Factors Affecting Allocative Afficiency of Teff Production in Southern Ethiopia: evidence from Gombora district: A Stochastic Frontier Analysis approach

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Abstract
Agriculture takes the best share of the Ethiopian Economy. Agriculture has been and continues to assume center stage in the economic policy of Ethiopia. Teff is Ethiopia's most significant staple food crop among cereal production. However, its productivity is low due to an increase by enlarged use of inputs or rising the efficiency of producers. Therefore, this study aimed to estimate the level of allocative efficiency and identify its determinants on teff producers in the district. For the study, cross-sectional survey data among 391 teff growers during the 2020/2021 teff growing season in the district were collected. For the study, descriptive statistics and econometric methods such as the stochastic cost frontier model and two-limit Tobit model were utilized. The results of diagnostic statistics of sigma squared (0.022) and gamma (0.876) were statistically significant at a 1% significance level. Further, the stochastic cost frontier model result showed that the cost of (land, seed, labor, oxen, and NSPB fertilizer) was statistically significant at a 1% probability level whereas the cost of UREA fertilizer was significant at a 5% probability level. The mean of allocative efficiency teff cultivator was 88%, while average teff grower achieve a 10.2% cost saving through best utilization of current given economic resource and technology. Moreover, the two-limit Tobit model result showed that farm size had positively significant at 1% significance level whereas farmers' age and sex had negatively significant at 5% significance level on allocative efficiency. Agricultural, rural development and extension office, and another concern body should give important attention to teff allocative efficiency which bases for enhancing teff yield. The summary of this teff production allocative efficiency by policymakers and plan designers could bring better enhancement on teff cultivator. Improving such a teff production allocative efficiency is a crucial option to enhance teff grower income and crop yield, which is, in turn, crucial to alleviate poverty and food insecurity in the study area.

Keywords: *Allocative Efficiency, Teff, stochastic frontier cost function, Two-limit Tobit, Gombora district, Ethiopia*

1. INTRODUCTION

Agriculture is crucial in the economy characterizes by the developed economic policy of agricultural development lead industrialization. Agricultural development is one of the foremost powerful tools to finish extreme poorness, boost shared prosperity and guarantee food security (Alston and Pardey, 2014). Developing countries and Africa account for massive shares of value, employment, and exports. It takes the biggest share of the economies of most Sub-Saharan African countries, which contributes between 15-60% of their GDP and provides employment for quite two-third of their population, however, Agriculture in the Social Security Administration remains dominated by the husbandman and subsistence sector (FAO, 2014). Therefore, Agricultural policy in Africa is vital for agricultural development for Africa's countries to extend the production and productivity of small holder farmers. However, they have not achieved the required goals. Production and productivity boost by either use of improved inputs and technology or enhance the potency of producers (Tadesse and Krishnamoorthy, 1997). The explanation can be the efficiency of the farmer cannot use the obtainable resources (Bati et al., 2017). However, major production efficiency analysis in Africa targeted solely technical efficiency therefore additional analysis is required that think about Allocative and economic efficiency (Sibiko et al., 2013). Measuring efficiencies has remained an area unit of vital analysis in developing countries wherever resources are scanty (Tadesse and Krishnamoorthy, 1997).

Agriculture is the bone of the Ethiopian economy (MoARD, 2010). The Ethiopian Government has been created different efforts to attain food security and scale back poorness at the family level by increasing production and productivity. However, Ethiopian Agriculture is dominated by subsistence and smallholder-oriented system (Bishaw, 2009). In Ethiopia agricultural sector dominates a large portion of the population, income, foreign exchange, and job creation. Consequently, the sector is crucial generates over 35.8% to national GDP, 50% to gross domestic product, 90% to export revenue, 85% labor force, and 72.7% raw material to country industries (Teklu, and Tefera, 2005). Hence, the yield, productivity, and efficiency level of agriculture are generally below the world mean due to poor attention is given to the sector. In general teff grower faces management inefficiency inputs, poor extension, the output varies per hectare, insufficient credit, inadequate marketing, backward teff growing technology, weak infrastructural access, and inappropriate agricultural development policies (Cheng et al., 2017). In the country, improving the total yield and productivity is a necessity and the most important concern in their plan and policies. Yield and productivity can be enhanced by using inputs and advancements in technology (Ayele et al., 2019).

