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Economic Efficiency in Sorghum Production: The Case of Some Selected Districts of Fafan, Somali Region, Ethiopia

Kader Ahmed Abdulahi[1], Abdi Mohammed Hussein[1], Shamsedin Mahdi Hassan[2*]

[1]Department of Rural Development and Agricultural Extension, College of Dryland Agriculture, Jigjiga University, Jigjiga, Ethiopia
[2]Department of Food Science and Nutrition, College of Dryland Agriculture, Jigjiga University, Jigjiga, Ethiopia
Email: *shamsedinmahdi1@gmail.com

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Abstract

This study examines the economic efficiency of sorghum production in designated districts of Fafan, Somali National Regional State, Ethiopia, with a focus on enhancing agricultural sustainability. Utilizing a mixed-methods approach, including quantitative surveys and qualitative interviews, the research assesses factors influencing efficiency, such as input utilization, farming practices, and socio-economic variables. Stochastic frontier analysis (SFA) is employed to gauge technical, allocative, and overall economic efficiency. Preliminary findings indicate variations in efficiency among districts, emphasizing the need for tailored interventions. Access to modern inputs, education, and extension services emerge as critical factors. The study offers recommendations to policymakers and stakeholders for targeted strategies to improve sorghum production, enhance food security, and uplift the livelihoods of farmers in the region.

Subject Areas

Agricultural Science, Agronomy, Food Science & Technology

Keywords

Economic Efficiency, Sorghum, Production, Somali Region, Ethiopia

1. Introduction

Ethiopia, the country with an area of about 1.12 million square kilometers, is one of the most populous Counties in Africa with the population of 115 million in 2018 with annual growth rate of 2.8% [1]. This growing population requires bet-

*Corresponding author.

ter economic performance than ever before at least to ensure food security. However, the agricultural sector in the country is characterized by; small-scale, subsistence-oriented, an adverse combination of agro climatic, demographic, economic and institutional constraints and shocks and heavily dependent on rainfall. Ethiopian agricultural sector contributes about 33.88% of the country's GDP and employs 65.62% of total labour force [2]. The sector plays a pivotal role to induce the industrialization process in the country. Therefore, enhancing the productivity of such a sector is crucial not only for the development of the sector themselves but also for the development of other sectors in the economy. Ethiopia is the country with the largest grain producers in Africa. However, it is characterized by large pockets of food insecurity and a net importer of grains. Despite its dominance, [3], indicated that there were more than seven million people in need of food assistance in the country. The country is food insecure mainly due to a lack of improved technology and economic inefficiency in production. The smallholder farmers, who provide the major share of the agricultural output in the country, commonly employ backward production technology and limited modern inputs [1]. Hence, being an agriculturally dependent country with a food deficit, increasing crop production and productivity is not a matter of choice rather a must to attain food self-sufficiency. The principal cereal crops grown in Ethiopia are teff, wheat and barley, which are primarily cool-weather crops; and maize, sorghum and millet, which are warm-weather grain crops. As far as sorghum production is concerned, it is a widely distributed cereal crop in the world. In Africa, sorghum is grown in a bulky belt that extends from the Atlantic coast to Ethiopia and Somalia Maize covers 23 million ha in Sub-Saharan Africa, largely in smallholders that produced 23 million tons in 2015, primarily for food [4]. Sorghum is a significant contributor to the economic and social development of Ethiopia as well. As indicated [5], it is a crop with the largest smallholder coverage with 9.29 million holders, it has a significant impact on the livelihood of smallholders in Ethiopia, as the vast majority of Ethiopian farmers are small-scale producers. About 95% of Ethiopian farmers rely on less than five ha of land, of which 55% cultivate less than two hectares [6]. The role of sorghum in smallholder livelihood in the country can be expanded as sorghum is the crop with the highest current and potential yield from available inputs, at 2.01 tons per ha in 2018/19 with a potential for 4.7 tons per ha according to field trials, when cultivated with fertilizer, hybrid seed, and farm management practices [5]. The total output of sorghum in the same year at national level was 61.58 million qt. The same source indicated that in the Oromia region, the total area covered by the sorghum in the production year of 2017/18 was 1.12 million ha and 3.7 million metric tons were produced with the productivity of 2.09 metric tons per ha. The purpose of this research is to bring attention to the complex aspects of Ethiopia's agricultural environment, focusing on the crucial role that sorghum plays in determining the country's economic development and its sources of subsistence for its smallholder farmers.

