Acta Sci. Pol., Administratio Locorum 20(3) 2021, 189–201.
https://czasopisma.uwm.edu.pl/index.php/aspal plISSN 1644-0749 eISSN 2450-0771 DOI: 10.31648/aspal.6248

ORIGINAL PAPER
Received: 31.12.2020 Accepted: 07.07.2021

PRODUCTION EFFICIENCY OF SESAME PRODUCER FARM HOUSEHOLDS: THE CASE OF BENCH MAJI ZONE, SOUTHWEST ETHIOPIA

Kusse Haile Gemeyida[1]✉, Engida Gebre Yesho[2]✉, Agegnehu Workye Belayneh[3]✉

[1] ORCID: 0000-0002-4726-3567
[2] ORCID: 0000-0002-6015-252X
[3] ORCID: 0000-0003-0303-7223
[1, 2, 3] Mizan-Tepi University
P.O Box: 260, Mizan Aman, **Ethiopia**

ABSTRACT

Motives: Agricultural sector in Ethiopia is characterized by its poor performance, despite the livelihoods of the large population of the country depends on agriculture. Sesame is an important cash crop and plays vital role in the livelihood of many people in Ethiopia. However a number of challenges hindered the development of sesame sector along with the productivity.
Aim: This study attempted to analyze production efficiency of sesame producers in Bench Maji Zone of Southwest Ethiopia. The study used both primary and secondary data sources. Purposive sampling techniques were employed to draw 270 sesame producer farm households. Descriptive statistics and econometric models were used to analyze the data.
Results: The estimated stochastic production frontier model indicated that input variables such as inorganic fertilizer, sesame seed, oxen power, labor and chemicals found to be important factors in increasing the level of sesame output in the study area. The result further revealed significant differences in production efficiency among sesame growing farmers in the study area. Applying the Cobb-Douglas functional form the average, technical, allocative and economic efficiencies found are 50.72%, 86.83% and 44.2% for sesame producers, respectively. Also among fourteen variables used in the analysis of determinants, experience in sesame farming, education level, farm income, total cultivated land, social responsibility, frequency of extension contact, participation in off/non-farm activities, credit, proximity to market and soil fertility were found to be significant sources of technical, allocative and economic inefficiencies of sesame producer farmers. Strengthening education, extension service, credit access at affordable interest rate and accessibility of transport services and motivating farm household to participate different training as well as their experience sharing with other sesame producing farmers improve productivity of sesame production. Therefore, those important socioeconomic and institutional factors which are mentioned above must take into account to improve the productivity of sesame in the study area.

Keywords: Cobb-Douglas Function, Dual cost, Efficiency, Stochastic Frontier, Sesame.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

INTRODUCTION

Ethiopia's oilseed sector, which is rapidly growing to meet both local and foreign demand, plays a vitally important economic role in generating foreign exchange earnings and income for the country. A variety of oilseeds are grown in Ethiopia, of which sesame is by far the most important both in terms of volume, value and export earnings [NABC, 2015]. Sesame is one of the oldest oilseeds known to human being with a wide production dimension extending from the tropics to temperate zones. Globally, the top largest producers of sesame are Myanmar, India, China, Sudan, Uganda and Ethiopia [Girmay, 2018]. Evidence also indicated that Ethiopia ranked third in Africa in terms of sesame production [Wijnands et al., 2009, Hagose, 2017]. In terms of export potential, Ethiopia is the third world exporter of sesame seeds after India and Sudan [Alemu & Meijerink, 2010, Temesgen et al., 2017]. Sesame is the second major export cash crop in Ethiopia, next to coffee [Abebe, 2016].

In Ethiopia, sesame mainly grows in Tigray, Amhara and Oromia regions of Ethiopia. Southern Nations, Nationalities and Peoples Region is also becoming an area of sesame production and attraction for investors because it produces sesame that meets international standards. According to [CSA, 2017] reports on area and production of sesame by small farmers and medium/large commercial farms, the total production of sesame by both small farmers and commercial farms was 2,678,665.46 quintals from 337,926.82 hectares of land with productivity of 7.93 quintals per hectare. Bench Maji Zone is one of the potential areas for sesame production. According to Bench Maji Zone Agricultural Office 2017, the total sesame produce was 34,915.91 quintals and 8,215.35 hectares were covered by sesame with average productivity of 4.25 quintals per hectare.

Increasing agricultural production especially producing high value crops for export and productivity focusing on smallholder agriculture is continued to be a priority during the Second Growth and Transformation Plan (GTP II) as source of growth and poverty reduction through ensuring household and national food security [MoFEC, 2015]. Towards the realization of the above objectives, several policies and strategies were designed and implemented. According to studies of [Wijnands et al., 2009, Sorsa, 2009, Kostka & Scharrer, 2011, FAO, 2015, Girmay, 2018] Ethiopia has ample potential for sesame production. This is mainly linked to sesame natural flexibility to adopt different soil types and harsh environments as well as Ethiopian diversified agroecology and potential of arable land, water, labor force, and market opportunities. Additionally, there is a considerable demand for Ethiopian sesame seed at international markets [Sorsa, 2009]. This indicates that, growth and improvement of the sesame sector can substantially contribute to the economic development at national, regional and family levels.

