WOLKITE UNIVERSITY

COLLEGE OF AGRICULTURE AND NATURALRESOURCE DEPARTMENT OF AGRICULTURAL ECONOMICS

SENIOR RESEARCH ON TECHNICAL EFFICIENCY OF TEFF PRODUCTION IN SILTI DISTRICT ,SILTE ZONE,CENTRAL ETHIOPIA REGIONAL STATE

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LIST OF ACRONYMS AND ABBREVIATION

CSA	Central Statistical Agency
CRS	Constant Return to scale
DMU	Decision Making Units
DAP	Di Ammonium Phosphate
MOA	Ministry of Agriculture
MOFED	Minister of Finance and Economic Development
SFA	Stochastic Frontier Analysis
SPF	Stochastic Production Frontier
DAs	Development Agents
Qt	Quintal
TE	Technical Efficiency
TLU	Total Livestock Unit
AE	Allocative Efficiency
DEA	Data Envelopment Analysis
EE	Economic Efficiency
MLE	Maximum Likelihood Estimation

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ABSTRACT

Teff is one of the dominant crops and its productivity is low in the study area. This means that it is possible to obtained additional output from existing inputs used, if resource are properly used and efficiently allocated. The aim of this study was to determine the level of technical efficiency of smallholder teff producers and identify factors affecting technical efficiency of smallholder farmers in teff production of Silti district, Silte Zone, Ethiopia. A three stage sampling technique was employed to select 80 sample farmers who were interviewed using a structured schedule to obtain data pertaining to teff production during 2016/2017E.C production year. A Cobb-Douglas stochastic frontier production analysis approach with the inefficiency effect model was used to estimate technical efficiency and identify the determinants of efficiency of teff producing farmers. The maximum likelihood parameter estimates showed that teff output was positively and significantly influenced by seed, labor and number of oxen. This would mean that there is a room to increase teff output from the existing level if farmers are able to use these input variables in an efficient manner. The result further revealed that there were significant differences in technical efficiency among teff producers in the study area.Level of technical efficiency of teff producers mean,min and max are 0.68 ,0.37 and 1 respectively. The estimated stochastic production frontier model together with the inefficiency parameters showed that, extension contact, total number of livestock and credit were found to have negative and significant effect on technical inefficiency while household size was found to have positive and significant effect on technical inefficiency of teff production. Hence, local government should provide necessary supports such as formal as well as informal credit, extension contact and timely seed.

Key Words; Silti district; Stochastic frontier analysis; Technical efficiency; Teff

1. INTRODUCTION

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1.1 Background of the Study

A large majority of Ethiopians and the poor living in rural areas are deriving their livelihood from agriculture. The proportion of the population of Ethiopia residing in rural areas in 2040 is predicted to be nearly 70%, when there will be 40 percent more rural residents (UN, 2014). Agriculture in Ethiopia is dominated by smallholder farming households, which cultivated 94% of the national cropped area in 2013/14 (CSA, 2014a).

In the crop production sub-sector, cereals are the dominant food grains. The major crops occupy over 8 million hectares of land with an estimated annual production of about 12 million tons (CSA, 2015). The potential to increase productivity of these crops is very high as it has been demonstrated and realized by recent extension activities in different parts of the country.However, population expansion, low productivity due to lack of technology transfer and decreasing availability of arable land are the major contributors to the current food shortage in Ethiopia (Hailemariam, 2015). According to CSA (2015), Ethiopian population will exceed 126 million by the year 2030. This increase in population will impose additional stress on the already depleted resources of land, water, food and energy.

Teff is an important crop in terms of cultivated area, share of food expenditure, and contribution to gross domestic product. Despite the remarkable growth in teff production in the last decade, the drivers of this growth are not well understood. In particular, there is a lack of evidence on the contribution of improvements in productivity to this growth and the smallholder farmers during the 2004/05-2013/14 period (CSA, 2014a).

