



COLLEGE OF AGRICULTURE AND NATURAL RESOURCE

DEPARTMENT OF AGRICULTURAL ECONOMICS

**ANALYSIS OF TECHNICAL EFFICIENCY OF SORGHUM
PRODUCTION IN HIDHABU ABOTE WOREDA, NORTH SHOA ZONE,
OROMIA REGION, ETHIOPIA**

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ACRONYMYS AND ABRIVATIONS

ADLI	Agricultural Development Led Industrialization
CSA	Central Statistical Agency), 2013
GDP	Gross Domestic Product
GTP	Growth Transformation Plan
ICPS	Inter-Censal Population Survey
MoFEC	Ministry of Finance and Economic Cooperation
OLS	Ordinary Least Square
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
SPF	Stochastic Production Frontier
TE	Technical Efficiency
WAO	Woreda Agricultural Office
WFP	World Food Program

ABSTRACT

Agriculture is the backbone of the Ethiopian economy because it constitutes almost half of the GDP and more than 85 % of the population still depends on it for their livelihood. As a result, the government has given attention to the development of agriculture. The key challenge here is how to increase the productivity of smallholder farmers so that they would increasingly benefit from the small plot of land, and surplus labor could increasingly move to industrial sector. Thus, this study was aimed to measure the level of technical efficiency and identify the factors that influence the efficiency levels of sorghum in Hidabu Abote district during the production year of 2021. A three stage sampling technique was employed to select 95 sorghum growing sample households. Primary and secondary data was collected through interview schedule from the sampled households and reviewing secondary sources, respectively descriptive statistics, and stochastic production functions were employed to analyze the collected data. The Stochastic Production Frontier (SPF) result revealed that seed, labor, oxen power and fertilizer were found to be significantly influencing sorghum production at 5%, 5%, 1%, and 5% significance level, respectively. The coefficient of the Cobb-Douglas production function interpreted as elasticity and summing the individual elasticity, yields a scale elasticity of 1.014% this indicated that farmers' scale of production belongs to increasing returns to scale. The result of the study further showed that household size, extension service, education, livestock holding, slope and off farm activity contributed significantly and positively to TE. There should be timely supply of fertilizer and quality improved seed to improve farmer's efficiency in production of sorghum.

Key words: Technical efficiency, Sorghum, Smallholder farmers, Stochastic production frontier, Hidabu Abote District

1. INTRODUCTION

1.1. Background of Study

Agriculture is important for comprehensive development because it produces food as well as economic wealth for many of the world's lowliest people that allows for improved livelihoods through better health care, education, infrastructure improvements and greater investment in environmentally sound practices (IFAD, 2013). For Sub Saharan Africa, growth generated by agriculture is eleven times more effective in reducing poverty than GDP growth in any other sectors. Rain fed, subsistence level, small land holding, and retrograde production technology characterize the agricultural sector in the Ethiopian economy (Weldegebriel, 2014).

Ethiopia, the country with an area of about 1,120,000 square kilometres, is one of the most populous countries in Africa with the population of 109 million in 2018 with annual growth rate of 2.65% (CSA, 2018). In 2019 this population size has reached 117.8 million with annual growth rate 2.53% as projected by the CSA (2020) based on the 2018 Inter-Censal Population Survey (ICPS). This growing population requires better economic performance than ever before at least to ensure food security. However, the agricultural sector in the country is largely small-scale, subsistence oriented and heavily dependent on rainfall, which is highly variable spatially and temporally. It is a dominant sector in Ethiopia and is accounting for about 35% of GDP and 80% for export commodity and about 75% of Ethiopians livelihood depends on agriculture (MoFEC, 2021).

The Ethiopian government has designed a second five year (2015/16-2019/20) growth and transformation plan (GTP II) which aims at boosting the national Gross Domestic Product (GDP). Based on the achievements and lessons drawn from implementations of Agricultural Development Led Industrialization (ADLI) strategy, building on Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) achievements and the country's five-year (2010-2015) first Growth Transformation Plan (GTP I), smallholder agriculture will continue to be the basis for agriculture sector development. Also, increasing agricultural production 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).

In Ethiopia, cereals are the major food crops both in terms of area coverage and volume of production. According to CSA (2017/2018) report, of the total area and production under crops, cereals accounted for about 80.78% and about 87.31% of the total production in quintals, respectively. Smallholders account for 96% of the total area cultivated and generate the key share of total production for the main crops. Cereals are predominantly produced by smallholders and are consumed as food, and the by-products are fed to livestock (Abu and Quintin, 2013).

In Ethiopia, sorghum accounts for the third largest share of total cereal production next to teff and wheat. Area under sorghum cultivation expanded from 1.83 million hectare in 2014/15 to 2.01 million in 2015/16 (CSA, 2015; 2016). Sorghum is the single most important staple in drought prone areas; The trade status of the country from 2005 – 2010 shows that, import in all years and most of the sorghum import takes the form of food aid (Demeke and Dimarcantonio, 2013)

Sorghum accounts for an average ten percent of daily caloric intake of households living in the eastern and northwest areas of the country. About three-quarters of the sorghum grain in Ethiopia is used for making injera (the traditional bread, made from teff in more productive areas of the country). Another 20 percent is used for feed and for local beer production, with the remainder held for seed. The entire plant is utilized, with sorghum stalks used for house construction and cooking fuel and leaves used for animal fodder (GAIN, 2015).

1.2. Statement of the problem

The major challenges facing most of developing countries such as Ethiopia is improving food security and to stimulate underlying food system development. There is an ever-increasing concern that it is becoming more and more difficult to achieve and sustain the needed increase in agricultural production based on intensification, because there are limited opportunities for area expansion. Hence, the solution to food problem would depend on measures, which help to increase yield through intensification (Awol, 2014).

The measurement of efficiency in agricultural production is important issue for agricultural development and it gives useful information for making relevant decision in the use of these scarce resources and for reformulating agricultural policies. Several empirical studies in developing countries have shown the existence of potential for improving agricultural production

through improvement in the efficiency of the farmers by using the available resources and technology. The role of efficient use of scarce resources in promoting agricultural production has long been recognized and has motivated considerable research into the extent and sources of efficiency differentials in smallholder farmers. Empirical evidence suggests that improving the productivity of smallholder farmers is important for economic development because smallholder farmers provide a source of employment and a more equitable distribution of income (Wassie, 2012; Jema, 2008; FAO, 2014).

Sorghum is a wonderful cereal crop that has a great advantage. Therefore, due attention should be given to strengthen the production and productivity of this crop. However, there is limited number of studies done in this regard in general and there is no similar study conducted on technical efficiency of smallholder sorghum producers in the study area. Hence, there is a need to fill this gap and provide possible intervention areas to improve the existing sorghum production and productivity (Dida et al., 2017).

The gaps of this crop is, not due to attention to increase productivity and to support farmers because the crop at the last time researchers and farmers that is not known the use of sorghum to ignore and does not attentively promotes or adverts, the farmer that to knowledge about the use and increasing productivity of sorghum production. But sorghum is a good crop compare to other crops because, it resistance of drought and rain shortage and cropping with degraded land. Then, it will introduce and promote the farmers to know and produce this crop and increase their productivity by using technical efficiency methodology that means use the same level of input to get maximum output (GDADO2017).

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to analyze technical efficiency of smallholder farmers in the production of sorghum in Hidhabu Abote district.

1.3.2. Specific Objectives

1. To measure the level of technical efficiency in the production of sorghum
2. To identify factor affecting technical efficiency of sorghum production in the study area.

1.4. Research Questions of the Study

- 1) How to measure the level of technical efficiency in sorghum production of smallholder sorghum producers in Hidabu Abote District?
- 2) What are the demographic and socio economic characteristics of farmers which influence technical efficiency of smallholder sorghum producers in Hidabu Abote District?

1.4. Significances of the Study

A technical efficiency study plays a significant role in providing useful information regarding technical inefficiencies in production and helps to identify those factors, which are associated with inefficiencies that may exist. Moreover, it helps extension workers of the area to come with some important idea of efficient utilization of available production inputs for those who are inefficient. They can play an important role in informing inefficient farmers to derive lessons about better production practices from more efficient farmers operating in the same environment and level of technology. The technical efficiency measurement is very important in any area of production because it is a factor for productivity growth. It may help to indicate a possibility of increasing production without increasing the consumption of inputs or decreasing the level of inputs and hence reduce total production cost without decreasing the level of output. Such, Studies help the economy by determining the extent to which it is possible to raise productivity by improving the neglected source, i.e. efficiency, with the existing resource base and available technology.