However, despite the country has high potential to increase production and rapidly demand growth in the international market of Ethiopian sesame, the productivity of the crop is low as compared to its potential yield due to different production-related problems as indicated in studies by [Wijnands et al., 2007, Sorsa, 2009, FAO, 2015, Girmay, 2018, Hagose, 2017, Desale, 2017, Kedir, 2017]. Nowadays, sesame mainly grows in Bench Maji Zone in a wide range but its production and productivity is low as compared to national productivity. This all shows there was wider gap of inefficiency in sesame production in the study area. Although the analysis of technical efficiency of sesame farming is important, there are limited empirical studies in Ethiopia, particularly on the estimation of allocative and economic efficiencies of sesame farming in southwestern parts of the country. Understanding the levels of these efficiencies and their determinants will contribute a lot to the identification of production constraints at farm level and thereby improve the food security and income of farm households. This study, therefore, sought of analyzing production efficiency of sesame producer farm households in Bench Maji Zone, Southwest Ethiopia. Specifically, the study aimed to estimate the level of technical, allocative and economic efficiencies of sesame producers; to identify the determinants for variation of inefficiencies of sesame producers in the study area.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

RESEARCH METHODOLOGY

Description of the Study Area

Bench Maji Zone is one of the zones in Southern Nations, Nationalities and Peoples Region, Ethiopia. The zone has a total area of 19965.90 km^2. It lies between $5^0$33'-$7^0$21' latitude and $34^0$88'-$36^0$14' longitude with an elevation ranging 500 up to 2005 meters above sea level. The zone has a total estimated population (in 2015) of about 806,381 [CSA, 2013]. The agroecology of the zone, out of the total land size 52% Kola, 43% Weinadega and 5% Dega. The mean annual temperature of the zone ranges between 15.1–27^{0}C and the mean annual rain fall ranges 400–2000 mm. According to the land utilization data of the region, 174,678 ha cultivated land, 335,030 ha forest, bushes and shrub covered land, 79,248 ha grazing land, and 493,395 ha of land is covered by others [BMZAO, 2017].

Types, Sources and Methods of Data Collection

Both primary and secondary data sources were used. Primary data was collected from sample farm households using interview schedule. The questionnaire was pre-tested and amended based on the feedback received during pre-test. The enumerators, who can speak the local languages and are familiar with the culture of the local people was selected and trained on data collection procedures and interview techniques in order to simplify the complexity of data collection. Secondary data sources was obtained from Meinit Goldiya and Guraferda Districts Agriculture Office, governmental and non-governmental institutions reports and others including both published and unpublished documents.

Sampling Technique

Purposive and three-stage random sampling techniques were employed for this study. Two Districts, namely Meinit Goldiya and Guraferda, were purposively selected based on the potentiality of sesame production from 9 (Nine) districts of Bench Maji Zone. In first stage, *Kebeles*[1] in each District was grouped in to sesame growers and non-growers. In the second stage, among the sesame growing *kebeles*, seven *kebeles* (*Kushanta*, *Dega* and *Genbab kebeles* from Meinit Goldiya district and *Kuja*, *Gabika*, *Semerta* and *Sega kebeles* form Guraferda district) were selected randomly. Third stage, from the list of 9210 sesame producers in Bench Maji Zone, 270 sample households was selected randomly, using probability proportionate to size. Sample size was determined following a simplified formula provided by Yamane [1967]. Accordingly, required sample size at 95% confidence level with degree of variability of 5% and level of precision equal to 6% was used.

$$n = \frac{N}{1 + N(e)^2} = \frac{9210}{1 + 9210(0.06)^2} = 270 \quad (1)$$

Where, *n* sample size, *N* population size (sampling frame) and *e* level of precision considered 6%.

METHOD OF DATA ANALYSIS

Descriptive statistical tools such as mean, standard deviation, percentages and frequency were used. In the econometric analyses model the stochastic frontier model along with dual cost frontier is applied to estimate efficiencies and the relation between farm level socio-economic and institutional variables.

To estimate sesame production efficiency, the parametric stochastic efficiency decomposition approach, in which an additional random error v_i is added to the non-negative random variable u_i, was specified as follows in Equation 2.

$$y_i = f(x_i; \beta_j) + v_i - u_i \quad (2)$$

Where: i – is the number of sesame producing farmers, y_i – is sesame output measured in quintals, x_i – is a vector of input quantities used by the i^{th} sample farmer, β_i – is a vector of unknown parameter to be estimated, $f(.)$ – is Cobb-Douglas production function, v_i – is the random error term, independently

[1] *Kebele* is the lowest administrative unit.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

Table 1. Description of the variables used in parametric stochastic production and cost frontier analysis

Variable Notation	Type	Description and measurement	Expected sign
Ln (SOUTP)	Continuous	Natural log of the total output of sesame obtained from the i^{th} farm in quintal	
Ln (LAND)	Continuous	Natural log of the total amount of land allocated for sesame in hectare by the i^{th} household	+
Ln (FERT)	Continuous	Natural log of the total amount of inorganic fertilizer in kilogram applied by the i^{th} household	+
Ln (OXN)	Continuous	Natural log of the total number of oxen days used by the i^{th} household	+
Ln (LABOR)	Continuous	Natural log of the labor force (family and hired) which is all measured in terms of man-days	+
Ln (SEED)	Continuous	Natural log of the quantity of sesame seed used by the i^{th} household measured in kilograms	+
Ln (PEST)	Continuous	Natural log of the quantity of chemicals such as herbicides or pesticides used as an input by the i^{th} household measured in Liters	+
Ln (C_i)	Continuous	Natural Log of the minimum cost of sesame production for the i^{th} household measured in Birr	
Ln (Px_1)	Continuous	Natural log of total rental price of land per hectare (Size of land * Price/hectare) measured in Birr	+/-
Ln (Px_2)	Continuous	Natural log of the total price of seed (Kilograms * price/kg) measured in Birr	+/-
Ln (Px_3)	Continuous	Natural log of the total price of fertilizer per hectare (Kilogram * Price/kg) measured in Birr	+/-
Ln (Px_4)	Continuous	Natural log of the total price of oxen days used by the i^{th} household measured in Birr	+/-
Ln (Px_5)	Continuous	Natural log of the total price of labor during farming measured in Birr	+/-
Ln (Px_6)	Continuous	Natural log of total price of chemicals such as pesticides and herbicides (Liter * price/liter)	+/-
Age	Continuous	Refers to the age of the household head measured in terms of years	-
Farming Experience	Continuous	Experience of household head in sesame farming; measured in years	+
EDUC	Continuous	Highest level of formal education (grades) completed in years	+
Family Size	Continuous	Number of people in the household in terms of count	+
Off/non-farm activity	Dummy	It is a dummy variable & measured as 1 if the household is involved in off/non-farm activities and, 0 otherwise	+
Livestock holding	Continuous	The number of livestock owned by the household in terms of TLU	+/-
Total cultivated land	Continuous	Refers to the area of cultivated land allocated to all crops that the house hold managed in terms of hectare	+
Farm Income	Continuous	It is the amount income obtained from farm activities measured in Ethiopian Birr	+
Frequency of ex-contact	Continuous	Frequency of the extension agents visit farm of households measured in terms of count	+
Credit Amount	Continuous	It is the amount of money that the household head borrowed from formal and informal financial institutions measured in Ethiopian Birr	+
Proximity to farm	Continuous	It is the average distance of the farm plots from the residence of the household measured in kilometers or walking minutes	+
Soil Fertility	Dummy	It takes a value of 1 if the household head perceives his/her plots as fertile and 0 otherwise	+
Proximity to Market	Continuous	Distance from the household's residence to the nearest market in terms of walking minutes	-
Social Responsibility	Dummy	It is a dummy variable that takes a value of 1 if the household head participate in social responsibility and 0 otherwise	-