Teff is one of the cereal crops and Ethiopia's most vital staple food crop by area and also the second most vital crop next to coffee (Alemu et al., 2018; Minten et al., 2016). From different cereals, teff is a major cereal food security crop in the country in terms of coverage and volume of yield. Teff covers 95% of yield, accounts for 87.48% of the grain yield, and is planted by 43% of teff growers in the country. In terms of yearly production, teff is the second crucial cereals/cash crop next to coffee with 100gram of teff cereals has 357 kcal in terms of nutrition. Teff cereal is very suitable for people with rich amino acid, protein, gluten-free and poor glycemic index, and contains two diabetes (Cheng et al., 2017; Teklu, and Tefera, 2005; Thiam, 2001). Enhancing teff allocative efficiency in yield allows growers to improve their yield without any additional inputs and advancing yield technologies which is resulting in advanced yield and productivity (Fischer et al., 2014). Enhancing economic teff allocative efficiency in yield on to improve yield without any additional inputs and technologies. That means using new improved technologies is less cost-effective than applying existing technologies. Yield enhancing teff allocative technology indicates the teff growers to reach the optimum output with existing technology. The use of the inputs in maximum proportions can be indicated at allocative efficiency (Ayele et al., 2019; Debebe et al., 2015). However; In Ethiopia, there's low productivity of teff output and production inefficiency (Elemo et al., 2017; Kebede et al., 2014; Wassie, 2014).

The expansion of teff yield in suitable agro-ecologies is the option to alleviate food insecurity and poverty Alston and Pardey, 2014). Backward method of sowing such as chemical fertilizer use, growing, and plowing has resulted higher reducing of yield and productivity in Ethiopia

(Solomon, 2014). Like other developing countries, in Ethiopia, teff yield is featured by low use of inputs, backward technology inefficiency of employing of scarce resources (Cheng et al., 2017). Hence, to enhance yield and productivity of teff at the grower level with efficient use of scarce resources or inputs needs to be improved (Ayele et al., 2019). A large portion of teff grower faces low use of existing technologies and inputs due to socio-economic and socio-cultural constraints. Teff main cereals growing area have been highly concentrated in the central and northwestern highlands of the country. Lack of yield system, climatic changes, improved seed varieties, yield inputs, management system, weed management system, pest management, and soil fertility maintenance are serious challenges of teff crop in general. Teff cereals in terms of productivity are low due to lack of high producing growers, erratic rainfall, lack of good management system, and low inputs application (Gela et al., 2019). According to their studies (Bekele et al., 2019), the losses of teff yield can decrease the number of teff cereals by up to 50%. The mean yield of teff in the country is 1.75t/ha at the growing level. To enhance efficiencies of growers, scarce resource distribution and allocation are crucial and known. In Ethiopia, the teff production gap is large among growers due to low access to seed and lack of well managed agronomic system (Abraha et al., 2017). Enhanced agricultural sector yield and productivity is crucial enhanced technology, despite minimum cereals productivity in general and teff productivity in particular. This is due to the difficulty to identify new technologies are applied by growers, weak finance cultivating techniques, low farm technologies, and the high price of cultivating technologies (Fischer et al., 2014). Cost-effective technologies are developed by using existing inputs and technologies. Therefore, allocative efficiency is important to indicate growers are efficient in the employ of the existing economic resource and the decision to conduct the new cultivating agricultural technologies (Debebe et al., 2015; Tijjani and Bakari, 2014).

The studies found that production inefficiency among teff growers in Ethiopia (Alemu and Haji, 2016; Alemu et al., 2018; Bati et al., 2017; Kebede et al., 2014; Wassie, 2014). Many studies are disbursed on production efficiency on numerous teff cultivator enterprises (Alemu et al., 2018; Bati et al., 2017; Kebede et al., 2014; Obare et al., 2010; Sibiko et al., 2013). Most researches focus on technical and profit efficiencies (Ahmed and Melesse, 2018; Alemu et al., 2018; Hyuha et al., 2017; Kebede et al., 2014; Madau et al., 2017; Sheahan and Barrett, 2017; Tung, 2013; Wassie, 2014). Understanding the determinants underlying teff growers of allocative efficiency is important to improving teff yield through enhanced participation of such an efficiency. There is different literature focusing on factors affecting the allocative efficiency (Aboki et al., 2013; Haile, 2015; Kareem et al., 2008; Ogundari and Ojo, 2017; Tijjani and Bakari, 2014). This research focused on the allocative efficiency to produce an optimum level of yield at economic efficiency or the least cost (Farrell, 1957). Employing the existing studies, the study expands the analysis by looking important set of poverty and food insecurity measures. Finally, this study was developed to evaluate the determinants of teff cultivating allocative efficiency. More specifically, the objective of the current study was to evaluate determinants that influencing the allocative efficiency of teff growing in the study area.