Therefore, results of this study would be important in designing sorghum extension packages in particular and the extension service in general that probably enhance the living standard of smallholders, mitigate the problem of food insecurity and improve competitiveness of the farmers. Also the results of the study would have positive outcome in availing relevant empirical evidence to agricultural extension agents, extension planners, researcher, and other concerned sectors in designing appropriate communication intervention in the study area

1.6. Scope and Limitations of the Study

The study was focused on the issue of technical efficiency in sorghum production and identifies factors associated with inefficiency among farmers in study area, the study was conducted by taking samples from a District which will select purposively that could not allow making generalization about the whole Region and though farmers in the study area produce a variety of crops, this study was focused only on sorghum and other crops is not included, and did not included Allocative and Economic efficiency of study. Only studies technical efficiency of sorghum production. The study was conducted using cross-sectional data. As cross sectional data reflects farmers' circumstances in a given year, specific climate of the year may affect the result as agriculture is weather dependent. Moreover, the result of cross-sectional data does not show inter temporal differences in efficiency levels of households. As a result, the study may be subject to bias to some extent.

2. LITERATURE REVIEW

2.1. Theoretical review

2.1.1. Definition of Conceptual Terms

Efficiency: - is a commonly used term in economics. It is usually concerned with the relative performance of the various processes used in transforming given inputs into outputs. According to Charnes et al (1978), efficiency is the degree to which the observed use of resources to produce outputs of a given quantity matches the optimal use of resources to produce output of a given quantity.

Technical efficiency:- is a component of productive efficiency and is derived from the production function. Technical efficiency is measured as the ratio between the observed output and the maximum output, under the assumption of fixed input, or, alternatively, as the ratio between the observed input and the minimum input under the assumption of fixed output (Porcelli, 2009). Technical efficiency which explains the physical performance of a firm measures the relative ability of a farmer to get the maximum possible output at a given input or set of inputs. Technical efficiency of a producer is a comparison between observed and optimal values of its outputs and inputs. It refers to the ability to avoid wastage either by producing as much output as technology and input usage allow or by using as little input as required by technology and output production (Farrell, 1957).

Productive efficiency:- consists of technical efficiency and Allocative or factor price efficiency. Production function is the relationship between the inputs and outputs of a production process. Hazarika and Subramanian (1999) also describe production function as a maximum possible output for any given set of inputs setting a limit or frontier on the observed value of dependent variable in the sense that no value of output is expected to lie above the production function.

Sorghum: - is an exhaustive cereal crop. It is a multipurpose crop that provides food for human, feed for animals especially poultry and livestock and raw material for the industries(Mude, et al, 2016).It is the third most important cereal crop after wheat and rice.

2.1.2. Overview of Sorghum Production and its Importance

Sorghum (*Sorghum bicolor* L. Moench) is one of the main staple crops for the world's poorest and food-insecure people. It is the second major crop (after maize) across all ecologies in Africa

and is one of the main staples for people in Eastern and Southern Africa (ESA). Globally, sorghum is grown on 46 million hectares accounting for an annual production of 60 million tones. Developing countries account for 90% of total area and 70% of total output, with Africa and Asia each accounting for 20% to 30% of the global production. In Africa sorghum is mainly cultivated by small-scale resource poor farmers and production is characterized by limited use of fertilizer and improved seeds.

Sorghum, because of its drought resistance, is the crop of choice for dry regions and areas with unreliable rainfall. Many annual and perennial species of sorghum are found in the wild form. The greatest variation in the genus is found in the northeast quadrants of Africa; north latitude of 10°N and east of longitude 25°E. Sorghum is adapted to wide range of ecological conditions and can be grown under conditions, which are unfavorable for most of the cereals (Eyob, 2007).

Sorghum is a dual-purpose crop where both grain and stock are highly valued outputs. There is a very rich genetic diversity of sorghum in eastern Ethiopia. Besides, there is a wealth of sorghum farming knowledge and systems that have been developed over thousands of years, as it is adapted to a wide range of environment. It is widely produced more than any other crops, in areas where there is moisture stress.

Sorghum's nutritional profile includes starch, vitamins and proteins as main constituents. The essential amino acid profile of sorghum protein is claimed to depend on the sorghum variety, soil and growing conditions. A wide variation has been reported in its contents of several minerals. The mineral fillings are unevenly distributed and are more concentrated in the germ and the seed coat. In milled sorghum flours, minerals such as phosphorus, iron, zinc and copper decrease with lower extraction rates. Similarly, piercing the grain to remove the fibrous seed coat resulted in considerable reductions in the mineral contents of sorghum. The presence of anti-nutrition factors such as tannins in sorghum reduces its mineral availability as food. It is important to process and prepare sorghum properly to improve its nutrition value. Sorghum is a good source of B-complex vitamins (Dida et al., 2008).

2.1.3. Approaches of Measuring Technical Efficiency

There are two approaches of measuring technical efficiency: output-oriented approach and input-oriented approach. In the output-oriented approach the interest is by how much output could be

expanded from a given level of inputs, hence known as output shortfall. Whereas in the input-oriented approach the concern is the amount by which all inputs could be proportionately reduced to achieve efficient level of production, hence, known as input over use. Both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli, 2005).

2.1.3.1. Input-oriented efficiency measures

Farrell (1957), technical efficiency can be obtained by using input and output quantity. Accordingly, two inputs to produce a single output i.e. one-output multi-input.

The measure of input-oriented technical efficiency shows the maximum amount of input quantities, which can be proportionately reduced without changing quantities produced as output and can be measured by comparing its actual input in use with the minimum input that would produce the given output level, i.e. by how much input quantities can be proportionally reduced without changing the actual output bundle (Farrell, 1957).

2.1.3.2. Output-oriented efficiency measures

In an output-oriented assessment, the efficiency is based on the ratio of achieved outputs per a given input level. While the input oriented approach answers the question by how much the input use can be reduced without affecting the level of output, in the output oriented approach one can alternatively answer the question by how much can output be increased without increasing the amount of inputs used (Coelliet al.,2005)

2.1.4. Challenges and opportunities of Technical efficiency of sorghum

2.1.4.1. Challenges of technical efficiency of sorghum

The country is located in a region of the world where human suffering and poverty due to food scarcity are most prevalent. The major limits to highland sorghum production in Ethiopia that result in decreased production and productivity are connected to factors resulting from adverse environmental (abiotic stresses) and biological (biotic stresses) conditions for crop production and growth. The major biological factors are grain and leaf diseases, as well as parasitic weeds, which have resulted in significant sorghum grain yield losses in terms of both quality and

quantity while the abiotic factors include soil nutrient depletion, soil acidity, frost, and low external inputs with poor agronomic practices used by the farmers.

Farmers can try to improve their farming situation, but it is well known that the farmer's own creative capacity can only provide a minor improvement over recent experience, and that further fundamental change can only be achieved if farmers are assisted with formal science-based knowledge (B Havertkort 1996). Although many improved technologies for various sorghum varieties have been released and developed as a result of research efforts made thus far, the release of technologies did not mean much in and of itself because they were not well promoted, popularized, multiplied and made available to farmers, and eventually adopted. Most of the country's growing areas are still using the conventional production system, despite the fact that developed sorghum technologies have not yet to be fully implemented.

2.1.4.2. Opportunities of technical efficiency of sorghum

Ethiopia is recognized as the centers of genetic diversity or origin for various essential crops Huff nagel HF (1961). The country owns large and diverse indigenous sorghum germplasm resources, which are genetically different and this genetic potential is not yet adequately exploited. The diverse and suitable production systems and production environment provides opportunities for development of alternative feed and food resource base. Diverse sorghum genetic resources are maintained by Institute of Biodiversity and national sorghum research program. These resources are pre-requirements for sorghum crop improvement. The highest majority of farmers rely on these species of sorghum next to teff and maize in agricultural production activities.

The opportunities for highland sorghum production in Ethiopia are high annual rainfall distributions, low temperatures, and favorable government policies that assist agriculture. Ethiopia is known as a center of genetic diversity or origin for a variety of important crops (Huff nagel HF 1961). The country has extensive and diversified indigenous sorghum germplasm resources, all of which are genetically distinct, and this genetic potential has not yet to be fully realized. The development of alternative feed and food resource bases is possible due to the diversified and adequate production methods and production environment. The Institute of Biodiversity and the national sorghum research program both conserve diverse sorghum genetic

resources. These resources are prerequisites for improving sorghum crops. Sorghum species, together with teff and maize, are used by the vast majority of farmers in agricultural output.

2.2. Review of Empirical Studies

2.2.1. Measurement of Technical Efficiency of Sorghum production

According to Beckhman et al., (2010) studied that estimates a stochastic frontier production function to examine the determinants of technical efficiency in rice farming in Bangladesh. The analysis of the determinants of technical efficiency revealed that the age and education of the household heads, availability of off-farm incomes, land fragmentation, extension visits, were the major factors that caused efficiency differentials among the farm households studied. Hence, the study proposed strategies such as providing better extension services and farmer training programs, reducing land fragmentation and raising educational level of the farmers to enhance technical efficiency.