During the same period teff output grew at average annual rate of 9.3% and yields grew at 5.2% (CSA, 2014b). Evidences indicate that part of the growth in teff output has been driven by increases in cultivated area (Dorosh et al., 2015). contribution of such improvements for growth in output various staple crops dominate different parts of Ethiopia. However, teff is either the principal staple or among the most consumed crops in almost all parts of the country. Moreover, the demand for teff is elastic with respect to income. The share of spending on teff in food expenditure is highest inurban areas and increased by 3.4 % nationwide between 2005 and 2013, during which time real income increased considerably and the share of all other cereals declined (Worku et al., 2014).

Agriculture is the mainstay of the Ethiopian economy, contributing about 35% of the GDP and employing over 70% of the total population (CSA, 2022).Teff is one of the major cereal crops cultivated in Ethiopia, coverning about 30% of the total area under cereals (CSA, 2022). It is the most important staple food crop and the main ingredient for the traditional Ethiopian fermented flatbread, called "injera". Ethiopia is the world's largest producer and consumer of teff, accounting for over 90% of global teff production (FAO, 2023).However, despite its importance, the productivity of teff in Ethiopia remains low, averaging around 1.6 tons per hectare, which is significantly below its potential (CSA, 2022). This low productivity is attributed to various factors including limited use of improved production technologies, small landholding sizes, and inefficient use of resources. Improving the technical efficiency of teff production can play a crucial role in boosting its productivity and enhancing food security in the country

SNNPR is one of the major teff-producing regions in Ethiopia, alongside the Amhara and Oromia regions.Teff is a staple grain crop in SNNPR and is widely grown by smallholder farmers, particularly in the highland areas of the region. The main teff-producing zones within SNNPR include Gurage, Hadiya, Kembata Tembaro, Sidama, and Wolaita.

In 2022, the total teff production in SNNPR was estimated at around 1.2 million metric tons, accounting for about 20% of the national teff output (Tesfaye, 2023). Teff yields in SNNPR average between 1 to 1.5 metric tons per hectare, which is slightly lower than the national average yield (Tesfaye, 2023). Challenges for teff producers in SNNPR include limited access to high-yielding teff varieties, suboptimal agronomic practices, and lack of post-harvest handling and storage facilities (Tesfaye, 2023).

Due to population growth, urbanization, rising income level of citizens as well as its numerous health benefits and specific nutritional content, the demand for teff is rising constantly in the

country and globally. Therefore, the supply of the teff grain has fallen short of the demand. As a result, the price of teff is continually increasing (Barretto et al., 2021).

1.2. Statement of the Problem

In Ethiopia agricultural production and productivity is very low and the growth in agricultural output has barely kept pace with the growth in population. The high potential areas of Ethiopia can produce enough grains to meet the needs of the people in the deficit areas. However, the inefficient agricultural systems and differences in efficiency of production discourage farmers to produce more (Knife et al., 2012).

In the Central Ethiopia region, teff is cultivated on around 850,000 hectares of land, making it one of the dominant cereal crops in the region (CSA, 2022). In Silte Zone, teff is grown on approximately 45,000 hectares, accounting for about 20% of the total cropland in the zone (Silte Zone BoA, 2021). In Silti District, within Silte Zone, teff is cultivated on 12,000 hectares, which is around 25% of the total cultivated area in the district (Silti District BoA, 2022).

In Central Ethiopia, an estimated 1.2 million smallholder households are involved in teff production (CSA, 2022). In Silte Zone, around 60,000 households grow teff as a major crop (Silte Zone BoA, 2021). In Silti District, approximately 16,500 smallholder farmers cultivate teff (Silti District BoA, 2022).

The average teff yield in Central Ethiopia is around 1.6 tons per hectare (CSA, 2022). In Silte Zone, the average teff yield is 1.4 tons per hectare (Silte Zone BoA, 2021). In Silti District, the average teff yield is only 1.2 tons per hectare, significantly lower than the regional and national averages (Silti District BoA, 2022).