Source: own elaboration.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

and identically distributed as $v_i \sim N(0, \delta_v^2)$ is intended to capture events beyond the control of farmers, u_i – it is a non-negative random variable as $u_i \sim N(\mu, \delta_u^2)$ is intended to capture technical inefficiency of the i^{th} farmer.

The technical efficiency (TE_i) of the i^{th} – farmers can be estimates by using the expectation of u_i conditional on the random variables (ε_i) as shown by Battese and Coelli [1995]. The TE_i of an individual farmer is defined in terms of the observed to the corresponding frontier output given the level of input can be calculates as

$$TE_i = \frac{y_i}{y^*} = \frac{exp(x_i\beta_j + v_i - u_i)}{exp(x_i\beta_j + v_i)} = exp(-u_i) \quad (3)$$

The functional relationship between input and output used in the SPF can be specified as follows:

$$LnSOUTP = f(\beta_0 + \beta_1 \ln LAND + \beta_2 \ln FERT + \beta_3 \ln OXN + \beta_4 \ln LABOR + \beta_5 \ln SEED + \beta_6 \ln PEST + \varepsilon_i) \quad (4)$$

Where: $SOUTP$ – it is the total output of sesame obtained from the i^{th} farm in quintal[2], $LAND$ – is the total amount of land allocated for sesame in hectare by the i^{th} household, $FERT$ – is the total amount of Inorganic fertilizer in kilogram applied by the i^{th} household, OXN – the total number of oxen days used by the i^{th} household, $LABOR$ – is the labor force (family and hired) which are all measured in terms of man-days, $SEED$ – is the quantity of sesame seed used by the i^{th} household measured in kilograms, $PEST$ – is chemicals such as herbicides or pesticides used as an input by the i^{th} household, f ( ) = Appropriate functional form (e.g. Cobb-Douglas or Translog functional form), β_{1-} β_6 = vector of unknown parameters to be estimated, and ε_i = composed error term; and β_0 = is the y – intercept, and where: $\varepsilon_i = v_i - u_i$

[2] 1 quintal = 100 kilogram.

The dual cost frontier was computed as:

$$LnC = \ln \alpha_o + \alpha_1 \ln P x_1 + \alpha_2 \ln P x_2 + \alpha_3 \ln P x_3 + \alpha_4 \ln P x_4 + \alpha_5 \ln P x_5 + \alpha_6 \ln P x_6 + \alpha_7 Y^* \quad (5)$$

Where, C – is minimum cost of production per sesame farmer, Px_1 – is the seasonal rent of a hectare of land in the study area (Birr), Px_2 – is the cost of seed (Birr), Px_3 – is the Cost of fertilizer (Birr), Px_4 – is the cost of oxen (Birr), Px_5 – is the cost of labor (Birr) and Px_6 – is the cost of chemicals (Birr), Y^* – is the output of sesame in quintals adjusted for statistical noise, α_1-α_6 are parameters to be estimated, a_0 is the y – intercept. It is expected a priori that the coefficients of Px_1, Px_2, Px_3, Px_4, Px_5 and Px_6 will be positive. The list of the variables used in the parametric stochastic Cobb-Douglas production, dual cost frontier and inefficiency effect model and their expected signs are summarized (Table 1).

RESULTS AND DISCUSSION

Descriptive statistics of variables used in the stochastic frontier model

The production function was estimated using six input variables. To draws some picture about the distribution and level of inputs, the mean and range of input variables presented in Table 2. The average sesame yield produced by farm households was 3.98 quintal per hectare, with a standard deviation of 3.31, maximum of 17.5 and minimum of 0.67 quintal per hectare which is dependent variable in the production function (Table 2). The higher standard deviation result shows high variability of sesame yield among the sample households in the study area. The land allocated for sesame production, by sampled farmers, ranges from 0.22 to 2.25 hectare with average land size and standard deviation of 0.69 hectare and 0.42 respectively. The average amount of inorganic fertilizers applied in the production of sesame by sampled households was 33.97 kg per hectare. There was high variation of fertilizer utilization in sesame production by sample households. Also, 42.59% of sesame

kussehaile@gmail.com, egebre954@gmail.com, agegnehuworkye@gmail.com

producers did not yet apply any fertility improvement inputs in their sesame farm (i.e., they perceive their soil fertility status as moderate or fertilizer). Whereas, the remaining 57.41% had applied inorganic fertilizer even though it was not as per the recommended rate (100 kilogram per hectare) for both inorganic fertilizers UREA and DAP (Table 2). Sample households, on average, use 42.41 man days per hectare of labour for the production of sesame during survey period. The average oxen power used by sample households was 11.67 oxen days per hectare. The other very important variable, out of which production is impossible, is seed. The amount of seed sample households' used was 12.70 kg, on average (Table 2). This indicates that the average seed rate application for sesame production by sample households is less than the research recommended seed rate of 7–10 kilogram under rain feed condition for broadcast planting. On average, sampled households applied 0.55 liter of chemicals such as herbicides, insecticides and pesticides per hectare in the study area for the protection of sesame farms (Table 2).