According to Goodness et al.,(2010) found that an investigated the technical efficiency of traditional and hybrid maize farmers in Nigeria. As estimates obtained from the distance frontier approaches indicated hybrid seed was found to have positive and significant impact technical efficiency. Other policy variables that had significant impact on technical efficiency included education, extension services, credit and land. The result reinforced the need for further investment in agricultural research and development for increased productivity, food security and poverty reduction in Nigeria.

Nyagaka et al (2010) assessed technical efficiency in resource use from smallholder Irish potato farmers from Nyandarua North District, Kenya. They used a dual stochastic parametric decomposition technique to derive technical efficiency indices while a two-limit Tobit model was to examine the effects of socio-economic characteristics and institutional factors on the derived technical efficiency indices. Their results showed that resource use was subject to decreasing returns to scale while the mean TE was 67%. Education, access to extension, access to credit and membership in farmers' association and innovations positively and significantly influence TE.

2.2.2. Empirical studies on efficiency in Ethiopia

According to Hassen et al., (2012) found that technical efficiency of the farmers by using the available resource and technology used parametric methods of efficiency measurement and the result revealed that most farmers in the study area were not efficient suggesting that efficiency improvement was one of the possible avenues for increasing agricultural production with available resource and technology. The mean TE, AE and EE of the household calculated from parametric approach of SFA were 62%, 51% and 29%, respectively. Farm size, livestock ownership, labor availability, off-farm income participation, total household asset, total household consumption expenditure and improved technology adoption were found to determine production efficiency.

According to Getachew and Bamlak, (2014) analyzed that the technical efficiency of small holder maize growing farmers in HoroGuduru Wollega Zone of Oromiya regional state. Cobb-Douglas stochastic production function model was used for their analysis. The average estimated technical efficiency for smallholder maize producers ranges from 6 % to 92 % with a mean technical efficiency of 66 %. This implies that technical efficiency in maize production in the study area could be increased by 34% through better use of available resources, given the current state of technology. The educational level of the farmer, age of house hold head, land fragmentation, extension services, engagement in off-farm activities, and total land holding of the farmer were the major socio-economic factors influencing farmer's technical efficiency and sorghum output.

According to Hailesilasie (2014) found that the technical efficiency of smallholder farmers in sorghum production of Raya-Azebo District, Southern Tigray of Northern Ethiopia. Cobb-Douglas functional form was used. He found that, the technical efficiency of the sample farmers ranges from about 16 to 97 % with the mean technical efficiency level of about 79 %. Among the farm specific socioeconomic and institutional factors hypothesized to affect level of efficiency, off-farm occupation, age, weeding, and extension contact are found to be important determinants of technical efficiency. Off-farm occupation had negative effect on the level of technical efficiency. Whereas, middle age farmers are also relatively operating at higher level of technical efficiency than the youngsters and old farmers. Weeding and extension contact also affect technical efficiency positively and significantly. His results revealed that there was a possibility

of increase sorghum output from the existing level if appropriate measures to reallocate the use of basic inputs. He also found that the Socio-economic as well as institutional variables was determinant factors of technical efficiency.

2.2.3. Empirical Studies on the Factors affecting Technical Efficiency of Sorghum

Production

According to Bamlaku et al (2009) studied that technical inefficiency factors across agro-ecological zones in East Gojjam was identified some efficiency variables like age and sex of household head, educational level of household head, membership status of household in organizations, participation in off-farm activities, labor endowment, proximity to the market, livestock ownership and family size-farm size ratio. The educational level of the farmer, age of household head, land fragmentation, extension services, engagement in off-farm activities, and total land holding of the farmer were the major socio-economic factors influencing farmer's technical efficiency and sorghum output(Getachew and Bamlak, 2014).

According to Kinde (2005) analyzed that technical efficiency to identify principal factors that cause efficiency differentials among sorghum producing farmers in Assosa district. According to his findings, the estimation of the frontier model with inefficiency variables shows that the mean technical efficiency of farmers in the production of sorghum is 0.67. The estimated factors that cause efficiency differentials are average educational status of the family members, age, credit availability, off/non-farm activities, proximity and fragmentation of land. The negative coefficient of average educational status of the family members, age, credit availability, off/non-farm activities, and fragmentation of land means these factors are important in determining the existing efficiency of farmers positively and significantly.

A study conducted by Wondimu and Hassen (2014) in Dhidhessa district of Illuababora zone in Ethiopia to measure the level of technical efficiency and identify its determinants in maize production using Stochastic Production Frontier (SPF) revealed that, the mean technical efficiency was 86%. The socio-economic variables that exercised important role for variations in technical efficiency were age, education, improved seed, training on maize production and labor availability in the household. Nevertheless, participation on off-farm income, interaction of off-farm income and education, distance to market, and number of livestock were found to decrease efficiency significantly among farm household

2.2.4 Conceptual Framework

The conceptual framework will use in the present study represents the links between the technical efficiency of sorghum production and their determinant factors to that affect production and productivity of sorghum. There is a need to examine the interrelationship and interactions of various factors revolving around the technical efficiency of sorghum producers.

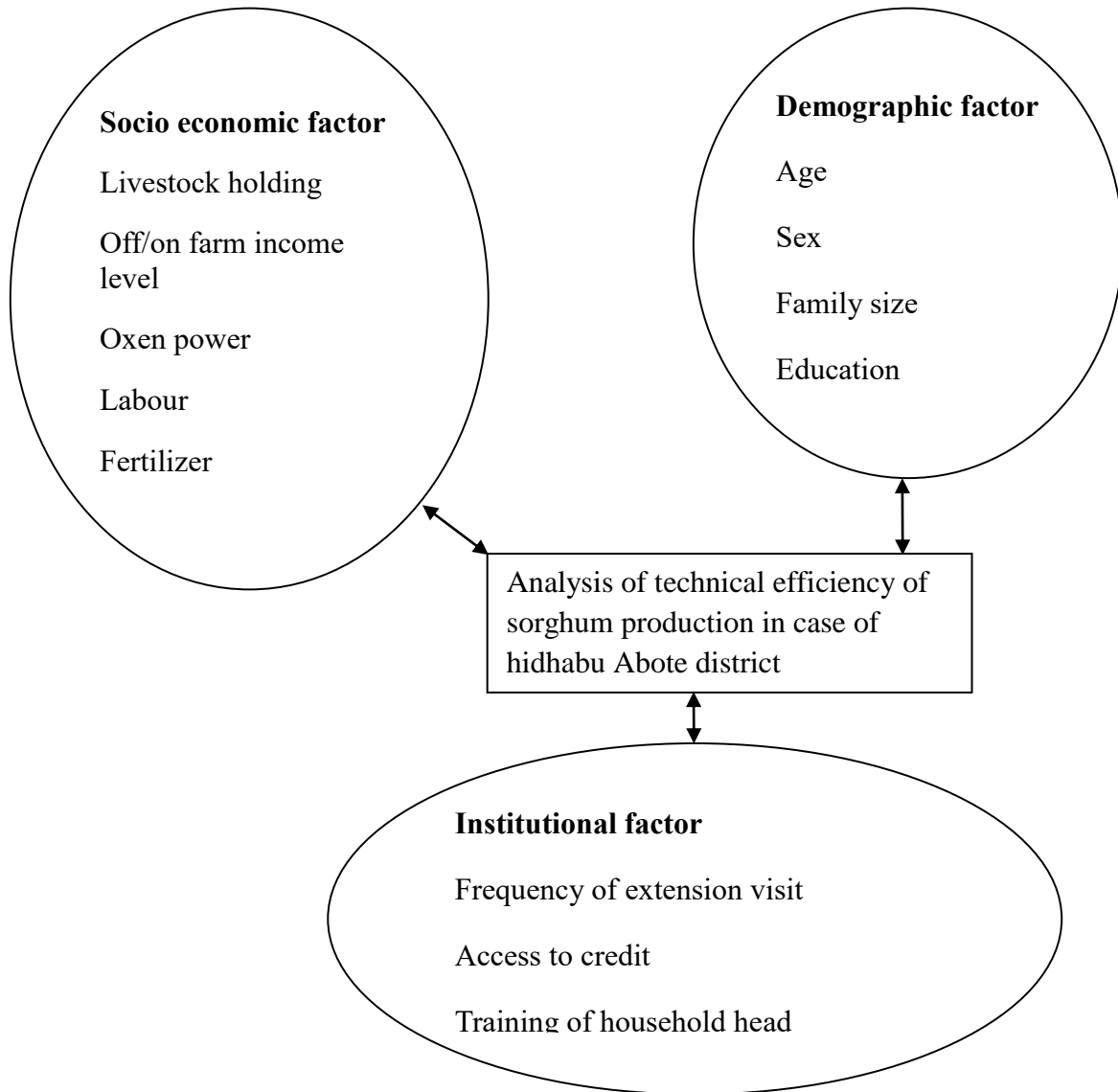


Figure 1. Conceptual framework of the study

Source: (Abate, 2018) with modification

3. METHODOLOGY

3.1. Description of the study area

Hidabu Abote woreda is one of the 13 Woredas in North Shoa Zone known for predominantly growing sorghum. It is located, on North by Dera woreda, on East by Degem woreda, on South by gabra-guracha woreda, on west by Wara-Jarso woreda, and about 42km from fitche (the capital of North Shoa Zonal administration) and 147km away from Addis Ababa. The total area of the woreda is 48600ha from this 32917 ha is agricultural land. There are 19 rural peasant associations and one urban peasant association. The number of agricultural households in the woreda is 20406 [18,000 male headed (89%)) and 2400female headed (11%)] while the total population of the Woreda is 104442 from which 51030 are males and 53412 females (Woreda Agricultural Office, 2018).