2. Methodology

2.1. Description of the Study Area

The study will be conducted in the selected districts of the Fafan and Sitti zones. Fafan is one of nine zones of the Somali Region in Ethiopia. Fafan is bordered on the south by Jarar, on the southwest by Nogob, on the west by the Oromia Region, on the north by Siti, and the east by Somalia. Other towns and cities in this zone include Kebribayah, Dhurwaale Awbare, Derwernache, Tuli Gulled, and Hart Sheik. Based on the [7], a census conducted (CSA), this Zone has a total population of 790,794 of whom 616,810 are men and 5414,794 women. The average annual rainfall of the zone ranges from 380.1 to 756 mm and the average temperature during the growing period in the area ranges from 20.1˚C to 22.5˚C. The altitude is between 500 and 2500 m.a.s.l. The average annual temperature ranges from 27.5˚C - 18˚C, the average annual rainfall ranges from 200 to 1400 mm, and the potential evapotranspiration was estimated to be from 1438 to 2099 mm [8], is one of eleven Zones of the Somali Region of Ethiopia.

Sitti zone is Located at the north-western point of the Somali Region and is bordered on the south by Dire Dawa and the Oromia Region, on the west by the Afar Region, on the north by Djibouti, on the east by Somalia, and on the southeast by Fafan Zone. Other towns and cities in this zone include Aysha, Shinile, Dewele, Harewa, Adigale, Erer, Bike and Afdem. Based on the [7], census conducted by the Central Statistical Agency of Ethiopia, this Zone has a total population of 750,320 of whom 324,120 are men and 326,200 women. The region elevation is the principal determinant in temperature levels, on average, as 17˚C (62˚F) and has rain fall ranges from 223 - 660 mm sorghum is cultivated at the southern part of the zone.

2.2. Sampling Technique and Sample Size

Due to the importance of sorghum and its extent of production in the area, the zone will be selected purposively. Then, a two-stage purposive and random sampling technique will be used to select sample districts and households for this study. In the first stage, six districts that produce sorghum will be selected purposively. In the second stage, sample farmers from randomly selected twelve kebeles will be selected using simple random sampling technique from each district proportional to the total number of households of the districts. The sample size will be determined based on the following formula given by [9].

$$n = \frac{N}{1 + Ne^2} \tag{1}$$

where n is the sample size, N is the number of sorghum-producing households in the district which is 4967 and e is the desired level of precision which was taken to be 8%. Hence, the sample size is 152.

2.3. Types of Data and Methods of Data Collections

The primary data for the study was collected through structured questionnaires administered by trained enumerators. These enumerators were selected based on their ability to speak the local language as well as English, enabling them to effectively communicate with respondents. They underwent training to ensure consistency and accuracy in data collection. The questionnaire was pre-tested to identify any issues, and necessary corrections were made before the actual data collection process began. Additionally, both the researcher and enumerators provided sufficient information about the study's objectives to the sample households to minimize potential biases in their responses. Furthermore, secondary data was also collected from relevant sources such as the Bureau of Agriculture in the study districts and other pertinent institutions. This secondary data provided additional context and background information for the study, as well as served to verify the primary data collected through the structured questionnaires. This secondary data provided additional context and background information for the study, as well as served to verify the primary data collected through the structured questionnaires. The secondary data for this study has been successfully collected from various reliable sources, including the Bureau of Agriculture of the selected districts and other relevant institutions.

These secondary data sources have provided a comprehensive background and context for the study, allowing for a thorough understanding of the agricultural landscape and socio-economic dynamics within the study areas. The Bureau of Agriculture served as a primary secondary data source, providing valuable information on agricultural practices, land use patterns, crop production statistics, and other relevant agricultural indicators specific to the selected districts. This data has been instrumental in validating and complementing the primary data collected through structured questionnaires.

In addition to the Bureau of Agriculture, other relevant institutions such as agricultural research centers, development agencies, and academic institutions were also tapped as secondary data sources. These institutions possess a wealth of data and research findings related to agricultural productivity, environmental factors, market trends, and socio-economic conditions within the study areas.

2.4. Methods of Data Analysis

The study will employ both descriptive and econometric methods. In the descriptive part, measures of central tendency, frequency, and percentages will be used and in the econometric analyses, a stochastic frontier approach will be utilized to estimate the level of efficiencies and the relation between hypothesized variables and farm-level efficiencies will be studied using the Tobit model.

2.4.1. Efficiency Estimation

The stochastic production frontier will be used for its ability to distinguish inefficiency from deviations that are caused by factors beyond the control of farmers. The model introduces the disturbance term representing noise, measurement error, and exogenous shocks that are beyond the control of the production unit and a component that captures deviations from the frontier due to inefficiency.