Table 2. Output and input variables used to estimate the production function

Variable description	Summary statistics			
	Mean	Standard deviation	Maximum	Minimum
Sesame output (Qt)	3.98	3.31	17.5	0.67
Land (Ha)	0.69	0.42	2.25	0.22
Seed (Kg/Ha)	12.70	11.12	38	2.12
Human labor (MDs/Ha)	42.41	20.82	128	14
Oxen power (ODs/Ha)	11.67	6.56	31.75	1.789
Inorganic fertilizer (Kg/Ha)	33.97	41.02	150	0
Chemicals (Lit/Ha)	0.55	0.78	2.75	0

Source: computed from survey data, 2018.

Econometric Model Outputs

This section presents the econometric model outputs of production function, individual efficiency scores and sources of differences in production efficiency in the study area are discussed.

Test of hypothesis

Tests of hypotheses for the parameters of the frontier model were conducted using the generalized likelihood ratio. Accordingly four hypotheses were tested, to select the correct functional form for the given data set, for the existence of inefficiency, for variables that explain the difference in efficiency.

The first test was made based on the value of likelihood ratio (LR) statistics, which can be computed from the log likelihood value obtained from estimation of Cobb-Douglas and Translog functional specifications. Then, this computed value is compared with the upper 5% critical value of the χ^2 at the degree of freedom equals to the difference between the numbers of explanatory variables used in the two functional forms (in this case df = 21). For the sample farm households, the estimated log likelihood values of the Cobb-Douglas and Translog production functions were -265.25 and -259.69, respectively. The computed value of likelihood ratio (LR = -2(259.69–265.25) = 11.12 is lower than the upper 5% critical value of the χ^2 with its respective degree of freedom (Table 3). Thus, the null hypothesis that all coefficients of the square and interaction terms in Translog specification are equal to zero was not rejected. This implies that the Cobb-Douglas functional form adequately represents the data.

Table 3. Generalized likelihood ratio tests of hypothesis for the parameters of SPF

Null hypothesis	LH_0	LH_1	Calculated $\chi 2$ (LR) value	Critical $\chi 2$ value	Decision
H_0: = $\beta_{7\ldots}$ β_{27} = 0	-265.25	-259.69	11.12	32.67	Accept
H_0: $\gamma = 0$					Reject H_0
H_0: = $\delta_1 = \ldots \delta_{14} = 0$	-286.03	-265.25	41.55	23.68	Reject H_0

Source: computed from survey data, 2018. δ

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

The second null hypothesis was H_0: $\gamma = 0$, which specifies that the inefficiency effects in the stochastic production function were not stochastic. Since after fitting the function with the required defined variables the model output found that, log likelihood value = 265.25 (chibar^2 (01)-value = 20.64 and p< = 0.000). Hereafter, the decision of null hypotheses H_0: $\gamma = 0$, which specifies that the inefficiency effects are absent from the model is rejected at 1% level of significance for the sample households. The coefficient for the discrepancy ratio (γ) could be interpreted in such a way that about 96.3% of the variability in sesame output in the study area was attributable to technical inefficiency effect, while the remaining 3.7% variation in output was due to the effect of random noise (Table 3).

The third null hypothesis that the explanatory variables associated with inefficiency effects are all zero (H_0: $\delta_1 = \delta_2 \ldots = \delta_{14} = 0$) was also tested. To test this hypothesis likewise, LR (the inefficiency effect) was calculated using the value of the Log-Likelihood function under the stochastic production function model (a model without explanatory variables of inefficiency effects: H_0) and the full frontier model (a model with explanatory variables that are supposed to determine inefficiency of each: H_1). The calculated value $\lambda_{LR} = -2(265.25–286.03) = 41.55$ is greater than the critical value of 23.68 at 14 degree of freedom (Table 3) the value of LR implying that, the null hypothesis (H_0) that explanatory variables are simultaneously equal to zero was rejected at 5% significance level.

Estimation of parameters of production function model

The result of the Cobb-Douglas stochastic production frontier showed that amount of seed, inorganic fertilizer, oxen power, human labour and chemicals such as pesticides and herbicides inputs were found to positively and significantly (at 1% significance level except inorganic fertilizer and chemicals which is at 10% level of significance) which are important variables in shifting the frontier output to the right as indicated in (Table 4). This indicated that at each and every unit of these variables there is a possibility to increase the level of output. But the amount of land under sesame is insignificant. This may imply absence of significant variation in the amount land used among households in sesame production in the study area.

One of the appealing features of the Cobb-Douglas functional form is the direct interpretation of its parametric coefficients as a partial elasticity of production with respect to the input used. This attribute allows one to evaluate the potential effects of changes

Table 4. OLS and Maximum likelihood estimate of stochastic production frontier model

	OLS estimate model		Maximum likelihood estimate of SPF	
Variable	Coefficients (Stand.Err)	t-value	Coefficients (Stand. Err)	Z-value
Ln(Land)	-0.00889 (0.05009)	-0.18	-0.00637 (0.03472)	-0.18
Ln(Fertilizer)	0.03114 (0.02130)	1.46	0.03058* (0.01629)	1.88
Ln(Oxen)	0.24008** (0.10039)	2.39	0.22676*** (0.07087)	3.20
Ln(Labor)	0.46759*** (0.14991)	3.12	0.45716*** (0.10412)	4.39
Ln(Seed)	0.20737 ** (0.09298)	2.23	0.23615*** (0.07539)	3.13
Ln(chemicals)	0.13667 (0.08667)	1.58	0.12063* (0.06671)	1.81
Intercept	-0.83388 (0.60268)	-1.38	0.01502 (0.45182)	0.03
Gamma (γ)			0.963***	
LR			-265.2526	
F statistics	5.72***			
Returns to scale			1.065	

*, ** and ***, means statistically significant at 10%, 5% and 1%, level of significance respectively
Source: computed from survey data, 2018.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

in the amount of each input on the output. The input variables inorganic fertilizer, sesame seed, oxen power, human labour, and chemicals are the main inputs in determining the output level of sesame for sample farmers in the study areas. Whereas, the elasticity of land allocated for sesame is very low implying that this have less effect in determining the output level at the best practice (the maximum technical efficiency score).