The average annual rainfall of the district is 800-1200 mm with low variability. It is bimodality distributed in which the small rainy season is from March to April and the main rainy season from June to September. Altitude in Hidabu Abote ranges from 1160 m to 3000 m above sea level(masl). The agro climate/ecological zone of the woreda is Dega6%,woyna dega 50% and kola 44% and specifically the three kebeles (Amuma Machara, Nyaa-Gobabu and Weyilu Modjo) are found in the Woyna Dega agro-climatic zone (Woreda agricultural office,2017). The temperature in the study area ranges from 13% - 20%.

The soil types in the study area are sandy soil 14%, clay soil 51% and silt 35%. Most parts of the woreda lay between 1387and 1643; and 1849 and 2067 m a.sl. The pH of the soils in Hidabu Abote ranges between 4.5 and 6.8. However, the commonly observed problem related to aluminum and magnesium toxicity as a result of low pH is minimal. There are about 8 perennial rivers in the woreda. Even though available land and water resources offer high potential for irrigation development in the woreda the present utilization level is very poor (Woreda Agricultural Office, 2018). This woreda is known by its high potential for sorghum production. The farming system in the district is mixed crop-livestock type, whereby crops contribute larger share to farmers income.the major crops grown in the area are wheat, teff, sorghum, bean, pea and chickpea and major livestock type are sheep, goat, cow, horse, donkey, cattle and so on.

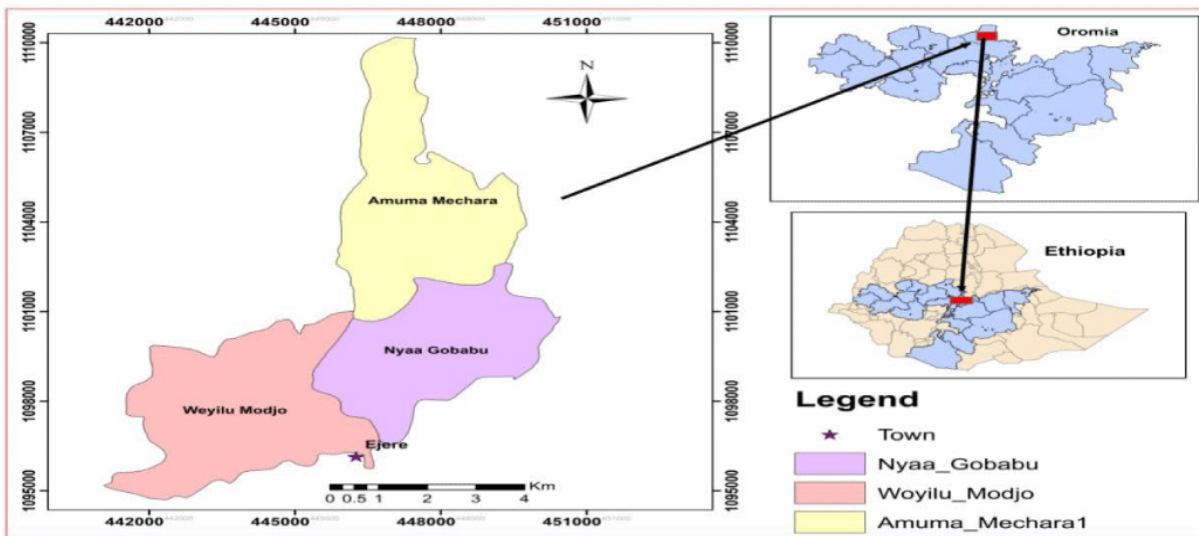


Figure2: Map of description of the study area

Source : (Abate, 2018)

3.2. Sampling Technique and Sample Size

Prior to the main sampling, discussion was held with district experts from the relevant field to make clear the purpose of the study and facilitate collaboration during the study. For this study, in order to select a representative sample a combination of purposive and simple random sampling techniques was implemented in order to select sorghum producer kebeles and sample farm households. The study area, Hidabu Abote woreda was selected purposively since the area is highly potential for sorghum production. Initially actors who are involved in sorghum producers were identified using review of related literature and interview of some key informants. A two-stage random sampling technique was then applied to select sample households. In the first stage out of 13 kebeles 3 sample kebeles were selected randomly. In the second stage, 95 producing households were selected randomly from three kebeles using simple random sampling technique. The sample size in each kebele was determined by probability proportional to size of the identified sorghum producers. Sorghum producers list in the selected kebeles used as the sampling frame and the sampling units are the household heads.

The sample size for this study was determined based on Yamane (1967) since the population is homogeneous in a population system. The simplified formula provided by Yamane was used to

determine the required sample size at 10% level of significance. The formula to determine sample size of the study was specified as,

$$n = \frac{N}{1 + N(0.1)^2} \quad \text{When, } n = \text{sample size for the research use}$$

N = total numbers of households who produce sorghum in three kebeles

e = margins of errors

$$n = \frac{1900}{1 + 1900(0.1)^2}$$

$$n = \underline{95}$$

Table 1. Sample distribution of farmers (sorghum producers)

NO	Name of kebele	Sorghum Producer Households	Sample Households
1.	Amuma Mechara	570	29
2.	Weyilu Modjo	768	38
3.	Nyaa Gobabu	562	28
4.	Total	1900	95

3.3. Data type, Sources and Methods of Data Collection

The study was conducted based on the cross-sectional data obtained through households survey data collected from Hidabu Abote District. Data was collected from Primary and secondary sources. The primary data on inputs such as DAP, labor, oxen power, seed, and sorghum output as well as efficiencies factors namely age, sex, education, family size, credit access, extension contact frequency, training access, plot size, slope, Row planting, off-farm income and livestock holding was collected by using interview schedule that was administered by the trained enumerators. The interview schedule was first pretested on 6 randomly selected farmers and based on the result of the pre-test, some modifications was made on the questionnaire before the execution of the formal survey. Enumerators, who have prior experience in data collection, know the area and communities' language was recruited. Secondary data was also collected from

relevant sources such as bureau of agriculture of the District and other relevant institutions for general description and to verify the primary data.

3.4. Methods of Data Analysis

After data collection both descriptive and econometric methods of data analysis was employed to analyze the data.

3.4.1. Descriptive analysis

This method was used to summarize and analyze the sample household input use, output levels and their socio-economic characteristics, which was use in the production frontier model.

Descriptive statistics such as mean, standard deviation, percentage and frequencies were used to analyze the socio economic characteristics of sorghum production of the sample farmers, by using stata software.

3.4.2 Econometric analysis

In the econometric analysis, a stochastic frontier approach was used to estimate the level of sorghum production efficiencies. In this analysis, ordinary least square (OLS) estimation techniques was employed in the form of multiple linear regression model. The reason why the researchers choose the ordinary least square method of estimation is that the dependent variable is continuous variable.

3.4.3. Specification of the econometric model

The model parameters in stochastic production frontier were analyzed using the STATA version 14.1 computer program; by employing a single stage estimation procedure. In using the two stage estimation procedure of efficiency level and factors determining, the efficiency index is estimated by the stochastic production function in the first stage and then regressed against a number of other farm specific and socioeconomic variables in the second stage. The one- stage estimation procedure of the inefficiency effects model together with the production frontier function would be used in the study. The two-stage procedure produces inconsistency in the assumption (Coelliet al., 1998). Moreover one-stage procedure is the most commonly used method in the analysis of technical efficiency. Thus one-stage procedure is selected for this study.