2. METHODS AND MATERIALS

Description of the study area

The study was developed in southern Ethiopia; Gombora district is situated 282 km southwest of the capital city of Ethiopia (Addis Ababa). Gombora district is situated at 70 37′ N and 370 40′ E latitude and longitude respectively. The total population of the Gombora district is 101,588 (100%), of which 53,053 (52.22%) is male and 48,535 (47.78%) is female. The total cereal growers in the Gombora district are 21,851, majority of growers which 20,240 (92.63%) are male. Agro ecological, the Gombora district is categorized into 3 agro ecological zones: Dega (6%), Weina Dega (49%), and kola (45%). The average annual rainfall varies from 1000 mm to 1085 mm and has an average yearly temperature of 26^0c. The total land area of the Gombora district is 45,795 ha, of which 33, 482.5 ha (73.11%) is high potentially cultivable land in the study area. The population density in the study district is high (693.37 per square km) and there is a high number of young cereal crop growers in the study district. Gombora district was a suitable district for cultivating teff for many reasons. Firstly, the Gombora district with high potential for teff yields. Secondly, the district allocative efficiency application has been expanded and implemented for teff production. Widely applicable extension and recommendation on teff growing allocative efficiency conducted in the Gombora district.

Sampling technique

For the study, multi-stage sampling methods were developed to select teff growers. In the first stage: Gombora district was purposely selected based on agroecology and potentials of teff yield. In the second stage: teff growing kebeles in the district were selected based on the teff yield and six teff growing kebeles namely Sage, Wera, Bole, First Ole, Second Ole, and Wabo randomly selected. Thirdly, the total number of teff growers in the yield year 2020/21 was identified. Total teff cultivators (18,424) were selected from teff cultivators kebeles stratified by employing allocative efficiency status. Finally, a total number of 391 teff growers were selected from six kebeles by employing a simple random sampling method. According [39] to sample size determination formula $n = \frac{N}{1+N\,(e^2)}$ the size sample were determined. Teff grower is an adopter of allocative efficiency with innovation from initial that teff grower becomes aware innovation to the emblements to apply allocative efficiency. Where n is sample teff grower, N is the total number of teff grower and e is the level of precision (0.05). A total number of 391 teff growers were selected from each stratum using proportionate selecting procedures (Table 1). Finally, a total number of 391 teff growers were selected from five kebeles by employing a simple random sampling method.

Table 1: Sample of teff cultivator based on the level of allocative efficiency

Selected Kebeles	Total number of teff grower (N_i)	A total sample size of teff grower (n_i)
Sage	3,068	65
Wera	2,994	64
Bole	2,989	63
First Ole	3,109	66
Second Ole	3,086	66
Wabo	3,178	67
Total	18,424	391

Note: n_i = total sample size of teff grower i (i = 1, 2, 3, 4, 5); N_i = total number of teff grower i

Types and sources of data

In this study, both primary and secondary data sets as well as both qualitative and quantitative primary data were developed for the study. The primary data sets were collected including teff grower environmental, demographic, institutional, and inputs characteristics and adoption decision of allocative efficiency. The primary data sets were collected from teff growers through questionnaires, interviews, and discussion. The structural questionaries employed were prepared to contain questions on teff outputs, prices of teff yield, quantities inputs, all environmental, demographic, and institutional factors that influencing the teff grower's allocative efficiency. Both open and close-ended questionnaires were conducted to achieve all objectives of the study. Primary data was prepared from February to June 2020/21 teff growing seasons. The supplementary data such as secondary data sets were collected from published and unpublished sources, agricultural and rural development administrative offices, internets, empirical literature, rural teff cultivators, and non – cultivators. The study was conducted cross-sectional field survey data of 2020/2021 main growing season was employed.