The positive coefficients of inputs indicate a 1% increase in inorganic fertilizer, sesame seed, oxen power, human labour and pesticides yields 0.03%, 0.24%, 0.23%, 0.46% and 0.12% increase in sesame output respectively. In other words, if all the inputs are increased by 1%, sesame output would increase by 1.065% as presented in Table 4 above. Labor was found to be statistically significant and with expected sign. Hence there may be shortage of labor during sesame production. This means there is overlapping of sesame farm activities with other crops usually happened and shared the available labors. Based on the estimated parameters of the Cobb-Douglas production function shown in Table 4, the parameters of the corresponding dual cost function were derived and formed the basis for computing allocative and economic efficiency indices. The dual cost frontier is given by:

$$LnC = 7.813 + 0.069Px_1 + 0.084Px_2 + 0.012Px_3 + 0.018Px_4 + 0.131Px_5 + 0.066Px_6 + 0.035Y^*$$

Production efficiency scores of sample households

As indicated in Table 5 below, the results of the efficiency scores indicated that there were wide ranges of differences in efficiency among sesame growing households in the study area. The mean technical efficiency of sample households during the survey period was 50.72%. The technical efficiency among households ranged from 7.06% to 91.35% (Table 5). This wide variation in household specific efficiency levels is consistent with study conducted by [Abu et al., 2012, Ike & Inoni, 2006, Ermiyas et al., 2015].

Table 5. Summary statistics of estimated TE, AE and EE of sample households

Description	Mean	Standard deviation	Maximum	Minimum
TE	0.5072108	0.2454264	0.9135043	0.0706201
AE	0.8683139	0.085605	0.9751402	0.5218924
EE	0.4420332	0.2212191	0.8209329	0.0633757

Source: computed from survey data, 2018.

Similarly, the average predicted allocative efficiency of smallholder sesame producers in the study areas is 86.83%, ranging from 52.19% to 97.51% (Table 5). Applying this procedure, the study found that the mean economic efficiency of sesame producers was 44.2% ranging from 6.34 to 82.09%. The mean economic efficiency found in this study for sesame producers is similar with the studies of [Endrias et al., 2013, Abu et al., 2012, Mekonnen et al., 2013, Ermiyas et al., 2015]. This also indicates the existence of substantial economic inefficiency in the production of sesame during the survey period (Table 5).

Determinants of efficiencies in sesame production

In previous section, information about the existence of production inefficiency and measuring its magnitude, examining the major factors causing this inefficiency level is the next most important step of this study. The driving force behind measuring households' efficiency in sesame production is to identify determinants to generate information in order to make an intervention and improve the existing level of efficiency. About 14 variables were hypothesized to affect level of technical, allocative, and economic inefficiency of sesame producers in the study areas, out of which three of them were dummy variables and the remaining were continuous variables. Most of the variables were discussed in the descriptive result section above. Hence, here only some of the variables in the inefficiency model were discussed.

The coefficient of sesame farming experience is positive as expected for both TE and EE significant at 1% and 5% respectively. This indicated that increased

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

farming experience may lead to better assessment of importance and complexities of good farming decision, including efficient use of inputs. This result is in consistent with the finding of [Kingsley et al., 2015, Berhan, 2015]. As expected, education level of the household head has a positive and significant effect on TE at 5% but have unexpected sign for AE and EE of sesame production at 5 and 10% level of significance, suggesting that better educated household head can understand agricultural instructions easily, have higher tendency to adopt improved agricultural technologies, have better access to information, and are able to apply technical skills imparted to them than uneducated ones. Thus, the level of education of household head emerges as an important factor in enhancing efficiencies of sesame production in the study areas. This result is consistent with other similar studies such as [Arega & Reshid, 2005, Msuya et al., 2008, Sisay et al., 2016].

The model result shows that farm income have positive and significant effect on farmers' technical efficiency in production. This shows that households having better farm income would devote their time and effort in day to day farming activities and able to use improved technologies thereby production efficiency improved. Also, farmers with more income from the farming sector could have the chance of buying the required inputs for sesame production. This finding is in line with the studies of [Berhan, 2015, Penda & Asogwa, 2011, Daniel, 2016]. The result in Table 6 shows that, the coefficients of off/non-farm activities indicated that the variable affects the level of allocative efficiency positively and significantly. In other words, those households engaged in some off/non-farm activities are more efficient relative to those who were not engaged in activities other than their farm operations. The possible explanation is that it would assist the households to supplement other costs associated with their living, perhaps. The result obtained is consistent with studies conducted by [Hassen & Wondimu, 2014, Ermiyas et al., 2015]. This implies that farmers with more off/non-farm income were technically efficient than their counterparts even if it has insignificant in technical efficiency.