Using Ordinary Least Squares (OLS) estimation procedure, it is possible to get consistent estimators for all the parameters in the model except the intercept term. But if we use the OLS method to estimate the intercept term it will be biased. This problem occurs due to the fact that the mean of $(v - u)$ is not zero by assumption. However, a consistent estimator of the intercept can be formed by using Corrected Ordinary Least Squares (COLS), which involves adjusting the OLS intercept by the mean of u .

In this study, ML estimation procedure is used to estimate the stochastic production function model described. To use ML estimation procedure, the assumptions made about the distributions of the error components u and v should be respected (Coelli, 1998). It is assumed that u is independently and identically distributed half-normal random variables with mean zero and variance σ_u^2 . While v is assumed to be independent and identically distributed normal random variables with mean zero and constant variance σ_v^2 . ($v \sim (0, \sigma_v^2)$), independent of the u is. In most empirical applications the half normal distribution for the technical inefficiency effects (u_i) has been more frequently assumed.

As far as factors determining technical efficiency are concerned, farmers have different characteristics that make them attain different levels of technical efficiency. Given a particular technology to transform physical inputs in to outputs, some farmers are able to achieve maximum output while others are not. These, factors need to be identified in order to define the problem of inefficiency thereby investigated for remedial measures to solve the problem. Most of the time in the area of efficiency analysis the following variables are commonly used. Given the specified explanatory variables below, the functional relationship between input and output used in the stochastic production function can be specified as follows:

$$\ln(\text{OUTPUT}) = f(\text{LAREA}, \text{OXD}, \text{HLAB}, \text{FERT}, \text{SEED}; \beta_i) + \varepsilon_i$$

Where: $\ln(\text{OUTPUT})$ = is the total output of sorghum obtained from the i^{th} farm in quintal.

AREA = the total size of land in hectare allocated for sorghum crop by the i^{th} household

OXD = the total number of oxen days used by the i^{th} household.

HLAB = the total labor force (family and hired) which are all measured in terms of man-day.

SEED = the total quantity of sorghum seed used by the i^{th} household measured in kg.

FERT = the total amount of fertilizer in kilogram applied by the i^{th} household

$f(\)$ = Appropriate functional form (e.g. Cobb-Douglas or Translog functional form)

β_i = vector of unknown parameters to be estimated, and ε_i = composed error term,

Where: $\varepsilon_i = V_i - U_i$

U_i = non-negative random variable, independently and identically distributed as $N(u_i, \delta^2 u)$ which is intended to capture the technical inefficiency effects in the production of sorghum measured as the ratio of observed output to maximum feasible output of the i^{th} farm and V_i = a disturbance term independently and identically distributed as $N(0, \delta^2 v)$ which is intended to capture events or factors outside the control of the farmers.

3.5. Variable Selection, Measurement Units and Hypothesis

The dependent variable

Sorghum output: sorghum output is described in terms of physical quantities. The output is made by standard unit, quintal. Output of sorghum production in quintal gets, that the sample households will obtain from their farm during the production season of 2020/21. This is the dependent variable of the production function taken as continuous variable.

The independent variables

Plot size: This refers to the area of plot of land allocated for sorghum production. The unit of measurement for area is also different in different parts of the country; hence the data is being changed to hectare for smoothness. Hence, area of land allocated for sorghum production, in hectare, during 2021 production season will consider for analysis. Therefore, for this study the plot size will hypothesize that have positive effect on technical efficiency.

Fertilizer (FERT): Refers to the quantity of DAP will applied on sorghum plot in kilogram to maintain frontier output. Amount of DAP will expected to have positive effect on yield for application of necessarily used, but when overdose happens it can lead to low yield or total crop failure because overdose or under standard application becomes low productivity of sorghum output.

Seed (SEED): It refers to the quantity of sorghum seed that will use. It will include in production function in physical quantity of 'kunna', by converting the local unit into standard unit, kg. Isaac (2011) using stochastic frontier production model found that seed influence efficiency of

production positively and significantly. I will also hypothesize that seed have positive and significant impact on technical efficiency.

Labor: These input consist of family and hired labor that will used for different agronomic practices of sorghum production such as land preparation, seeding, input application, weed management that will measured in man-days. It will be converted to Man-day equivalent using conversion factors for different labor classes participated in the production process. The available labor supply within a given farming household affects production activities. Hence to make a homogeneous group of labour to be added, the individual labour will be changed in to Man Days (MDs) using the standard developed by Storck et al. (1991). Therefore, it will hypothesize that labour have positive effect on technical efficiency.

Oxen power: the total number of oxen days that will employ for performing different farming activities of plowing and will measured in pair of oxen-days. Then it included in the production frontier model. Hence, oxen power is measured using the total amount of oxen days allocated for ploughing and hoeing activities of sorghum production. It will be measured in oxen-days (one oxen day is equivalent to eight working hours). Therefore, it will hypothesize that Oxen power have positive effect on technical efficiency.

Education status of Household Head (Educ): This variable is a discrete: 1 if the respondent is literate and 0 otherwise. Household heads that are literate are expected to have a better knowledge of how to make a living. Literate household heads are very ambitious to get information and use it. It was made farmers to be aware of new technologies and farming practices that help to increase yield. Farmers who attended some level of education are expected to be active in looking for updated agricultural information (Haileselassie, 2005; Agerie, 2013).

Hence, the level of education attainment of the household head will be expected to have positive impact on the level of technical efficiency.

Age of household head (Age): it is continuous variable, age of the smallholder farmer, which was measured in number of years. It will hypothesize that as the age of the household head increases, the smallholder farmer becomes more skillful in the method of production and optimal resource allocation. However, after certain age limit as smallholder farmers get older and

older they start to be more conservative and his managerial ability is expected to decrease as well as less willing to adopt technologies as a result of which their technical efficiency decline.

Therefore, it will be hypothesize that either positive or negative affect on technical efficiency smallholder farmers. All of them concluded that the middle age farmers are found to be more technically efficient than the two other groups. Moreover, age is negatively related to technical efficiency for creditconstrained farm households imply that older farmers are less efficient than younger farmers (Hussien 2007).

Sex of the household head (SEXHH): This is a dummy variable measured as 0 if the household head is female and 1, otherwise. Since women were the one who were responsible for the many household activities, they may not accomplish the farming activities on time and efficiently. It has significantly positive contribution for technical efficiency indicating that male-headed households have higher efficiency levels than females (Awol, 2014). Men are carrying out most of the activities on the farm, especially on land preparation and have more frequent follow up and supervision of their farm than women. Therefore, it will hypothesize that female household heads are less efficient than male household heads.

Training of household head (Tg): Training is an important tool in building the managerial capacity of the household. Household's head that get training related with crop production and marketing or any related agricultural training is hypothesized to be more efficient than those who did not receive training. It is dummy variable having value equal to 1 if the household has got training at least one day training in the cropping season and zero otherwise. It was found to be positively related to technical efficiency (Fekadu, 2004; Abebe, 2009). Thus, it will hypothesize that trained farmers are more efficient than untrained ones.

Off-farm activities (OFNFA): This is a dummy variable which was measured as 1 if the household obtained income from off-farm activities and 0, otherwise. Because the income obtained could be used for the purchase of agricultural inputs and augments financing of household expenditures (Betty, 2005). Therefore, it will hypothesize that households engaged in off/nonfarm activities are more efficient than their counterparts.

Household size (HHSZE): Household is an important source of labor supply in rural areas. It is expected that households with many members have better advantage of being able to use labor

resources at the right time, particularly during peak cultivation periods. Therefore, household size had positive effect in raising the farmers' production efficiency, if actually the members are in the working force. Family size was hypothesized to determine efficiency positively (Fantu et al., 2011 and Mustafa, 2014). For this study the household size will hypothesize that have positive effect on technical efficiency.

Credit access (CrAc): This is a dummy variable which represents whether the farmer has obtained credit or not during the same year. If the farmer had access to credit, the variable will take a value of one and, otherwise zero. This variable is expected to have positive effect on efficiency. Farmers who got credit are to get capacity to purchase inputs which are necessary to improve productivity at the required time. The farmers who have access to credit facilities might have a chance to obtain agricultural inputs and, thereby increase farm production and productivity (Nyangaka et al., 2009 and Awol, 2014). This indicated that access to credit affects technical efficiency positively. For this study it will hypothesize as it had positive effect on technical efficiency.

Extension service (EXES): Extension service is a dummy variable which represents whether the farmer has get extension service or not get during the same year. Extension contact is medium for the diffusion of new technologies among farmers and hence improves the efficiency of farmers (Gedefa, 2014). Therefore for this study, extension service was expected to have a positive effect on efficiency. If the farmer to have got an extension contact from developing agent to value added their knowledge, capacity build and production technology translate. And then improve the technical efficiency level.