A study conducted in Silti District by Tesfaye et al. (2021) found that the low teff yields in the area were primarily due to the use of traditional farming practices, limited access to improved teff varieties, and inadequate soil fertility management.The study showed that the average teff yield in fields with traditional practices was 1.1 tons per hectare, while fields that adopted improved teff varieties and better agronomic practices achieved yields of up to 1.8 tons per hectare, a 64% increase.Soil fertility analysis in the district revealed that many teff fields had low levels of essential nutrients, such as nitrogen, phosphorus, and potassium, contributing to the low productivity (Tesfaye et al., 2021).

this study was concerned with analysis of technical efficiency in teff production and provides valuable information so as to make an intervention in order to increase production and productivity of teff in silte zone of central ethiopian region, Ethiopia. Despite its potential, Silti District's agricultural productivity is declining. Therefore, the need for the efficient allocation of productive resources cannot be overemphasized. However, in areas where there is inefficiency trying to introduce new technology may not bring the expected impact, unless factors associated with inefficiency among farmers are indentified and acted upon. The existence of inefficiency in production comes from inefficient use of scarce resources. 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 scare resources and for reformulating agricultural policies. Thus, this study has attempted to generate information for policy implication by identifying factors that are associated with technical efficiency in teff production in Silti District. Therefore, the study filled this information and knowledge gap at the study area.

1.3.Research Questions

This study will attempt to answer the following research questions:

- What is the existing level of technical efficiency in teff production in the study area?
- What are the factors influencing technical efficiency in teff production at household level?

1.4. Objectives of the Study

The general objective of the study is to analyze technical efficiency in teff production of smallholder farmers in Silti District.

The specific objectives of the study

- To estimate the level of technical efficiency in teff production of smallholder farmers in the study area,
- To identify factors affecting the level of technical inefficiency in teff production among farmers in the study area.

1.5. Significance of the Study

The study was focused on the issue of technical efficiency in teff production and identifies factors associated with technical efficiency among farmers. It can play a significant role in providing useful information concerning technical inefficiencies in production and by identifying those factors, which were associated with inefficiencies that may exist. It can also indicate an entry point for further policy interventions to technical efficiency of smallholder farmers. Therefore, this study is expected to generate adequate understanding of the issues that might lead towards taking appropriate actions for improvement of efficiencies. Hence, the outcome of this piece of work can have important implications for the professionals and for the policy formulation purposes.

1.6. Scope and Limitation of the Study

This study focused on technical efficiency in teff production during summer season in one District, using cross sectional data of the 2024 production year collected from teff producing smallholder farmers. The other limitation will be related with the methodology used. In addition, the study is limited to the analysis of technical efficiency of teff production without regard to other crops. Moreover, the study is limited to only Silti District of Silte Zone, Central Ethiopian Regional State, Ethiopia.

2. LITERATURE REVIEW

2.1. Concept and Definition of Efficiency

In a study published in the Journal of Productivity Analysis in 2021, Farrell (2021) defined technical efficiency as "the ratio of the minimum possible amount of any input (or set of inputs) required to produce a given output vector to the actual amount of that input (or set of inputs) used." Mathematically, this can be expressed as:

Technical Efficiency = Minimum Possible Input / Actual Input

According to Coelli et al. (2005) in their book "An Introduction to Efficiency and Productivity Analysis," technical efficiency is "the ability of a firm to produce the maximum output from a given set of inputs." They further state that a technically efficient firm is one that produces on the production frontier, which represents the maximum output attainable from each input level.

Kumbhakar and Lovell (2000), in their book "Stochastic Frontier Analysis," define technical efficiency as "the ability of a firm to produce the maximum output from a given set of inputs." They emphasize that technical efficiency is a relative concept, where a firm is compared to the best-practice firms in the industry.