Table 6. Model results on production efficiency of sesame production significant variables

Variables	TE		AE		EE	
	Coefficient	Std.Err	Coefficient	Std.Err	Coefficient	Std.Err
Age	0.003756	0.010507	-0.001843	0.001887	-0.006608	0.008425
Sesame farming experience	-0.115749***	0.035325	0.003592	0.005218	-0.052338**	0.0233716
Education Level	-0.112688 **	0.047575	0.0287998*	0.014732	0.076292**	0.036524
Family size	0.037461	0.044289	-0.007470	0.0074505	0.018363	0.033239
Off/non-farm activity	0.000100	0.000122	-0.007479***	0.002806	-0.000113	0.000097
Farm income	-0.000385***	0.0001063	0.0029776	0.075399	0.000225***	0.000079
Total cultivated land	-0.560713*	0.3197096	0.0857461	0.053451	0.368759*	0.219108
Extension contact frequency	-0.062574	0.0895049	0.0335769**	0.014158	0.0386882	0.0624756
Credit Amount	0.0196534	0.0123576	-0.005373**	0.002343	-0.0166639*	0.0100841
Livestock holding	-0.0483543	0.0317711	0.0035908	0.004796	0.0062035	0.0213434
Proximity to farm	0.0948362	0.0763032	0.0040572	0.008106	-0.0789699	0.0655422
Soil fertility status	-0.859717 ***	0.2578617	-0.0575575	0.04166	-0.774897***	0.1855452
Social Responsibility	-0.378203*	0.211051	-0.082360**	0.036374	-0.416829**	0.162718
Proximity to market	0.177999***	0.0568428	0.027953**	0.009679	0.159124***	0.043517
Constant	2.279698 **	1.076654	3.480399**	0.7046029	0.7625497	0.806685

*, ** and ***, means statistically significant at 10%, 5% and 1%, level of significance respectively
Source: Model output, 2017/18.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

Extension contact has negative sign and is significant at 5% significance level. Thus, this result shows that consultation of extension agents increase sesame production by decreasing level of allocative inefficiency. This implies that the more the household had extension visit, the less he/she would become inefficient and the household thereby giving a room for improvement in farm efficiency. This result is in line with the results of [Fekadu, 2004, Musa, 2013, Hailemaraim, 2015]. Contrary to this, Jema [2008] found positive relationship between level of inefficiency and extension service. The coefficient of amount of credit had a positive and significant effect on both allocative and economic efficiencies at 5% and 10% significance level respectively. It is an important element in agricultural production systems. It allows producer to satisfy their cash needs induced by the production cycle. Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs that they cannot provide from their own sources. This finding was consistent with [Mussa, et al., 2012, Meftu, 2016].

Social responsibility of the household head has a positive and significant effect on TE, AE and EE of sesame production at 10 and 5% level of significance, suggesting that responsibility in different social and committee leadership give the farmers opportunity of sharing information on improved production techniques by interacting with other farmers and experts thereby improve efficiency of sesame production. Also, the coefficient of soil fertility status is positive and significant at 1% level of significance for TE and EE. This implies that, fertility of land is an important factor in influencing the level of inefficiency in the production of sesame or positively contributes to economic efficiency of sesame. This implies that households who allocated land which was relatively fertile were better in economic efficiency. The result is in line with the arguments of [Fekadu, 2004, Mustefa, 2014]. Finally, proximity to market negatively and significantly influenced the technical, allocative and economic efficiency of sesame production. Households located in proximity to the nearby markets are found to be more efficient than others. Nearby markets play a role in easily accessing the required farm inputs and sale of output without much cost/effort/ for transport, travel time and search for information. A study by [Hassen, 2011, Musa et al., 2015, Sisay et al., 2016, Daniel, 2016] also confirmed the negative association of distance of the farmers from the nearest market with efficiency.

CONCLUSIONS

Result of the production function indicated that, inorganic fertilizer, sesame seed, oxen power, human labor, and chemicals were limiting constraints, with positive sign as expected. The positive coefficients of these variables indicate that, increased use of these inputs will increase the production level to greater extent.

Based on the study results found, this study concludes that, there is a considerable variability in all efficiencies and efficiency score of sample households in the study area. Farming experience, education level, farm income, cultivated land, social responsibility, extension contact frequency, off/non-farm activities, credit, proximity to market and soil fertility were found to be significant sources of inefficiencies. This suggests that, there exists a considerable room to enhance the level of sesame production efficiency i.e., integrated development efforts that will improve the existing level of input use and policy measures towards decreasing the existing level of inefficiency will have paramount importance in improving the productivity. Thus, the following recommendations are forwarded based on the result of the study.

- Interventions by higher education institutions, research institutes/centers in collaboration with FTCs should plan, implement, and conduct practical demonstrations in comprehensive way considering issues like efficient resource use, cost reduction, input optimization so that farmers could be benefited from accelerated increase in productivity.
- The local government should give more attention to facilitate formal education for all to attain educated farmers in order to increase efficiency and agricultural productivity of the country in the long run.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

– Development programs should strength their support for farmers to improve and maintain fertility of land through awareness creation and introduction of technologies that maintains fertility for efficient production.
– Furthermore, attention should be given by local government and supporting institutions through developing crop specific extension packages, improve market integration, and financial accessibility which encourages the farmers to produce efficiently. Therefore, those important socioeconomic and institutional factors which are mentioned above should be taken into account to improve the productivity of sesame in the study areas.

Authors' contributions: Authors have given approval to the final version of the article. Authors contributed to this work as follows: for Conceptualization: Kusse Haile, Engida Gebre, and Agegnehu Workye; Methodology: Kusse Haile, Engida Gebre, and Agegnehu Workye; Software: Kusse Haile, Engida Gebre, and Agegnehu Workye; Formal Analysis: Kusse Haile; Investigation: Kusse Haile, Engida Gebre, and Agegnehu Workye; Resources: Kusse Haile, Engida Gebre, and Agegnehu Workye; Data Curation: Kusse Haile, Engida Gebre, and Agegnehu Workye; Writing – Original Draft Preparation: Kusse Haile; Writing – Review and Editing: Kusse Haile, Engida Gebre, and Agegnehu Workye; Visualization: Kusse Haile, Engida Gebre, and Agegnehu Workye; Supervision: Kusse Haile, Engida Gebre, and Agegnehu Workye; Project Administration: Kusse Haile; Funding Acquisition: Kusse Haile, Engida Gebre, and Agegnehu Workye.