Livestock holding: This variable is measured as the value of livestock holding of the farmers in TLU. As a source of income; livestock holding allow farmers to make the necessary input available on time at the required amount (Mohammed et al., 2010). It will hypothesize that the farmer with more livestock unit is expected to be more technical efficient.

Slope: Slope is taken as a dummy variable, where 0 indicates that the land is steep and 1 otherwise. Relatively steep land reduces the output level of sorghum production because steep land is susceptible for water erosion problem. Slopes of plot were found to be related negatively to technical efficiency (Abebe Dagnaw, 2009). Based on this, it will hypothesize that farmers

who sow sorghum on steep land are less efficient than those with gentle or plain slope. If the land was steep when the rain rainfalls or wind winding the fertile soil degraded by this erratic movement, and then negatively related technical efficiency.

4. RESULTS AND DISCUSSION

This chapter is divided into two main sections: descriptive statistics and econometric results. Results on descriptive analysis in which survey data were used to describe the socio-economic factors of households are discussed in the first section. In the second section, econometric results were discussed by comparing and contrasting with other research findings.

4.1 Descriptive statistical results

4.1.1. Descriptive statistics for dummy variables in the study

Sex of smallholder farmers

With regards to the sex of smallholder farmers, about 31.58% of farmers were female and the remaining 68.42% were male (Table 2). It is obvious that female smallholder farmers face greater challenges in the agricultural production compared with their counterparts. This is due to the fact that female are the one who were responsible for the many household domestic activities; they may not accomplish the farming activities on time and efficiently. Besides, female smallholder farmers have less practical experiences in farming operation and would probably use minimum inputs than male smallholder farmers. And then, if female smallholder farmers get a chance of equally to male smallholder farmers to get an efficient product of sorghum.

Education

Education is a tool to modernize the farming systems through the adoption of new technologies and practices. In addition to this, it would help farmers to able to produce higher output using the existing resources more efficiently through increasing their information acquisition and decision making abilities. The survey result indicated that 49.47% of the farmers those were unable to read and write while 50.53% were educated in formal and informal education such as adult education and religious schools (Table 2). This implies that the majority of the smallholder sorghum producer farmers were expected to be moderately technically efficient than illiterates

Credit access

Agricultural credit facilities are vital in productive resources mobilization through purchase of agricultural inputs, availing resources for meeting social obligations, etc. Formal and informal

institutions were the two main sources of credit in the study area. The major source of formal credit is SCI (Saving and Credit Institution) and, informal credit were friends, relatives and neighbors.

According to the survey result, it has been seen that many smallholder farmers were not used credit services for production of sorghum. As far as access to credit is concerned, about 56.84% of households reported that they did not obtain credit from credit providing institutions whereas; the remaining 43.16% of **households** were received credit. Hence, the majority of the **smallholder** sorghum producer farmers those received credit used formal credit services than informal institutions since the latter imposed higher interest rate; which erodes the input purchasing power of the producers, intern make them more technically inefficient.

Off-farm Activities

The livelihood of farmers also relies on different off-farm activities during the production season in addition to farm sector. From the total sample farmers, 57.89% of them have reported that they were involved in off-farm activities such as petty trading, tailors, weaving and selling of fire wood. However, 42.11% of the total sample farmers were solely engaged in agricultural activities (Table 2). This implies that fewer farmers work only agricultural activity and many of them work off-farm activity for wanting profitability of livelihood.

Slope of plot

According to the Table (2), the survey result indicated that based on the farmers perceptions, 40.00% of the household responded that the nature of land allocated for sorghum production was steeper slope whereas 60.00% of the household responded that the allocated land was plain slope respectively. If the plot of farm land is flatter, it is not easily affected by any natural conditions like flooding. It implies that fewer of the study area of land was steeper and faced for erosion wind, but much lands were plain and to favorable for cultivation of sorghum to produce efficiently.

Extension service

In order to give effective extension service to the farmers, the region assigned development service in each Kebeles Administrations. The major sources of agricultural information for

farmers are extension service. A regular contact with extension service makes farmers to be aware of adoption of new technologies which helps them to maximize the agricultural production and productivity. According to the survey result (table 2), it has been seen that many smallholder farmers were got extension services for production of sorghum. As far as extension service is concerned, about 57.89% of households reported that they did get extension service from extension providing institutions whereas; the remaining 42.11% of households were not got extension service.

Table: 2. Descriptive analysis results of dummy explanatory variables

Variables		Number	Percent
Sex	Male	65	68.42
	Female	30	31.58
Education	Literate	48	50.53
	Illiterate	47	49.47
Credit access	Yes	41	43.16
	No	54	56.84
Off-farm activity	Yes	55	57.89
	No	40	42.11
Slop of plot	Steeper	38	40.00
	Plain	57	60.00
Extension service	Get	55	57.89
	Not get	40	42.11

Source: Computed from Field Survey Data, 2022

4.1.2 Descriptive statistics for continuous variables in the study

Age and Family size of the sample farmers

The mean age of the sample farmers was 43.02 years with a minimum of 25 years, maximum of 71 years and standard deviation of 11.23 This implies that majority of the farmers are still in their active age and thus expected to be productive. Labor is the most important input for sorghum production, especially with respect to small-scale farmers. The family size of the surveyed farmers ranged from 2 to 12, with a mean of 4.90 persons per household (Table 3).

Large family size is source of labor for subsistence farming practice in developing country like Ethiopia especially in the study area. Family size or the number of persons living in the household is hypothesized to determine efficiency positively. **The result shows that family size has positive and significant effect on efficiency.** This means that households with large family size would manage sorghum plots on time than their counterparts. This is because at the time of peak seasons, there is shortage of labor. This is possible since more labor can be deployed during peak season in order to timely undertake the necessary farming activities like plough, weeding and harvesting that raise efficiency. (Shumet Asefa.2011).

Livestock ownership

This variable measures the number of livestock holding of the household heads in TLU. Given a mixed farming system in the study area, livestock has considerable contribution for farmer income and food security. Farmers who have more livestock holding may not have difficulties to purchase inputs of production like fertilizer. The survey result showed that the mean, minimum and maximum in TLU owned were 14.29, 7.587 and 19.892, respectively (Table 3). It is hypothesized that number of livestock owned determine technical efficiency level of households positively. It is obvious that crop production is highly supplemented and complemented by animal husbandry. In addition it indicates the wealth status of household. The number and value of livestock holding was found to be related technical efficiency positively (Mohammed et al., 2000; Fekadu, 2004; Aynalem, 2006).

Table: 3. Descriptive analysis results of continuous explanatory variables:

Variable	Obs	Mean	Std. Dev.	Min	Max
Age(in year)	95	43.02	11.23	25	71
HHSZE(household size)	95	4.90	2.00	2	12
LH(livestock holding in TLU)	95	14.29	3.67	7.587	19.892

Source: Computed from Field Survey Data, 2022

4.1.3 Description of variables used in production function

The production function for this study was estimated using five input variables. The average sorghum output in the study area was about 7.44Ku per hectare, which ranges from 1.5Ku per hectare to 13Ku per hectare with a standard deviation of 2.93Ku (Table 4).

The land allocated for sorghum production by the sampled smallholder sorghum producer farmers ranged from 0.25 to 1.25 ha with an average of 0.83ha. The survey revealed that sample farmers on average used 6.60kg, 77.53kg, of seed and DAP, respectively. According to the survey results, the average person-day families, exchange and hired labor used to produce sorghum in the study area was found to be 4.64 with standard deviation of 1.39. Besides, the average oxen power used for sorghum production was 15.90 oxen days with a standard deviation of 6.74 oxen days.

Table: 4. Descriptive statics of variables used in the production function

Variable	Obs	Mean	Std. Dev.	Min	Max
OUTPUT (Ku/ha)	95	7.44	2.93	1.5	13
LAND (ha)	95	.83	.26	.25	1.25
SEED (kg/ha)	95	6.60	2.53	1.5	12
LABOUR (MDE)	95	4.64	1.39	2.1	7.7
FERT (kg/ha)	95	77.53	25.07	25	150
OXENP(ODE)	95	15.90	6.74	3.25	26.79

Source: Computed from Field Survey Data, 2022

4.2 Econometric Results

This section presents the econometric results of the study and determinants of efficiency were discussed.

4.2.1 Estimation of parameters of production function model

Individual technical efficiency levels in sorghum production were estimated using the stochastic frontier production function. The input variables used in the stochastic frontier production model were Land allocated for sorghum (ha), chemical fertilizer (kg), oxen power (ODs), Human labour (MDs), and Quantity of seed (kg). The coefficients of the input variables were estimated under the full frontier production function (MLE).(Table below). The maximum

likelihood estimation for the best practice households, the output elasticity with respect to all the selected variables has the expected sign. That means all input variables entered in the production frontier function have been found positive sign of estimated coefficients that generally confirm to prior expectations.

