 69% to achieve the minimum cost level given current crop output. The study also reveals that this improvement in resource use efficiency could add about 31.28% of the minimum annual income required for the sustenance of an average farm household. In addition, most resource use inefficient farms are operating under decreasing returns to scale which implies that farmers use above the recommended level of inputs.

There should be policies and strategies toward expansion and promotion of nationwide nonfarm sectors which provide off farm employment and absorb the excess labor from the agricultural sector. This would reduce the pressure on agricultural land which in turn improves labor productivity in the agricultural sector. Moreover, reduction of population pressure on the rural farm will also help to reduce encroachment of agricultural practice to the marginal areas.

Development of market, road infrastructure, and decision making process of farmers' institutions could reduce resource use inefficiency and increase productivity. These also reduce transaction cost and improve productivity hence encourage farmers to participate in high value and market oriented production activities.

Moreover, supporting and facilitating of community based organizations with agricultural production orientation and enhance their ability to participate in community activities would likely improve farmers' efficiency and productivity.

Furthermore, access to credit should be combined with continued availability of complementary agricultural support services, including extension and training. This facilitates transfer and adoption of technologies by farmers that leads to improvement in resource use efficiency and productivity. However, there is a need for further investigation of why farmers use more resources than recommended level.

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