Acknowledgements: We would like to thank Mizan-Tepi University for funding this research. Development agents and government office workers of Gurafarda and Meinit Goldya District are acknowledged for their cooperation during the data collection.

Data Availability: The data used to support the findings of this study are available from the corresponding author upon request.

Conflict of interests: The authors declare that they have no conflicting interests.

REFERENCES

Abebe, N.T. (2016). Review of sesame value chain in Ethiopia. *International Journal of African and Asian Studies*, 19, pp. 36–47. https://iiste.org/Journals/index.php/JAAS/article/view/29286/30075, date: 05.01.2017.

Abu, G.A., Ater, P.I., Abah, D. (2012). Profit efficiency among sesame farmers in Nasarawa State, Nigeria. *Current Research Journal of Social Sciences*, 4(4), pp. 261–268. https://maxwellsci.com, date: 30.07.2012.

Alemu, D., Meijerink, W.G. (2010). Sesame traders and the ECX: An overview with focus on transaction costs and risks, VC4PPD report #8, Addis Ababa. https:// www.wur.nl/upload_mm/4/1/8/73de144c-a-7e6-45cd-8374-746b25526cc7_Report_8_Alemu__Meijerink_0707102.pdf, date: 25.02.2017.

Arega, D., Rashid, M.H. (2005). The efficiency of traditional and hybrid maize production in eastern Ethiopia: An extended efficiency decomposition approach. *Journal of African Economics*, 15, pp. 91–116. doi:10.1093/jae/eji017.

Battese, G.E., Coelli, T. (1995). A model of technical efficiency effects in a stochastic frontier production functions for panel data. *Empirical Economics*, 20(2), pp. 325–332. doi:10.1007/BF01205442.

Berhan, T. (2015). Determinants of technical, allocative and economic efficiencies among onion producing farmers in irrigated agriculture: Empirical evidence from Kobo district, Amhara region, Ethiopia. *African Journal of Agricultural Research*, 10(20), pp. 2180–2189. doi:10.5897/AJAR2015.9564.

BMZAO. (2017). Bench Maji Zone Agricultural Office Area Description, Annual Report.

CSA. (2013). Central Statistical Agency report on Population Projection of Ethiopia for All Regions At Wereda Level from 2014–2017. FDRE, Addis Ababa, August, 2013.

CSA. (2017). Central Statistical Agency Agricultural sample survey 2016/2017 (2009 E.C), report on area and production of major crops, agricultural sample survey. Vol. 1, Statistical Bulletin 584, April, 2017, Addis Ababa, Ethiopia. https://www.statsethiopia.gov.et, date: 05.08.2017.

Daniel, M. (2016). Smallholder Households' Technology Adoption, Efficiency And Welfare Effect Of Improved White Haricot Beans Production In East Shewa Zone Of South-Eastern Ethiopia (unpublished doctoral dissertation). Haramaya University, Haramaya, Ethiopia.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

Desale, G. (2017). Technical, Allocative and Economic Efficiencies and Sources of Inefficiencies a mong Large-scale Sesame Producers in Kafta Humera District, Western Zone of Tigray, Ethiopia: Non-parametric approach. *International Journal of Scientific & Engineering Research*, 8(6), pp. 2041–2061. http://www.ijser.org/, date: 05.06.2017.

Endrias, G., Ayalneh, B., Belay, K., Eyasu, E. (2013). Productivity and efficiency analysis of small-scale maize producers in Southern Ethiopia. *Journal of Human Ecology*, 41(1), pp. 67–75. doi:10.1080/09709274.2013.11906554.

Ermiyas, M., Endrias, G., Belaineh, L. (2015). Production Efficiency of Sesame in Selamago District of South Omo Zone, Southern Ethiopia. *Current Research in Agricultural Sciences*, 2(1), pp. 8–21. doi:10.18488/journal.68/2015.2.1/68.1.8.21.

FAO. (2015). Food and Agriculture Organizations for United Nations. *Analysis of price incentives for sesame seed in Ethiopia for the time period 2005–2012*. Technical notes series, MAFAP, by Kuma Worako, T., MasAparisi, A., Lanos, B., Rome. http://www.fao.org/3/a-i4528e.pdf, date: 04.11.2017.

Fekadu, G. (2004). Analysis of Technical Efficiency of Wheat production: A Study in Machakal Woreda, Ethiopia (unpublished MSc thesis). Alemaya University, Alemaya, Ethiopia.

Girmay, A. (2018). Sesame production, challenges and opportunities in Ethiopia. *Agricultural Research and Technology*, 15(5), pp. 51–56. doi:10.5958/2229-4473.2018.00007.1.

Hagose, L.W. (2017). Strategic analysis of sesame (Sesamum indicum L.) market chain in Ethiopia a case of Humera district. *International Journal of Plant and Soil Science*, 15(4), pp. 1–10. doi:10.9734/IJPSS/2017/31928.

Hailemaraim, L. (2015). Technical Efficiency in Tef Production: The Case of Bereh District, Oromia National Regional State (unpublished MSc thesis). Haramaya University, Haramaya, Ethiopia.

Hassen, B. (2011). Analysis of agricultural technology adoption and Production efficiency: the case of smallholder farmers in North eastern highlands of Ethiopia (unpublished doctoral dissertation). Haramaya University, Haramaya, Ethiopia.

Hassen, B., Wondimu, T. (2014). Determinants of Technical Efficiency in Maize Production: The Case of Smallholder Farmers in Dhidhessa District of Illuababora Zone, Ethiopia. *Journal of Economics and Sustainable Development*, 5(15), pp. 274–284. https://www.iiste.org/Journals/index.php/JEDS/article/view/15328/15543.2014.