Method of data analysis

The data for the study were analyzed by using both descriptive and econometrics data analysis. Descriptive analysis was identifying teff grower environmental, demographic, institutional, and inputs characteristics. For the descriptive analysis frequency, percentages, averages, stander deviation, maximum values, minimum values, t-test, and $\chi 2$ were developed. Particularly, this study employs $\chi 2$ tests for examining relations between teff growing allocative efficiency and qualitative determinants of allocative efficiency. Additionally, a t-test should be employed for assessing associations between teff growing allocative efficiency and quantitative factors affecting allocative efficiency. Furthermore, this study developed econometric methods to evaluate in-depth analysis. This study develops a stochastic yield frontier model to examine factors influencing the teff grower allocative efficiency among teff cultivating farmers. Stochastic cost frontier model was developed to estimate allocative efficiency of teff grower, whereas stochastic frontier model was applied to estimate the extent of teff production efficiency. Two limit Tobit model was employed to identify factors that affect the allocative and economic efficiency level of teff growers. The stochastic frontier approach is more relatively better measure of efficiency (Coelli et al., 2005). Moreover, a Tobit model is more appropriate when the dependent variable is delimited between 0 and 1 (Greene, 2003). The estimate agricultural production efficiency by using stochastic frontier (Aigner et al., 1977; Alemu and Haji, 2016; Alemu et al., 2018; Bati et al., 2017; Kebede et al., 2014; Meeusen and van Den Broeck, 1977; Obare et al., 2010; Ogundari and Ojo, 2017; Sibiko et al., 2013; Tijjani and Bakari, 2014; Wassie, 2014), independently proposed the stochastic frontier production function model in the following from (Eq. (1)):

$$Y_i = f(X_{ij};\beta)exp^{(v_i-\mu_i)} \quad (1)$$

Where Y_i is the potential production level of the ith firm; $f(X_i;\beta)$ is a suitable function; X_{ij} is Vector of actual jth inputs used by the ith firm; β is a vector of parameters to be estimated, and v_i is random variability in the production that cannot be influenced by the firm, and μ_i is a deviation from maximum potential output attributable to technical inefficiency of ith teff grower or a non-random error term associated with the farm-specific factors which contribute to the i^{th} the farm does not attain maximum efficiency. The symmetric error term (v_i) captures the stochastic effects outside the teff grower's control. The error term μ_i is a one-sided ($\mu \geq 0$) efficiency component that captures technical inefficiency. The one-sided error can follow such distributions as half-normal, exponential, and gamma (Aigner et al., 1977). The two components v_i and μ_i are also assumed to be independent of each other.

The stochastic frontier cost function is a dual function derived from the stochastic frontier production function model for estimating farm level of Allocative efficiency. To specify a stochastic frontier cost function, the error term specification is simply altered from $(v_i - \mu_i$ to $(v_i + \mu_i$ .This substitution would transform the production function defined by (1) into the cost function. The stochastic frontier cost function is specified as the equation from (Eq. (2)):

$$C_i = g(Y_i, P_i, \alpha) + \left(v_i + \mu_i\right);\ i = 1, 2, \ldots\ldots, n \tag{2}$$

Where C_i is total production cost, g is a suitable functional form, Y_i is teff output produced, P_i is the cost of input, α is parameters of the cost function to be estimated, and v_i is the systematic component which represents random disturbance cost due to factors outside of the scope of the teff growers. It is assumed to be identically and normally distributed with mean zero and constant variance as $(0, \delta^2 v)$, and μ_i *is* also a one-sided disturbance term used to represent cost inefficiency and it is independent of v_i. Thus, $\mu_i = 0$ for a farm whose cost lays on the frontier, $\mu_i > 0$ for farms whose cost is above the frontier, $\mu_i < 0$ for farms whose cost is below the frontier. The two error terms are proceeded by positive signs because inefficiencies are always assumed to increase the cost (Coelli et al., 2005).