The assumption that all deviations from the frontier are associated with inefficiency, as assumed in DEA, is difficult to accept, given the inherent variability of agricultural production due to many factors like climatic hazards, plant pathology, insects, and pests [10]. Furthermore, smallholder farmers in Ethiopia are characterized by low levels of education and keeping of records is thus non-existent. Thus, most available data on production are likely to be subject to measurement errors. Therefore, the stochastic efficiency decomposition methodology will be chosen as more appropriate for this study. The stochastic frontier production function can be written as:

$$Y_i = F\left(X_i;\beta\right)\exp\left(V_i - U_i\right),\ i = 1,2,3,\cdots,n \tag{2}$$

where Y_i is the production of the i^{th} farmer, X_i is a vector of inputs used by the i^{th} farmer, β is a vector of unknown parameters, V_i is a random variable which is assumed to be $N\left(0,\sigma_v^2\right)$ and independent of the U_i which is nonnegative random variable assumed to account for technical inefficiency in production.

As the stochastic frontier method requires a prior specification of the functional form, for this study, the Cobb-Douglas production function will be selected. The linear form of the Cobb-Douglas production function is represented in Equation (3).

$$\ln Y_i = \beta_0 + \ln\sum_{j=1}^{n}\beta_j X_{ij} + \varepsilon_i \tag{3}$$

where

$$\varepsilon_i = v_i - u_i;$$

ln = denotes the natural *logarithm*;

j = represents the number of inputs used;

i = represents the i^{th} farmer in the sample;

Y_i = represents the observed sorghum production of the i^{th} farmer;

X_{ij} = denotes j^{th} farmer input variables used in sorghum production of the i^{th} farmer;

β = stands for the vector of unknown parameters to be estimated;

ε_i = is a composed disturbance term made up of two elements (v_i and UI);

v_i = accounts for the stochastic effects beyond the farmer's control, measurement errors as well as other statistical noises and;

UI =captures the technical inefficiency.

Cobb-Douglas production function is attractive due to its simplicity and because of the logarithmic nature of the production function that makes econometric estimation of the parameters a simple matter. It is also very parsimonious with respect to degrees of freedom and it is convenient in interpreting elasticity of production. It is true, as [11] points out, that this function may be criticized for its restrictive assumptions such as unitary elasticity of substitution and constant returns to scale and input elasticities. The alternatives such as trans log production functions also have their own limitations such as being susceptible to multicollinearity and degrees of freedom problems. A study done by [12], suggests that functional specification has only a small impact on measuring efficiency. The self-dual nature of the Cobb-Douglas production and cost functions also provides the computational advantage in obtaining the estimates of TE and EE. Beside this, in smallholders farming, the technology is unlikely to be substantially affected by variable returns to scale [13].

For driving the dual cost frontier, the solution for the minimization problem given in Equation (4) will be essential.

$$\begin{aligned} &\min_{x} C = \sum_{n} \omega_n x_n \\ &\text{subject to } Y_k^{i*} = \hat{A} \prod_{n} x_n^{\hat{\beta}_n} \end{aligned} \tag{4}$$

where $\hat{A} = \exp\left(\widehat{B}_0\right)$

ω_n = input prices;

$\hat{\beta}$ = parameter estimates of the stochastic production function and;

Y_k^{i*} = input-oriented adjusted output level from Equation (11).

The following dual cost function will be found by substituting the cost-minimizing input quantities into Equation (5).

$$C\left(Y_k^{i*}, w\right) = HY_k^{i*\mu} \prod_{n} \omega_n^{\alpha_n} \tag{5}$$

where $\alpha_n = \mu \hat{\beta}_n$, $\mu = \left(\sum_n \hat{\beta}_n\right)^{-1}$ and $H = \frac{1}{\mu}\left(\hat{A} \prod_{n} \hat{\beta}_n^{\hat{\beta}_n}\right)^{-\mu}$

Generally, the dual cost frontier function can be represented in general form as follows:

$$C_i = C\left(\omega_i, Y_i^{i*}; \alpha\right) \tag{6}$$

where C_i: is the minimum cost of i^{th} farm associated with output Y_i^{i*}

ω_i : is the vector of input prices for the i^{th} firm;

α : is the vector of parameters to be estimated.

The economically efficient input vector for the i^{th} farmer will be derived by applying Shepard's Lemma and substituting the firm input price and adjusted output level into the resulting system of input-demand equations.

$$\frac{\alpha C_i}{\alpha \omega_n} = X_i^e\left(\omega_i, Y_i^{i*}; \theta\right) \tag{7}$$

where θ is the vector of parameters and $n = 1, 2, 3, \cdots, N$ inputs.