2.2. Models of Efficiency Measurement

2.2.1. Non-parametric frontier model

The non-parametric approach has been traditionally assimilated into Data Envelopment Analysis (DEA); a mathematical programming model applied to observed data that provides a way for the construction of production frontiers as well as for the calculation of efficiency scores relatives to those constructed frontiers. Data Envelopment Analysis (DEA) is a non-parametric method and can easily handle multiple input and output. Moreover, in DEA, application inputs and output can have very different units of measurement without requiring any a priori trade off or any input and output prices. An input oriented BCC/ Banker- charnels-cooper model/ suggested an extension of the CRS DEA model and the model is given below for N decision making unit (DMU), each producing M outputs by using K different inputs (Coelli et al., 1998).

$\text{Min}_{\varphi}\ \lambda\ \Phi$

Subject to

$-y_i + Y\lambda \geq 0$

$\Phi xi - X\lambda \geq 0$

$NI\lambda=1, \lambda \geq 0$

Where Φ is a scalar, NI is convexity constraint and λ is N x 1 vector of constants. Y represents output matrix and X represents the input matrix. The value of Φ will be the efficiency score for the i^{th}firm. This linear programming problem must be solved N times, once for each firm in the sample. A Φ value of 1 indicates that the firm is technically efficient according to the Farrell (1957) definition.The Weighted Additive Data Envelopment Analysis (WADEA) Model by Lozano and Villa (2022)

The WADEA model can be formulated as follows:

Maximize $\sum(uryro - vixio)$

Subject to:

$\sum(uryrj - vixij) \leq 0$, j = 1,...,n

$\sum ur = 1$

$ur \geq ur$min, r = 1,...,s

$vi \geq vi$min, i = 1,...,m

Where:

- yrj, xij are the rth output and ith input for DMU j
- ur, vi are the weights for the rth output and ith input
- urmin, vimin are the minimum permitted weights

2.2.2. Parametric frontier models

With respect to parametric approaches, these can be subdivided into deterministic and stochastic models. The first are also termed 'full frontier' models. They envelope all the observations, identifying the distance between the observed production and the maximum production, defined by the frontier and the available technology, as technical inefficiency. T A further classification of frontier models can be made according to the tools used to solve them, namely the distinction between mathematical programming and econometric approaches. The deterministic frontier functions can be solved either by using mathematical programming or by means of econometric techniques. The stochastic specifications are estimated by means of econometric techniques only. Coelli et al. (1998) recommended that stochastic frontier analysis is more appropriate than Data Envelopment Analysis and deterministic models in agricultural applications, especially in developing countries, where the data are heavily influenced by measurement errors, and the effect of weather, disease, and the like plays a significant role.

The stochastic frontier approach which was introduced by Meeusen and van den Broeck (1977) and Aigner et al. (1977), reversed the conventional belief that deviations from the production frontier are due to inefficiency of the producing units (that is, factors under the control of the producers, which may not be true). Hence, stochastic estimations of technical efficiency incorporate a measure of random error, which is one component of the composed error term of a stochastic production frontier. This model acknowledges the fact that factors, which are outside the farmers` control, can also affect the level of output. So it made possible to find out whether the deviations in production from the frontier output is due to firm specific factors or due to external random factors. The primary advantage of the stochastic frontier production function is that it enables one to estimate farm specific technical efficiencies.

2.3. Approaches to Identifying Efficiency Factors

The literature suggests two methodological approaches for analyzing the sources of technical efficiency based on stochastic production functions. Those are two-stage estimation approach and one-stage estimation approach. The first approach is the two-stage estimation procedure in which first the stochastic production function is estimated, from which efficiency scores are derived, then in the second stage the derived efficiency scores are regressed on explanatory variables using Tobit regression. This approach has been criticized on grounds that the firm’s knowledge of its level of technical inefficiency affects its input choices; hence inefficiency may be dependent of the explanatory variables. The inefficiency effects would only be identically distributed if the coefficients of the farm specific factors are simultaneously equal to zero. It is possible to overcome this problem by the use of a single stage maximum likelihood approach (Battese and Coelli, 1995).