The cost-efficiency of individual teff growing farm is defined in terms of the ratio of the observed cost (C) to the corresponding minimum cost(C^*) given the available technology. That is, cost-efficiency(C_{EE}) developed is specified as (Eq. (3)):

$$C_{EE} = \frac{C}{C^*} = \frac{g(P_i, Y_i, \alpha) + \left(v_i + \mu_i\right)}{g(P_i, Y_i, \alpha) + (v_i)} = \exp\left(\mu_i\right) \tag{3}$$

Where the observed cost (C) is the actual production cost whereas the minimum cost (C^*) is the frontier total production cost or the least total production cost level. In this study the stochastic frontier Cobb-Douglas stochastic frontier cost function for sample teff growers in the study area was specified as following equation (Eq. (4)):

$$\ln C_i = \alpha_0 + \alpha_1 \ln P_{1i} + \alpha_2 \ln P_{2i} + \alpha_3 \ln P_{3i} + \alpha_4 \ln P_{4i} + \alpha_5 \ln P_{5i} + \alpha_6 \ln P_{6i} + \alpha_7 \ln Y_i + (v_i + \mu_i) \tag{4}$$

Where C_i is the total production cost of teff; $P_1$is the rental value of the land; P_2 is the cost of seed; P_3 is the cost of labor, P_4 is the cost of oxen, P_5 is the cost of UREA fertilizer and P_6 is the cost of NSPB fertilizer, Y_i is teff output in kg and α_i are parameters to be estimated and v_i and μ_i are defined earlier in equation (1). The Allocative efficiency of individual teff growers is defined in terms of the ratio of the predicted minimum cost (C_i*) to observed cost (C_i). Therefore, Allocative efficiency is an inverse function of cost efficiency and so, ranges between 0 and 1. Allocative efficiency of farm-level is computed, obtained using the relationship in the form of following function (Eq. (5)):

$$\mathrm{AE} = \frac{\mathrm{Ci}*}{\mathrm{Ci}} = \exp(\mu_i) \quad (5)$$

To determine the relationship between socioeconomic and institutional factors, and the computed indices of allocative efficiencies, a two-limit Tobit model was utilized. A two-limit Tobit model is a censored normal regression model where the dependent variable is continuous but its range is constrained both from above and below by cut-off points and delimited between 0 and 1. Therefore, the empirical econometric model in this study for the investigation of socio-economic and institutional factors of allocative efficiency levels was estimated by the following model (Eq. (6)):

$$AE_i = \delta_0 + \delta_1\mathrm{AGEHH} + \delta_2\mathrm{SEXHH} + \delta_3\mathrm{EDUCLEVEL} + \delta_4\mathrm{FARMSIZE} + \delta_5\mathrm{LANDFRAG} + \delta_6\mathrm{TLU} + \delta_7\mathrm{CREDRECEIVE} + \delta_8\mathrm{REMIRECEIVE} + \delta_9\mathrm{FAMSIZE} + \delta_{10}\mathrm{SEEDVAR} + \delta_{11}\mathrm{FREQEXTVISIT} + \delta_{12}\mathrm{LANDOWNER} + \delta_{13}\mathrm{LANDSLOPE} + \delta_{14}\mathrm{SOILFERTILITY} + \mu_i \quad (6)$$

Where AE_i is allocative efficiency indices, the subscription, indicates the i^{th} teff growers in the sample ($i = 1, \ldots, 193$), $\delta_0, \delta_{1i}, \ldots, \delta_{14i}$ are parameters to be estimated, μ_i error term, AGEHH is the age of the teff growers, SEXHH is the sex of the sample teff growers, EDUCLEVEL is the educational level of the teff growers, FARM SIZE is the total Farm size of the teff growers, LANDFRAG is land fragmentation of f teff growers, TLU is the number of livestock in terms of Tropical Livestock Unit (TLU), CREDRECEIVE is Credit received or not, REMIRECEIVE is remittance received or not, FAMSIZE is the family size in Man days, SEEDVAR is seed variety used, FREQEXTVISIT is the frequency of extension contact, LANDOWNER is land ownership of farmers, LANDSLOPE is teff Plot of the land slope, and SOIL FERTILITY is effed plot of soil fertility.

3. RESULTS AND DISCUSSIONS

Descriptive analysis

(Table 2) indicates that the descriptive summary statistics of the teff cultivator by type of teff growing yield of allocative efficiency (i.e., achieving allocative efficiency status). Out of a total of 391 (100%), about 231 (59%) of the teff cultivators allocative inefficient method of sowing, which was relatively larger than those who did 160 (41%) during the 2020/21 sowing season.