The observed, technically and economically efficient cost of production of the i^{th} farm are equal to $\omega_i^{'} X_i$, $\omega_i^{'} X_i^t$ and $\omega_i^{'} X_i^t$. Those cost measures will be used to compute technically and economically efficient indices of the i^{th} farmer as follows:

$$TE_i = \frac{\omega_i^{'} X_i^t}{\omega_i^{'} X_i} \tag{8}$$

$$EE_i = \frac{\omega' X_i^t}{\omega_i^{'} X_i} \tag{9}$$

Following Farrell (1957), allocative efficiency index of the i^{th} farmer can be derived from Equations (8) and (9) as follows;

$$AE_i = \frac{EE_i}{TE_i} = \frac{\omega_i^{'} X_i^t}{\omega_i^{'} X_i^t} \tag{10}$$

To determine the relationship between socioeconomic and institutional factors and the computed indices of efficiencies, a Tobit model will be utilized. The Tobit model will be adopted because the efficiency scores are double truncated at 0 and 1 as the scores lie within the range of 0 to 1.

2.4.2. Definition of Variables and Hypotheses

1) Production Function Variables

These will be the dependent and independent variables measured in physical terms. These variables will be used in determining the stochastic frontier production function of maize in the study areas and will be specified as follows:

Output: It will be the physical amount of sorghum in qt that the sample households obtained from their farm during the production season of 2020/21. This will be the dependent variable of the production function that will be taken as a continuous variable.

Land: This will be the physical amount of land allocated to sorghum production during the production season of 2013/14 measured in ha. It will be taken as a continuous.

Labor: This input will capture family and hired labor used by the sample households for different agronomic practices of sorghum production measured in man-days. It will be converted to man-equivalent using conversion factors for different labor classes participating in the production process.

Seed: This will be the quantity of sorghum seed used by respondents measured in kg.

Fertilizer (Urea/DAP): This will be the number of fertilizers used by the sample farmers for their sorghum crop in the production year of 2020/21 measured in kg.

Oxen: This will be the amount of oxen that will be used for agricultural activities by the farmers to produce sorghum. It will be measured in oxen-day used to perform activities by the sample respondents.

2) Input Prices

This includes variables that will be used in the frontier cost. These variables will be assumed to be positively related to the total variable cost of sorghum production.

Price of fertilizers: (Urea/DAP): This will be recorded as the market price paid to purchase the fertilizers during the 2020/21 production period.

Price of seed: The amount that paid by farmers to purchased seed will be recorded and for owned seed the price required for the same quality and quantity in the local market during the same production season will be considered.

Price of labor: For hired labor, the wage paid to the workers will be recorded and for family labor (unpaid workers) it will be estimated as the wage paid in the locality for the same quality labor.

Price of land: Land does not have a market price so the rental price will be used. For owned land, land rent paid to the same quality and size paid in the locality will be taken and for rented-in land, the amount paid will be taken as its price.

Price for animal power: This will be estimated as the amount of cash paid for the renters per oxen day.

3) Definition of Efficiency Variables and Hypothesis

These are variables hypothesized to explain the difference in production efficiency among farmers. Those variables were selected based on previous studies and the socioeconomic conditions of the study area.

Education: Formal education commonly measured in years of schooling of the farmer will be expected to influence production efficiency positively. Educated farmers are expected to have more exposure to the external environment and accumulated knowledge through formal learning which might enable them to pursue production strategy that leads to better efficiency and resource allocation by making use of available knowledge. Ismat *et al.*, [14] investigated economic efficiency and argued evidence that schooling improves technical and economic efficiencies.

Cultivated land: This variable will be taken as a continuous variable measured as the total cropped area in hectares under the household management (be its own land or rented-in land). It will be hypothesized that as the farm size increases the efficiency of the farmer will decrease. This is because, as the farm size increases the managing ability of the farmer will decrease given the level of technology. Essa *et al.*, [15] have argued that total area cultivated had a negative effect on technical efficiency.

Extension contact: This variable will be measured as a discrete variable of the frequency of contacts with extension workers in a year. The higher the linkage between farmers and development agents, the more the information flows and the technological (knowledge) transfer from the latter to the former. Those farmers who have frequent contact with development agents are likely to produce better than others. Extension contact was argued to affect economic efficiency positively in the work of [16].

Family size: This variable will be measured as a continuous variable by taking the total number of family members in the household. Then it will be aggregated by employing adult equivalent conversion factors after categorizing the members based on their sex and age. This variable will be hypothesized to affect the efficiency level of the farmers positively. This is because, as labor is the main input in crop production, a farmer who has a large family size could carry out important crop husbandry practices timely. Family size was related to economic efficiency positively in the work of [17]. On the other hand, others argued that an increase in family size would increase expenditure for home consumption which can affect the efficiency of farmers negatively by creating financial constraints.

Mekdes, [18], argued that technical inefficiency was positively related to family size.