Ike, P.C., Inoni, O.E. (2006). Determinants of Yam Production and Economic Efficiency among Small-Holder Farmers in Southeastern Nigeria. *Journal of Central European Agriculture*, 7(2), pp. 337–342. https://jcea.agr.hr/en/issues/article/383, date: 27.06.2006.

Jema, H. (2008). Economic Efficiency and Marketing Performance of Vegetable Production in Eastern and Central Parts of Ethiopia (unpublished doctoral dissertation). Acta Universitatis Agriculture Sueciae (SLU) Uppsala, Sweden.

Kedir, M. (2017). Value chain analysis of sesame in Ethiopia. *Journal of Agricultural Economics, Extension and Rural Development*, 5(5), pp. 620–631. http://www.springjournals.net/fullarticles/springjournals.net-jaeerdarticlesindex=13musba.pdf?view=download, date: 04.05.2017.

Kingsley, O.I., Eucharia, A.A., Uket, I.O., Otu, E.A. (2015). Technical Efficiency Analysis of Small Scale Cassava Farmers in Cross River State, Nigeria: A Stochastic Production Frontier Approach. *Applied Economics and Finance*, 2(4), pp. 10–18. doi:10.11114/aef.v2i4.1028.

Kostka, G., Scharrer, J. (2011). Ethiopia's sesame sector: The contribution of different farming models to poverty alleviation, climate resilience and women's empowerment. *Oxfam Research Reports*. https://oi-files-d8-prod.s3.eu-west-2.amazonaws.com/s3fs-public/file_attachments/rr-ethiopias-sesame-sector-210711-en_3.pdf, date: 21.07.2017.

Meftu, A. (2016). Economic Efficiency of Groundnut (Arachis Hypogaea L.) Production: The Case of Gursum District, East Hararghe Zone (unpublished MSc thesis). Harmaya Univesity, Haramaya, Ethiopia.

Mekonnen, D.K., Dorfman, J.H., Fonsah, E.G. (2013, February 2-5). Productivity and Efficiency of Small Scale Agriculture in Ethiopia, paper presented on Annual Meeting of Southern Agricultural Economics Association, Orlando, Florida 143038.

MoFEC. (2015). Ministry of Finance and Economic Cooperation report 2015. Development and Poverty Profile of Ethiopia, Addis Ababa, Ethiopia.

Msuya, E.E., Hisano, S., Nariu, T. (2008, January 6–11). An Analysis of Technical Efficiency of Maize Farmers in Tanzania in the Globalization Era, Paper presented in the XII World Congress of Rural Sociology of the

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com

International Rural Sociology Association, Goyang, Korea.

Mussa, E.C., Gideon, A.O., Bogale, A., Franklin, P.S. (2012). Analysis of resource use efficiency in smallholder mixed crop-livestock agricultural systems: Empirical evidence from the central highlands of Ethiopia. *Developing Country Studies*, 2(9), pp. 30–40. https://www.iiste.org/Journals/index.php/DCS/article/view/2964, date: 02.03.2017.

Musa, H. (2013). Economic Efficiency of Smallholder Farmers in Maize Production: The Case of Arsi Negelle District, Oromia National Regional State, Ethiopia (unpublished MSc thesis). Haramaya University, Ethiopia.

Musa, H., Lemma, Z., Endrias, G. (2015). Measuring technical, economic and allocative efficiency of maize production in subsistence farming: Evidence from the Central Rift Valley of Ethiopia. *Applied Studies in Agribusiness and Commerce*, 9(3), pp. 63–74. doi:10.19041/APSTRACT/2015/3/9.

Mustefa, B. (2014). Economic Efficiency of Barley Production: The Case of Chole District, Ethiopia (unpublished MSc thesis). Haramaya University, Ethiopia.

NABC. (2015). Netherlands African Business Council 2015. Business opportunity report on oilseeds and pulses in Ethiopia. Netherlands Enterprise Agency, Ministry of Economic Affairs and Ministry of Foreign Affairs.

Penda, S.T., Asogwa, B.C. (2011). Efficiency and Income among the Rural Farmers in Nigeria. *Journal of Human Ecology*, 35(3), pp. 173–179. doi:10.1080/09709274.2011.11906404.

Sisay, D., Jema, H., Degye, G., Abdi-Khalil, E. (2016). Technical, allocative, and economic efficiency among smallholder maize farmers in Southwestern Ethiopia. *Journal of Development and Agricultural Economic*, 7(8), pp. 282–291. doi:10.5897/JDAE2015.0652.

Sorsa, D. (2009). *Sesame trade arrangements, costs and risks in Ethiopia: A baseline survey*. Wageningen, February 2009. https://www.wur.nl/upload_mm/9/a/9/59d09a46-b629-4014-b2bd-adf765894adc_Report-2Gelalcha170610.pdf, date: 05.11.2018.

Temesgen, F., Gobena, E., Megersa, H. (2017). Analysis of sesame marketing chain in case of Gimbi districts, Ethiopia. *Journal of Education and Practice*, 8(10), pp. 86–102. https://eric.ed.gov/?id=EJ1139722, date: 08.01.2018.

Wijnands, J.H.M., Biersteker, J., Hiel, R. (2007). *Oilseeds Business Opportunities in Ethiopia*. Den Haag, The Hague: Ministry of Agriculture, Nature and Food Quality – 36. https://library.wur.nl/WebQuery/wurpubs/361069, date: 05.01.2017.

Wijnands, J.H.M., Biersteker, J., Van Loo, E.N. (2009). *Oilseeds Business Opportunities in Ethiopia*. The Netherlands, The Hague: PPP – 62. https://library.wur.nl/WebQuery/wurpubs/personal/384340?wq_inf1=102, date: 05.01.2017.

Yamane, T. (1967). *Statistics: An Introductory Analysis 2nd Edition*. New York, Harper and Row.

✉kussehaile@gmail.com, ✉egebre954@gmail.com, ✉agegnehuworkye@gmail.com