Table 2: Sample teff growers by of allocative efficiency status

Allocative efficiency status	Frequency	Percent	Cumm. percent
Allocative inefficiency	231	59	59
Allocative efficiency	160	41	100
Total	391	100	

Source: Computed from own survey data 2020/21

According to the teff growers of Gombora district, there is high allocative inefficiency of teff crop due to low interest to grow teff cereal, topography not suitable of planted land due to shortage of availably family labor, poor access to infrastructure, low credit access, and weak fertilizer distribution, and logging water were among the reasons found to face teff yield allocative inefficiency. Additionally, some of them mentioned that government needs to consider distributing teff yield-enhancing allocative efficiency machines to substitute labor force by machine and to save the time of teff growing.

(Table 3), summary statistics of rental value teff grower land ranged between 2,986 ETB to 16,000 ETB, and the average land cost was 6,540.27 ETB. The mean teff seed cost of teff growers was 273.28 ETB. Like another input, the cost of inputs on average human cost (cost of labor was 5,387.22 ETB), and the cost of animal (cost of oxen was 3,363.74 ETB). Summary statistics of average teff grower fertilizer spent was 975.30 ETB for purchasing UREA while 858.21 ETB for purchasing of NSPB fertilizer. The average size of teff growers was 5.12 Man days (MDs), ranging from 2 MDs to 9 MDs, and the standard deviation is 1.48. The average age of teff growers was 46 years, which indicated that growers are active and expected to enhance teff production, and improve allocative efficiency. The average cultivated land size was 1.38 ha, average land fragmentations were 4.75 plots, and mean livestock holding was 5.27 TLU. Extension visit is key to enhancing the production and efficiency of teff crop. The mean extension visit of the teff grower in the study area was 3.75. Similar results have been presented (Aboki et al., 2013; Bati et al., 2017; Cheng et al., 2017; Haile, 2015; Kareem et al., 2008; Teklu, and Tefera, 2005; Thiam, 2001; Tijjani and Bakari, 2014), for Gombora district.

Table 3: Summary statistics of teff growers for continuous variables

Variables	Unit of measurement	Mean	Std. Deviation	Min.	Max.
Input cost variables					
Output	Kg	728.94	399.66	150	1,500
Land cost	ETB	6,540.27	4,384.44	2,986	16,000
Seed cost	ETB	273.28	93.87	53.86	767.36
Labor cost	ETB	5,387.22	2,834.86	2,230	22,375
Oxen cost	ETB	3,363.74	884.78	790	7230
UREA cost	ETB	975.30	641.52	267.36	3,600
NSPB cost	ETB	858.21	522.46	267.36	2,986
The efficiency of factor variables					
Age		46	13.73	21	85
Size of family		5.12	1.48	2	9
Farm size		1.38	0.72	0.25	4.25
Land fragment		4.75	1.75	2.25	9.55
Livestock holding (TLU)		5.27	1.82	1.25	11.85
Extension visit		3.75	1.48	0	7.25

Source: Computed from own survey data 2020/21

(Table 4), accordingly, 77.24% of teff growers were illiterate, and 22.76% literate cultivators attained primary and above primary schooling. As the estimated majority of teff growers were males (82%). Most of the teff growers were perceived plot as not fertile (61.38%), 57.54% of the land slope is plain. 79.28% of cultivators used local teff variety, followed by improved variety

(20.72%). An expected 82.35% of cultivators had their land, 69% had no access to credit, and 69.82% had not got remittance. The findings of current research are in line with the findings of (Ahmed and Melesse, 2018; Alemu et al., 2018; Ayele et al., 2019; Debebe et al., 2015; Ogundari and Ojo, 2017; Tijjani and Bakari, 2014), employed study on allocative efficiency.

Table 4: Summary statistics of teff growers for dummy variables

Variables	**Type**	**Frequency**	**Percent**
Sex	Female	70	18
	Male	321	82
Seed variety	Local	310	79.28
	Improved	81	20.72
Land ownership	Rental	69	17.65
	Own	322	82.35
Land slope	Steep	166	42.46
	Plain	225	57.54
Remittance received	No	273	69.82
	Yes	118	30.18
Educational status	Illiterate	302	77.24
	Literate	89	22.76
Soil fertility	Fertile	151	38.62
	Not fertile	240	61.38
Credit received	No	270	69
	Yes	121	31

Source: Computed from own survey data 2020/21

The result presented at the (Table 5), the summary statistics of allocative efficiency indicated a moderate difference is observed ranging from 65% to 98%, and a mean of 88%. This presented average teff cultivators were to achieve the allocative efficiency level of their most efficient counterpart. Average growers could achieve a 10.2% cost saving$\left[i.e.,\left(1-(88/98)\right)*100\right]$, and allocative inefficient of cost savings of 33.67%$\left[i.e.,\left(1-(65/98)\right)*100\right]$.