Credit: This is a dummy variable that represents whether the farmer has obtained credit or not. If the farmer had access to the credit facility, the variable takes a value of one and zero, otherwise. This variable will be expected to have a positive coefficient. Farmers who get credit will get the capacity to purchase inputs that are necessary to improve productivity at the required time that access to credit affects economic efficiency positively.

Proximity: This is the distance between the farm where maize was cultivated and the residence of the respondents measured in km and it would be assumed to harm efficiency. This is because the farmer requires a longer time to visit the farm and manage properly and the frequency of the visit will reduce. The argument made by [19], indicated that the inefficiency of farmers increases as the distance between the farm and the homestead increases.

Crop rotation: This is a dummy variable which represents whether the farmer adopted crop rotation practice or not. It will take the value of one if the farmer adopted it and zero, otherwise. It will be hypothesized that farmers who practiced it could be more efficient than others as it helps to increase output by recycling and restoring nutrients required for maize production.

Training: Training increases the awareness of farmers and exposes to new ideas and information about the productivity of inputs, opportunities, input and output management, and prudent handling of cash. Farmers who trained will be hypothesized to be more efficient than those who did not receive training. It will be represented as a dummy variable taking a value of 1 if a household got training and 0, otherwise. Ismat *et al.*, [15], argued that training is positively related to technical and economic efficiency.

Soil fertility: This will be measured as a dummy variable that will take a value of 1 if a household perceives its farm as fertile and 0, otherwise. This variable will be hypothesized to determine efficiency positively as fertile land is more productive than less fertile once. A similar argument was made by [20].

Livestock size: This variable will be measured as the value of livestock holding of the farmers in TLU. This can be taken as a proxy variable for the wealth position of the farmers. The farmer who possesses more livestock will have a better capacity to purchase agricultural inputs as an income obtained from livestock serves for investment in crop production that would improve productivity. A farmer with a larger livestock unit has also the chance to get oxen for draught power. The number of livestock holding was found to relate positively to allocative and economic efficiency [21]. Others also argue that when all types of animals, poultry, and beehive production are considered, its supplementary effect could diminish and it is likely to become competitive.

Off/non-farm activities: This variable will be measured as a dummy variable that will take the value of 1 if a farmer was engaged in off /non-farm activities and 0 otherwise. If farmer spends more time on off/non-farm activities relative to farm activities, this might negatively affect agricultural activities. A similar argument was made by [22].

3. Result and Discussion

This chapter consists of two parts. The first part depicts and discusses results obtained from the descriptive statistics while the rest one tries to address econometric results gained from the stochastic frontier model and Tobit models.

3.1. Results of Descriptive Statistics

It is of quite worthy to begin with presenting the results that summarize the demographic, socio-economic, farm features and Institutional elements; input and output information of the sample farm households. After that, focus on presenting and discussing the results obtained from the econometric model.

3.1.1. Demographic and Socio-Economic Characters

Age, sex, and marital status: Regarding age, the result displayed that the average age of the sample household heads was about 32.67 years with a minimum of 24 and a maximum of 63 years. Concerning to Sex and marital status, the result of the survey indicates that nearly around 11.49% of the sample households were female-headed, and about 89.51% were male-headed. In the district male-headed households are responsible for undertaking almost all issues about agricultural production activities while female household heads in the rural area have also responsibilities in charge of various activities like looking after children, managing the house, collecting wood for fire from the field, fetching water, helping their husband in their field at their free time and the like. The survey result displayed that the total number of married, divorced, and widowed households was 119, 8, and 24 respectively. In the area Females when they were divorced or widowed, opted to play the role of both male and female and undertake the task of farming, rearing livestock, and managing the house unless their children help them.

Family size: Based on the survey result, the average family size of the sample households was revealed as 5.78 with a minimum of 3 and a maximum of 14. In the study area, the average family size was about 3.61 man equivalents per farm household. The greatest family size was 6.5 while the least was a man equivalent per household. Family size is considered the source of labor on which the success and failure of smallholder farming practices depend as it saves the cost of hiring labor and achieves many farming activities on time.

Educational level: according to the survey, the education level of the respondents which is measured in years of schooling shows that the average level of education is 2.03. The education level of the households varies from zero (illiterate) where most of the respondents were illiterate to grade 12 which is attended by none of the respondents. It is obvious that educations are a tool that enables the farmers advance the quality of labour and develop the managerial skill through which efficiency of farmers improved. Furthermore, the higher the education level of the farmers, the more farmers achieve their farm activities in a good manner.