The result of the Cobb-Douglas stochastic production frontier showed that the amount of seed, fertilizer, oxen power and human labour inputs were found to positively and significantly (at 5% significance level except oxen power which is at 1% level of significance) explained the level of efficiency of sorghum production (Table 5), which are important variables in shifting the frontier output to the right. This indicated that at each and every unit of these variables there is a possibility to increase the level of output. But land allocated for sorghum is insignificant.

Table 5: MLE and OLS estimates for Cobb-Douglas production function

Variables	parameters	Std. Err.	Coefficient	z-value
_cons	β_0	0.190	-0.789***	-3.71
LnOxenP	β_1	0.042	0.561***	13.30
LnLand	β_2	0.038	0.041	1.06
LnSeed	β_3	0.051	0.161**	3.16
LnLabor	β_4	0.032	0.111**	3.44
LnFert	β_5	0.057	0.181**	3.18
Sigma-square	σ^2	0.001	0.009	
sigma_v			0.093	
sigma_u			0.003	
Lambda	λ		0.027	
Returns to scale			1.014	

Source: Computed from Field Survey Data, 2022

Note: ***, ** and *sign represents significance at 1%, 5% and 10% levels, respectively. The result of the stochastic production frontier model show that four of the input variables in the production function such as oxen power, seed, labor and fertilizer had a positive and significant

effect on the level of **sorghum production** (Table 5). Hence, the increase in these inputs variables would increase production of sorghum significantly.

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 in the amount of each input on the output. The variables, oxen power, human labour and fertilizer are the main inputs in determining the output level of sorghum for sample households in the study area. The positive coefficients of inputs indicate a 1% increase in oxen power, seed, human labour and fertilizer, 0.561%, 0.161%, 0.111% and 0.181% increase in sorghum output, respectively. In other words, if all the inputs are increased by 1%, sorghum output would increase by 1.014% (Table above).

Labor input used for sorghum production was found to be statistically significant and with expected sign for sample households. So, in this case labor would be the important variable in determining sorghum output level in the study area. Since the major concern of this study is to know the level of technical efficiency of sorghum growing households and the major factors determining the technical efficiency differentials in the study area, in-depth discussions on the structure of production function and coefficients of input variables is not required as such. The maximum-likelihood parameter estimates of the model show the relative importance of individual inputs and their aggregate significance in the production process as well as being useful in predicting the level of individual household's TE.

According to the model result of stochastic production function (Table 5) the value of λ is 0.027. The presence or absence of technical inefficiency was tested in the study using the important parameter of log likelihood in the half normal model $\lambda = \sigma_u/\sigma_v$. if $\lambda = 0$ there were no effects of technical inefficiency, and all deviations from the frontier were due to noise as stated in Aigner et al. (1977), the estimated value of $\lambda = 0.027$ significantly different from zero.

Returns to scale is the sum of elasticities of Cobb-Douglas frontier production function with respect to all inputs used, reflects the degree to which a proportional increase in all the inputs increase output. The sum of elasticity $\Sigma\beta$ as presented in Table above is 1.01 which implies

increasing returns to scale such that when all inputs specified in the model for the production of sorghum are increased by 1 unit, output will in turn increase by 1.01 units.

4.2.2 Multicollinearity Test

The multicollinearity test was carried out using the STATA version 14 when the regression coefficients were computed. As a result, continuous variables selected for estimation were checked for the problem of multicollinearity using Variance Inflation Factor (VIF). According to Gujarati, 2004, value of VIF more than 10 was usually considered as an indicator of serious multicollinearity. VIF is defined as:

$$VIF_i = \frac{1}{1 - R_i^2}$$

Where: x_i = the i th explanatory variable regressed on the other explanatory variables.

R_i^2 = the coefficient of determination in the (auxiliary) regression of x_i on the remaining regressors.

The degree of association between the discrete variables is also computed using contingency coefficients. The contingency coefficients are calculated for each pair of discrete variables using contingency coefficient test.

$$C = \sqrt{\frac{\chi^2}{N + \chi^2}}$$

Where: C=Contingency Coefficient, χ^2 =Chi-square test, n=total sample size

(Appendix Table 5) presents results of the contingency coefficient test. According to Gujarati (1995), a contingency coefficient value of 0.75 and above (i.e. ≥ 0.75) indicates the existence of a stronger relationship between the variables. Appendix Table 3,4 and 5 results have shown that there was no multi-collinearity problem among variables.

4.2.3 Determinant of technical efficiency among sorghum producing farmers

Having the information about the existence of technical efficiency variation and measuring its magnitude, examining the major factors causing technical efficiency variation is the next most important step of the study. From the very beginning about ten socio-economic variables were

hypothesized to affect level of technical efficiency of sorghum growing farmers of the study area. The coefficients of those socio-economic, institutional and agro-ecological variables included in the model were estimated simultaneously by the MLE procedure using the estimated level of TE as dependent variable.

The important point to be considered is that the dependent is the efficiency component of the total error term estimated in combination with the production frontier. The coefficients of variables should be read as the effect of each variable on the level of efficiency. Thus, one can read the estimated coefficients directly as the effect of the variable on technical efficiency by taking sign of respective coefficients.

Table 6: TE determinants for Cobb-Douglas production function.

Variables	Coefficient	Std. Err.	z-value
_cons	-1.707	1.437	-1.19
Age	-0.042	0.031	-1.36
SEXHH	-0.495	0.364	-1.36
OFA	0.602*	0.339	1.78
CrAC	0.525	0.336	1.56
EDUC	0.782*	0.423	1.85
HHSZE	0.735***	0.171	4.30
EXSE	0.939**	0.453	2.07
SLOP	0.706**	0.310	2.27
Tg	-0.654	0.399	-1.64
LH	0.434***	0.051	8.55

Source: Computed from Field Survey Data, 2022

According to the results of the one stage regressions, presented in (Table 6), education and off-farm activity of household heads have positive and significant impact on TE which is at 10% level. Frequency of extension contact and slope are affecting TE at 5% level. Household family size and livestock holdings of household heads have positive and significant impact on TE which

is at 1% level. This implies that these factors are important in causing efficiency differentials among sorghum farmers in the study area.

Education: Education had significant effect on TE with expected sign. It was positive and significant at 10% level of significance. Education equips farm household with the necessary knowledge of how to allocate their scarce resource in appropriate way by increase the adoption and spread technological innovations that shifts their production frontier outward. Educated farmers have strong desire to get information and use it than their counterpart. Thus, this variable is a powerful variable in determining the technical efficiency variation among sorghum producers since it increases decisions of the farmer to adopt productivity enhancing technologies. Then, this variable affects technical efficiency positively and statistically significant at 10% significance level. This finding of the study was similar with finding of (Dlamini et al., 2010; Getahun Gemechu, 2014; Addai and Owusu, 2014).

Off-farm activity: An off-farm activity refers to the opportunity that the farm households had to work outside their own farm operations. It was hypothesized that farmers who have engaged in off-farm activity are more efficient than others. The estimated result showed positive relationship between off-farm activity and technical efficiency and statistically significant effect on TE level at 10%. It affected technical efficiency positively for the reason that the income obtained from such off-farm activities could be used for the purchase of agricultural inputs, and augment financing of household expenditures which would otherwise. It may have affected technical efficiency negatively for the reason that households may allocate more of their time to off-farm activities and there was an overlapping between both activities and thus may lag in agricultural activities. The result obtained is consistent with studies of Wondimu and Hassen (2014). But inconsistent with studies by Kinde(2005),Haileselassie (2005) and Hailemaraim (2015).

Extension service: Consultation given by extension agents improves productivity of households. The output of efficiency model also revealed that extension service utilization has positive sign and is significant at 5% significance level. This indicates that the more the household had extension visit, the more he/she will become efficient. Thus, this result shows that consultation of extension agents increase sorghum production by increasing level of technical efficiency. This implies that a extension contact facilitates the flow of new ideas between the extension agent and

the household thereby giving a room for improvement in farm efficiency. Advisory service rendered to the households in general can help households to improve their average performance in the overall farming operation as the service widens the household's knowledge with regard to the use of improved agricultural inputs and agricultural technologies. This result is in line with the results of Fekadu (2004), Abebe (2009), Musa (2013) and Hailemaraim (2015).

Slope of sorghum plot: It affected positively and significantly to technical efficiency at 1% significance level. This is consistent with the priori expectation. This implies that the plain plot is less vulnerable to erosion than the steeper plot. Farmers operating on plain plots were more efficient than those cultivated sorghum on steeper plots. This is because of the fertility status of steeper land was poor, that aggravated the decline of the productivity of farm plots.