Table 5: Summary statistics of the frequency distribution of AE estimate indices

Class	Allocative efficiency	
	Frequency	Percent
0.11-0.20		
0.21-0.30		
0.31-0.40		
0.41-0.50		
0.51-0.60		
0.61-0.70	10	2.56
0.71-0.80	34	8. 69
0.81-0.90	115	29.41
>0.90	232	59.34

Total	391	100
Mean	0.88	
Minimum	0.65	
Maximum	0.98	

Source: Computed from own survey data 2020/21

Econometric results

According to the (Table 6), stochastic frontier cost function result estimated diagnostic statistics of inefficiency sigma squared (δ^2) is 0.022, statistically significant at 1% level. Therefore, the gamma (γ) value of was 0.876 indicated that 87.6% variation in cost because of in allocative inefficiencies of teff growers while variation was the effect of the disturbance term. This improved opportunity for saving the cost of teff yield by investigating factors that affect efficiency. The results in Table 6 estimated the stochastic frontier cost function was found the cost of (land, seed, labor; oxen power, UREA, and NSPB fertilizer) were significant at a 1% probability level. These all-significant variables are crucial in enhancing teff yield. The cost elasticity was positively influenced total teff yield cost i.e., a 1% increase in the cost of (land, seed, labor, oxen power, UREA, and NSPB fertilizer), will increase the total cost of teff yield by 0.258%, 0.043%, 0.175%, 0.065%, 0.028%, and 0.065% respectively. This regression result was found to have similar results of (Bati et al., 2017; Cheng et al., 2017; Haile, 2015; Kareem et al., 2008; Teklu, and Tefera, 2005; Tijjani and Bakari, 2014), conducted a study on the allocative efficiency.

Table 6: Parameter estimation of maximum likelihood of Cobb-Douglas stochastic cost frontier function

Variables	OLS estimates		MLE estimates	
	Coefficient	SE	Coefficient	SE
ln (land) cost	0.286***	0.027	0.258***	0.012
ln(seed)cost	0.082***	0.012	0.043***	0.018
ln (labor) cost	0.152***	0.018	0.175***	0.015
ln (oxen) cost	0.031	0.017	0.065***	0.019
ln (UREA) cost	0.002	0.013	0.028**	0.017
ln (NSPB)cost	0.076***	0.013	0.065***	0.015
ln (output)	-0.058	0.035	0.001	0.018
Constant	1.881***	0.140	1.202***	0.115
Model parameters				
Likelihood function	143.4		157.7	
Sigma^2			0.022***	
Lambda			6.601	
Gamma			0.876***	
Observations	391		391	

Source: Computed from own survey data 2020/21; *** p<0.01, ** p<0.05, * p<0.1

(Table 7), regression result of two-limit Tobit model estimated allocative efficiency was significantly affected by age, sex, educational status, livestock holding, credit use, farm size, seed variety, land holding, and soil fertility of teff growers. From these key determinants age, sex, educational status was negatively influenced allocative efficiency while farm size, livestock holding, credit use, seed variety, landholding, and soil fertility determine negatively. The marginal effect of significant variables ranges between -2.4% and 2.1%. Marginal effect livestock holding, credit use, seed variety, landholding, farm size, and soil fertility were 1.4%, 1.2%, 1.7%, 1.2%, 2.1% and 1.1% respectively while age, sex and educational status were -0.2%, -2.4% and -1.4% respectively. Teff growers increase farm size of teff on average for the allocative efficiency of teff by 1%, they can enhance the level of allocative efficiency by 2.1% while the age of teff grower increase by one year, allocative efficiency decreases by 0.2%, ceteris paribus. The result presented sex of the teff grower negatively influences allocative efficiency. The result in the Table 7 revealed male growers were less allocative efficient than their counterparts. Male growers' allocative efficiency will decrease by 2.4% than their counterparts. Two-limit Tobit model regression result found to have similar results of (Aboki et al., 2013; Alemu and Haji, 2016; Alemu et al., 2018; Haile, 2015; Kareem et al., 2008; Ogundari and Ojo, 2017; Tijjani and Bakari, 2014), conducted a study on the allocative efficiency.