Livestock ownership: According to the result of the survey and focus group discussion undertaken, it is addressed that Livestock in the study area known by providing multiple product and services for farmers engaged in mixed farming system. They deliver products like meat, milk, and services like draught power and manure that serve as production inputs and even as means of income through selling it to other farmers. Moreover, livestock were considered as source of income and wealth. The survey result depicted that 69.73% of the household had number of livestock within that varies from 2 to 7 TLU. This indicates that nearly about 98.86% of total households own up to a maximum of 18 TLU while 1.01% sample households had no livestock. Besides this, 3.18% of the households owned livestock ranges 17.01 to 28.97 TLU. Livestock ownership of sample household ranges from 1 to 29.91 with a mean and standard deviation of 7.24 and 4.61 respectively. In the study area, in addition to tractor, oxen were the used as sources of ploughing power in the area. The farmer mostly uses the ox to generate income and purchase farm inputs and for home consumption. Conditionally, land preparation is undertaken through deploying a pair of oxen, however, the result shows that 27.4% of the sample respondents failed cultivate their farm using their oxen as they have only one ox. This leads to the scarcity of oxen power that in turn forces them toward hiring the tractors. Those who cannot afford tractors face the challenges of preparing the land and undertaking farm operations lately which harms production. Accordingly, the results illustrate that 29.1% of the farm households owned three oxen of three and above. Roughly 62.9% of the farm households have pairs of oxen. While 27.4% have a single ox and 2.1% have no ox at all.

Off/non-farm activities: Most of the respondents in the study area do not participate in off/non-farm activities. This may be due to the absence of opportunities (e.g. starting capital) that enable them to engage in off/non-farm activities along with the agricultural activities. Some off/non-farm activities like handicrafts, pottery, petty trade and the like require skills that are why there is a fear of bankruptcy among respondents. Given this few farmers engaged in off/non-farm activities and generated incomes. Accordingly, 25.53% of them participated in different types of off/non-farm activities while 75.47% are not take part in off/non-farm activities (See Table 1).

3.1.2. Farm Features

The result of focus group discussion revealed that most the famers perceived that as the number of ploughing increase the probability of proper germination of the seed increases and thus farm productivity also increase. This is contrary with the concept of conservation tillage or minimum tillage, which enhances the sustainable fertility of the land and minimizes the chance of soil erosion through maintaining the organic structure of the soil. The result of the survey stated that on average, sample respondents cultivated their sorghum land 2.72 times with a minimum of 1 time and a maximum of 4 times during the production year.

Table 1. Summarizes the demographic and socio-economic characteristics of the surveyed households in the study area.

Demographic and Socio-Economic Characters	Survey Result
Age	32.67 years (average) 24 years (minimum) 63 years (maximum)
Sex and Marital Status	Female-headed households: 11.49% Male-headed households: 89.51% Married households: 119 Divorced households: 8 Widowed households: 24
Family Size	5.78 (average) 3 (minimum) 14 (maximum)
Educational Level	2.03 years of schooling (average) Education level varies from illiterate to grade 12
Livestock Ownership	Average number of livestock per household: 7.24 Range of livestock ownership: 1 to 29.91 TLU Percentage of households owning livestock: 69.73%
Off/Non-farm Activities	Participants in off/non-farm activities: 25.53% Non-participants in off/non-farm activities: 75.47%

Soil fertility: Farmers' perception of the soil fertility status of their land depends mainly on the amount of manure applied on the farm. Hence, the result of the survey exhibited that 23% of respondents categorized their farm as "highly fertile", while 52% of the households rated it as "medium". The remaining 25% expressed their farm as low (infertile) in fertility status.

Land acquisition and utilization: In the study area 96% of the respondents acquired their land from their fathers in the form of inheritance while only 4% acquired in the form of rent and shared it with the owner of the land. The land is the most significant determinant of production for the people of the study area and almost the entire respondent uses most of their land (92.37%) for crop production and only a few parts (8.63%) for animal grassing. The results of the survey demonstrated that the mean land possessed by the farmers in the study area was 1.34 ha. About 29.1% of the sample respondents held land less than 0.9 ha whereas 15.9% of sample farmers owned greater than two ha of land. The mean size of land cultivated was 1.14 ha (See Table 2).

3.1.3. Institutional Factors

Extension service: The result of the survey revealed that there is a great disparity among farmers in the percentage of getting extension services from the existing development agents in the study area where some farmers are being visited more than 96.15% by extension workers while some respondents were visited only 4.85% by extension workers during production year. To ensure the diffusion and adoption of agricultural knowledge and technologies, increase efficiencies and fill the managerial and technical skill gap of the farmers, three development agents were assigned in each kebele. However, some respondents claim that extension workers were not well equipped and their knowledge were too

Table 2. Farm features.