Hence, on the plain slope plots under continuous cultivation and with soil fertility maintenance than steep slope plots in which soil fertility deteriorates overtime. This leads to the decline of the productivity of farm land. This result is in full agreement with Getu et al. (1998). Kebede (2006) and Yitayal (2004) recommended that soil and water conservation practice should be done in order to maintain at least the existing fertility status of the steep farm land in the short run.

Family size: The coefficient of family size for technical efficiency is positive and statistically significant at 1% significance level. The result is similar to the previous expectation that farmers those having large family size are more efficient than farmers having small family size. Since labor was significant input variable, farmers with many family members have better advantage of being able to use labor resources at the right time, particularly during peak cultivation periods. Under the subsistence farming system, family labor constitutes the major labor supply to the farm. This agrees with the findings of Essa Chanei and Shumet (2011) However, Endalkachew (2012) had contrasting result that being household size reduces technical efficiency level.

Livestock holding: Number of livestock the households have in terms of tropical livestock unit was hypothesized to have positive influence in the efficiency model. That means households who have better livestock holding are more efficient than others. However, the finding shows that, the coefficient is positive and significant at 1% level of significance indicating that household with higher livestock holding are more efficient than those who have less livestock size. Livestock in

a mixed crop-livestock farming system have two fold importance in that, it supply oxen power (draught power) for ploughing and threshing, provide manure that will be used to maintain soil fertility and it serves as shock absorber to an unexpected hazard in crop failure as sources of food and income (cash) for the family. Timely ploughing and threshing is decisive in the production of crops thus access of livestock is important to better production. Since all types of animals and poultry production are considered in this study, livestock competitive effect has dominated its supplementary effect. This result is in line with the results of Fekadu (2004),Assefa (2012), Wondimu and Hassen (2014) andHassen (2016).

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

The main aim of this study was to analyze determinants of technical efficiency of smallholder sorghum production system in H/Abote District. This was achieved by measuring the efficiency of smallholder sorghum farmers and identifying the determinant factors of technical efficiency that influence technical efficiency of sorghum production. Improvement of agricultural productivity provides an important solution in addressing the problems of food insecurity and enhancing the development of agriculture in Ethiopia. Understanding the existence of inefficiency and different factors contributing to the inefficiency in advance is a factor that helps to improve production efficiency with a view to bring a desired change in the sector.

In this study, three-stage sampling procedures were adopted to select a sample of 95 sorghum producer farmer that represented the population. The data were collected from both primary and secondary sources. The primary data were collected through household survey using pretested and updated interview schedule. Besides the primary data, secondary data from different sources were collected and organized. Data analysis was carried out using descriptive statistics and econometric models.

The descriptive statistics was used to analyze the socio-economic characteristics of sample farmers and the production characteristics. The stochastic frontier model was used to analyze the maximum likelihood estimates of the production function. The estimated stochastic production frontier model indicated that oxen power, seed, labor and fertilizer were significant determinants of production level.

5.2. Recommendations

Based on the above results, the followings recommendations are made:

Education has a positive influence on technical efficiency. This indicates that education is fundamental in improving the technical efficiency thereby the performance of sample farmers. Hence, government should have designed appropriate policy to provide adequate and effective basic educational opportunities to the rural population, both formal and non-formal education for farmers in the study area so that farmers can use the available inputs more efficiently under the existing technology seems crucial.

The positive contribution of family size on technical efficiency of farmers' needs policy attention that would motivate and mobilize the rural population, particularly the youth, in agricultural activities by providing incentives.

From the study results suggest that extension services have to keep on providing information and practical farming knowledge for all households to improve resource utilization in agricultural production. In other words increased investment in extension service and education could jointly contribute to an improvement in efficiency of sorghum producing households in the study area. That means, efficiency of households can better improve if the development agents equally give the extension service for all households. Therefore, the extension service given by development agents should be properly followed by the respective department of woredas agricultural office.

There should be timely supply of fertilizer and quality improved seed to improve farmers' efficiency in production of sorghum.

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7. APPENDICES

7.1 Appendix A. Tables

Appendix Table 1: Conversion factor used to calculate man days equivalent

Age group(Years)	Male	Female
<10	0	0
10–13	0.2	0.2
14–16	0.5	0.4
17–49	1.00	0.8
>50	0.7	0.5

Source: Storck et.al (1991)

Appendix Table 2: Conversion factors used to estimate Tropical Livestock Unit

Animal Category	TLU
Cow and oxen	1
Calf	0.25
Bull	1
Heifer	0.75
Sheep and Goat (adult)	0.13
Horse and Mule	1.10
Chicken	0.013
Donkey	0.70

Source: Storck et. al (1991).

Appendix: Table 3: VIF of the Input Variables

Variables	VIF	1/VIF
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SEED	6.17	0.162088
OXENP	5.93	0.168769
FERT	3.42	0.292643
LAND	2.59	0.386613
LABOUR	1.21	0.824566

Source: Computed from Field Survey Data, 2022

Appendix: Table 4: The VIF for the continuous variables used to determine overall efficiency

Variable	VIF	1/VIF
HHSZE	4.73	0.211534
Age	4.13	0.241879
LH	1.38	0.725460

Source: Computed from Field Survey Data, 2022

Appendix Table 5: Contingency Coefficients for the Dummy Explanatory Variables

	SEXHH	OFA	CrAC	EDUC	EXSE	SLOP	Tg
SEXHH	1.0000						
OFA	-0.2583	1.0000					
CrAC	0.1348	-0.2469	1.0000				
EDUC	0.2789	-0.3322	0.3946	1.0000			
EXSE	0.1086	-0.1227	0.2266	0.5633	1.0000		
SLOP	0.0462	0.2176	0.0607	-0.0774	0.0000	1.0000	
Tg	-0.0530	-0.0665	0.2163	0.2748	0.6102	-0.0364	1.0000

Source: Computed from Field Survey Data, 2022

7.2 Appendix B. Interview schedule is developed to data collection

This interview schedule will developed to gather information from smallholder farmers in H/Abote woreda for analysis of technical efficiency of sorghum production. In 2021 Ethiopian cereal crops production year.

1. General information about the sample house holds

1.1. Name-----

1.2. Sex. 1, male 0, female

1.3. Age of household head..... (In year).

1.4. Educational status of the household head

1. Illiterate 2. Literate

1.5. Family size of household..... (In number).

1.6. Did you engaged in off-farming activities in 2021 cropping season?

1, yes 0, no

1.6.1 If your answer in question number "1.6" is yes in what type of off-farm activity do you engaged? A, Trade B, weaving. C, animal husbandry

D, If others (specify).....

1.7. Total land holding..... in hectare?

1.7.1 From the total land holding what amount of land you used for Sorghum production.....in hectare?

1.8. How many oxen do you have for plough in 2021 cropping season?

1.9. Did you use improved seed during production year? 1, Yes 0, No

1.9.1 If your answer in question number "1.9" is No what is the main reason?

A, Lack of access B, Lack of awareness. C, price expensiveness

D, If others, specify.....

1.9.2 If your answer in question number "19" is yes how many kilogram of selected seed did you use per hectare?.....

2. Did you use credit to your Sorghum production? 1, Yes 0, No

2.1 If your answer in question number "2" is yes What sources of credit do you have in production of sorghum in 2021?

No	source	remarks
1		
2		
3		

NB: formal sources include banks, cooperatives and other programs; informal sources may include money lenders, traders, rotating savings and credit associations, friends, and relatives.

2.2 If your answer in question number "2" is No, why?

A, Lack of access B, Lack of enterest. C, If others, specify.....

3. Did you get any practical training with regarded to sorghum production?

1. Yes, 0, No

4. Do you have extension contact? 1, Yes 0, No

5 Do you use chemical fertilizer in sorghum production? 1, Yes 0, No

5.1 If your answer in question number "5" is yes, what kind of chemicals fertilizer did you use?

1. DAP 2. UREA

If yes how many Kg of chemicals fertilizer did you use?

1. DAP-----kg? 2 .UREA-----kg

5.2 If your answer in question number “5” is No, why?

1. Too expensive 2. not timely available 3. others, specify-----

6. What types of your land’s slope is? 1. Gentle 0. Otherwise

7. Crop production and Livestock holding and household income

7.1 Number of livestock owned

7.1.1 Do you have your own livestock? A) Yes B) No

If yes, for Q no. 7.1.1 please provide the detail of livestock you have?

NO	Type of herd	Total number
1	Cow	
2	Oxen	
3	Bulls	
4	Sheep	
5	Goats	
6	Donkey	
7	hen	
8	horse	
9	calves	

8. How many you produce sorghum on 2021 cropping season in kuntal? _____

APPROVAL SHEET
WOLKITE UNIVERSITY

Analysis of Technical efficiency of Smallholder farmer in sorghum production: the case of H/Abote District, North shoa Zone, Ethiopia”:

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