Table 7: Two-limit Tobit model estimates for determinates of allocative efficiency (AE)

Variables	AE		AE	
	Coef.	Std. Err.	Marginal effect Coef.	Marginal effect Std. Err.
Age of grower	-0.00137**	0.000574	-0.002**	0.002
Sex of grower	-0.0241**	0.0146	-0.024**	0.012
Educational status	-0.0143**	0.0132	-0.014**	0.013
Farm size	0.0205***	0.0212	0.021***	0.011
Land fragmentation	-0.02215	0.00277	-0.012	0.014
Livestock holding	0.00412***	0.00274	0.014***	0.017
Credit	0.00215***	0.0123	0.012***	0.016
Remittance	-0.00627	0.0132	-0.016	0.018
Family size	-0.00302	0.00406	-0.014	0.015
Seed variety	0.00265***	0.0145	0.017***	0.016
Extension visit	-0.00794	0.00456	-0.014	0.012
Land holding	0.00142***	0.0279	0.012***	0.019
Land slope	0.00152	0.0221	0.015	0.015
Soil fertility	0.00114***	0.0224	0.011***	0.013
Constant	0.876***	0.0411	0.876***	0.031
Observations	391		391	

Source: Computed from own survey data 2020/21; Robust std. err. *** p<0.01, ** p<0.05, * p<0.1

Limitations and future research directions

This study has its own limitations. Firstly, the current research may be limited by in scope and depth as it only focused allocative efficiency of teff productivity. Secondly, this research only was in Gombora district; hence, this research was unable to incorporate quantitative data from other area in the country. As a result researchers are advised to investigate this research by expanding the scope, depth, and comparisons among different countries. Other considered limitations were COVID-19 pandemic, interaction of knowledge, strategy, and promoting study for allocative efficiency of teff productivity. Therefore, to enhance the allocative efficiency of teff productivity, increasing the implementation action is very vital.

4. CONCLUSIONS AND POLICY IMPLICATIONS

The agricultural sector is crucial *i*n deriving sustainable economic development by enhancing productivity and efficiency in yield with alleviating poverty and food insecurity. This study was aimed at investigating the factors affecting allocative efficiency among teff growers in the Gombora district in southern Ethiopia. For the data analysis, both primary and secondary data were presented. For the study, descriptive statistics and econometric methods such as the stochastic cost frontier model and two-limit Tobit model were utilized. The two-limit Tobit model was employed to represent factors that influence the extent of allocative efficiency. There is a big variation in allocative efficiency between 65% and 98%, and the average of allocative efficiency was 88%. Teff growers could achieve a 10.2% cost saving through optimum utilization of scarce resources and technology. Maximum likelihood estimation of Cobb-Douglas stochastic frontier cost model presents diagnostic statistics of inefficiency component sigma squared (0.022), composite error term and gamma (0.876), and differences in production from allocative inefficiency of teff producers was 87.6%, and 12.4% of the variation. This variation is due to the effect of the disturbance term, and random variation. The estimated results of stochastic frontier cost function were found the cost of land; cost seed, cost labor, cost oxen power, cost UREA, and cost NSPB fertilizer were significant at a 1% significance level. Moreover, the two-limit Tobit model result showed that age, sex, educational status, farm size, livestock holding, credit use, seed variety, landholding, and soil fertility of teff growers affect the allocative efficiency level of teff cultivators. Therefore, more importantly, the study results presenting the crucial factors underlying teff growers' decision of enhancing allocative efficiency should serve as key input designing plan and making policies. Hence, strengthening the credit use of teff growers through awareness and knowledge enhances teff yield allocative efficiency. Effective use of credit, livestock holding, landholding, seed variety, and soil fertility positively enhances teff yield allocative efficiency. Consequently, credit use recommended as enhanced productivity and allocative efficiency should also help increase agronomic practices. Concern bodies should create a conducive environment in credit, livestock holding, landholding, seed variety, and soil fertility to help to enhance efficiency in teff yield.

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