Farm Features	Survey Result
Number of Ploughings per Production Year	Average: 2.72 times Minimum: 1 time Maximum: 4 times
Soil Fertility	Highly Fertile: 23% Medium: 52% Low (Infertile): 25%
Land Acquisition and Utilization	Inheritance: 96% Rent: 4% Land Used for Crop Production: 92.37% Land Used for Animal Grazing: 8.63% Mean Land Possessed: 1.34 ha Mean Cultivated Land: 1.14 ha
Institutional Factors	
Extension Service	Frequency of Extension Contact: Mean - 8.96, Standard Deviation - 6.68
Access to Credit	Formal: 7.51%, Informal: 57.12% Purposes: Agricultural Inputs, Home Consumption, Social Obligation, Live Animals
Distance to Nearest Market	Mean: 1.25 km, Range: 0.83 km to 6 km
Distance to Main Road	Mean: 48 minutes, Range: 5 minutes to 87 minutes
Communication Asset	Radio: 34.2%, Mobile: 51.7%, TV: 18% No Radio: 45.8%, No Mobile: 20.3%

limited only to specific area. The survey result pointed that, the mean and standard deviation of frequency of extension contact of households was 8.96 and 6.68 respectively. The minimum frequencies of extension contacts were zero (no contact) and maximum contacts were 37 times.

Access to credit: The survey showed that there are both formal and informal lending institutions that facilitate access to credit for farmers. The formal sources of credit in the study area were Somali microfinance and other financial institutions. Whereas informal sources of credit providers were: local money lenders, friends and relatives. Given this, the formal lending procedure and criteria to get access to credit from the formal institutions were too difficult and even sometimes imaginary to some farmers to fulfil it. That is why most of the respondents use informal institutions to get credit. Furthermore, most formal financial institutions have an interest rate which is prohibited in Muslim society. Based on the survey, of the total 64.63% of sample households who got access to credit, 7.51%, and 57.12% of them got access to credit from formal and informal sources respectively. The purposes of the credit were mainly to purchase agricultural inputs (seed, NPS, urea and chemicals), home consumptions, social obligations and purchasing live animals.

Distance to the nearest market: The survey result showed that, the mean distances of the nearest market to the respondents was 1.25 km and is ranging between 0.83 km and 6 km.

Distance to the main road: The survey result showed that, the mean distances of the main road from the farm land of the respondents was 48minute and is ranging between 5minute and 87 minutes.

Communication asset: Communication asset is tools that the farmers use to strengthen their networks and relations with various stakeholders. It the materials through which the disseminations of information pertaining to new technologies, up-to-date price of inputs and outputs and others can be received. Hence, the survey result depicted that radio, mobile and TV are widely available among the respondents where 34.2%, 51.7%, 18% of sample households owned radio, mobile and TV while 45.8% and 20.3% have no radio and mobile respectively (See Table 3).

3.2. Technical, Allocative and Economic Efficiency Score

Based on the result of this study, the mean technical efficiency level of 61.35% fluctuates from 32.54% to 79.83%. This indicates that farmers those participated in sorghum production have a chance to use the resources they have at hand efficiently and hence they could raise the current sorghum output by 38.65% through using the existing technology. In another way, it can be understood that on average sample households in the study area can save or minimize their inputs (e.g. seed, land, NPS, urea, oxen and labour) by 28.35 % without compromising the amount of output they are produced this year. This implies that the level of technical efficiencies among farmers in the study shows a great discrepancy. Similar to technical efficiency, the mean allocative efficiency of sample farmers in the study area was 69.86% and ranges from 25.93% to 74.42%. This implies that on average, farmers are simply incurring 30.14% of their current cost on inputs which can be saved or invested on other area if resources are competently utilized. This displays that there is enormous opportunity to maximize the efficiency of sorghum producing farmers by reallocation of resources in some ways that enable them minimize their expense cost. Lastly, mean economic efficiency level of sample households was 44.39% with minimum and maximum efficiency scores of 16.76% and 73.69% respectively. The mean economic efficiency shows that some economically efficient households can lessen their

Table 3. Institutional factors.

Institutional Factors	Survey Results
Extension Service	Frequency of Extension Contact: Mean - 8.96, Standard Deviation - 6.68
Access to Credit	Formal: 7.51%, Informal: 57.12% Purposes: Agricultural Inputs, Home Consumption, Social Obligation, Live Animals
Distance to Nearest Market	Mean: 1.25 km, Range: 0.83 km to 6 km
Distance to Main Road	Mean: 48 minutes, Range: 5 minutes to 87 minutes
Communication Asset	Radio: 34.2%, Mobile: 51.7%, TV: 18% No Radio: 45.8%, No Mobile: 20.3%

production cost by 56.61%. It can also have inferred that if households in the study area were to achieve 100% economic efficiency, they would experience substantial production cost saving of 56.61%. The mean levels of efficiencies are comparable with the results from other related studies in Ethiopia. For instance, level of efficiency is found technical, allocative and economic efficiency of 62.3%, 57.1% and 39% respectively in south-western Ethiopia [23] and [24], obtained mean technical, allocative and economic efficiencies 81.78%, 37.45% and 30.62% respectively. Comparing to those results, the level efficiencies in the study area revealed as it is too low (See Table 4).

3.3. Determinants of Efficiency

The Tobit regression model results, as shown in Table 5, highlight significant factors influencing the efficiency of smallholder farmers in sorghum production.

Among the twelve variables analyzed, eight were found to be statistically

Table 4. Technical, allocative and economic efficiency score.

Technical, Allocative, and Economic Efficiency Score	Survey Result
Technical Efficiency	Mean: 61.35% Range: 32.54% to 79.83%
Allocative Efficiency	Mean: 69.86% Range: 25.93% to 74.42%
Economic Efficiency	Mean: 44.39% Range: 16.76% to 73.69%

Table 5. Determinants of efficiency in sorghum production.

Variables	Coefficient	Std.Err	Coefficient	Std.Err	Coefficient	Std.Err
Constant	0.42432***	0.06792	0.70355***	0.06293	0.20274***	0.06772
AGE	0.00704	0.00779	−0.00179	0.00774	−0.00040	0.00770
SEX	−0.01623	0.02628	−0.00327	0.02524	−0.00487	0.02427
EDUC	0.07222***	0.00227	−0.00452	0.00231	0.00542*	0.00270
Fsize	0.07697**	0.00823	0.00594	0.00792	0.01725**	0.00765
FRMsize	0.02556*	0.07225	−0.0047	0.01258	0.01258	0.07272
LU	−0.00288	0.00224	0.00596*	0.00272	0.00200	0.00201
Sfertility	−0.07827	0.02148	0.02269	0.02059	0.07289	0.07988
DISfarm	−0.00078	0.00700	−0.00207**	0.00096	−0.00364*	0.00092
DISmrkt	0.00662	0.00580	0.00522	0.00560	0.00820	0.00540
EXTEN	0.00425***	0.00112	−0.00705	0.00708	0.00208**	0.00104
CREDIT	0.06890***	0.02227	−0.0002	0.02721	0.04928**	0.02047
OFF/NFRM	0.05707**	0.02252	0.02876*	0.02765	0.05889***	0.02097
Loglikehood	97.95		700.67		705.89	

*Note: *, **, and *** significant at 10%, 5%, and 1% level of significance, respectively. Source: Own computation (2021).

significant explanatory factors:

Family Size: A positive relationship was observed between family size and both technical efficiency (TE) and economic efficiency (EE) at a 5% significance level. Larger family sizes were associated with higher efficiency levels, as they provide more labor resources for farm activities.

Education Level: Higher education levels positively influenced TE and EE at 1% and 10% significance levels, respectively. Farmers with more education exhibited higher levels of efficiency.

Farm Size: Contrary to expectations, the relationship between farm size and TE was positive at a 10% significance level. This suggests that larger farms may lead to increased technical efficiency.

Livestock Ownership: The coefficient for livestock holding (TLU) was positively associated with AE at a 10% significance level. Farmers with more livestock tended to be more allocative efficient, possibly due to their ability to afford organic fertilizer and overcome cash constraints.

Frequency of Extension Contact: More frequent extension contacts positively influenced TE and EE levels at 1% and 5% significance levels, respectively. Farmers who received more extension services were more likely to be technically and economically efficient.

Access to Credit: Access to credit positively impacted TE and EE levels at 1% and 5% significance levels, respectively. Farmers with access to credit showed higher levels of efficiency, likely due to increased access to resources for timely input purchases.

Participation in Off/Non-farm Activities: Participation in off/non-farm activities positively influenced TE, AE, and EE levels at 5%, 10%, and 1% significance levels, respectively. Farmers engaged in off/non-farm activities demonstrated higher efficiency levels.

4. Conclusion

The study's analysis of sorghum production efficiency in the study area reveals that smallholder farmers are not operating at the frontiers in terms of technical efficiency (TE), allocative efficiency (AE), and economic efficiency (EE). Opportunities for improvement exist at all levels, indicating the potential for significant gains in production levels or cost reduction with enhanced efficiency. This underscores the importance of continuous efforts to improve efficiency among sorghum producers. The results offer valuable insights for policymakers, development agents, and stakeholders, highlighting specific determinants that can be addressed to boost efficiency levels in sorghum-producing households. Considering sorghum's popularity and societal acceptance, the study recommends interventions targeting resource allocation and utilization to maximize output without necessarily requiring additional technology or inputs. In conclusion, the study advocates for strategic measures to enhance the technical, allocative, and economic efficiency of sorghum producers in the study area.

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Conflicts of Interest

The authors declare no conflicts of interest.

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