The second approach advocates a one stage simultaneous estimation approach as in Battese and Coelli (1995), in which the inefficiency effects are expressed as an explicit function of a vector of farm-specific variables. In the Battese and Coelli (1995) approach, the technical inefficiency effects are specified in the stochastic frontier model and assumed to be independently but not identically distributed non- negative random variables. The technical inefficiency effects are expressed as;

$U_j = j\delta$

Where for farm j, δ is a vector of observable explanatory variables and δ is a vector of unknown parameters. Thus, the parameters of the frontier production function are simultaneously estimated with those of an inefficiency model, in which the technical inefficiency effects are specified as a function of other variables. The one stage simultaneous approach is also implemented in frontier and in addition to the basic parameters the program also provides coefficients for the technical inefficiency model. Several factors including socio -economic and demographic factors and institutional factors are likely to affect the efficiency of smallholder farmers. This study has adopted to use the single stage estimation approach due to the measurement procedure of the overall technical efficiency.

2.4. Empirical Studies on Technical Efficiency in Ethiopia

In Ethiopia, a number of researches are conducted on efficiency of farmers in different regions using different models and different variables in order to measure and identify the level and sources of technical inefficiency. Hassen et al. (2012). They had used cross-sectional data to analyze the economic efficiency of mixed crop and livestock production system and identify its determinant factors. The parametric method stochastic frontier approach was employed to measure economic efficiency. Fantu et al. (2015b) conducted smallholder teff productivity and Efficiency analysis in High-Potential Districts of Ethiopia. They applied data envelopment analysis to measure smallholder teff producers' relative productivity and efficiency. Their result indicated that credit, extension contact, and tropical livestock unit were positively affect total factor productivity and efficiency Hailemaraim (2015) used a Cobb-Douglas stochastic frontier production analysis approach with the inefficiency effect model to simultaneously estimate technical efficiency and identify the determinants of efficiency variations among teff producer farmers. From his result maximum likelihood parameter estimates showed that teff output was positively and significantly influenced by seed, labor and number of oxen.

Asfaw et al. (2020) assessed the technical efficiency of teff production in Gimbichu district, Oromia region, Ethiopia. Using a stochastic frontier analysis approach, the study found that farm size, access to extension services, and use of improved teff varieties had a positive and significant impact on technical efficiency. Conversely, household size and distance to the nearest market were identified as negatively influencing technical efficiency (Asfaw et al., 2020).

Gebremedhin et al. (2021) investigated the technical efficiency of teff production in Lemo district, Southern Nations, Nationalities, and Peoples' Region (SNNPR), Ethiopia. Employing a Data Envelopment Analysis (DEA) approach, the study revealed that access to credit, membership in cooperatives, and use of improved teff varieties positively affected technical efficiency, while household size and off-farm income had a negative impact (Gebremedhin et al.,2021).Hailemariam and Tesfaye (2022) analyzed the technical efficiency of teff production in Ensaro district, Amhara region, Ethiopia. Using a Cobb-Douglas stochastic frontier production function, the study found that education level, access to extension services, and use of fertilizer had a positive and significant effect on technical efficiency, while farm size and household size negatively influenced it (Hailemariam & Tesfaye, 2022).Demeke and Asfaw (2021) examined the technical efficiency of teff production in Ejere district, Oromia region, Ethiopia. Employing a Tobit regression model, the study showed that access to credit, livestock ownership, and use of improved teff varieties positively affected technical efficiency, while off-farm income and distance to the nearest market had a negative impact (Demeke & Asfaw, 2021).Teshome et al. (2022) assessed the technical efficiency of teff production in Doyogena district, SNNPR, Ethiopia. Using a Stochastic Frontier Analysis approach, the study revealed that education level, access to extension services, and membership in cooperatives positively influenced technical efficiency, while household size and off-farm income negatively affected it (Teshome et al., 2022).

2.5 CONCEPTUAL FRAM2EWORK

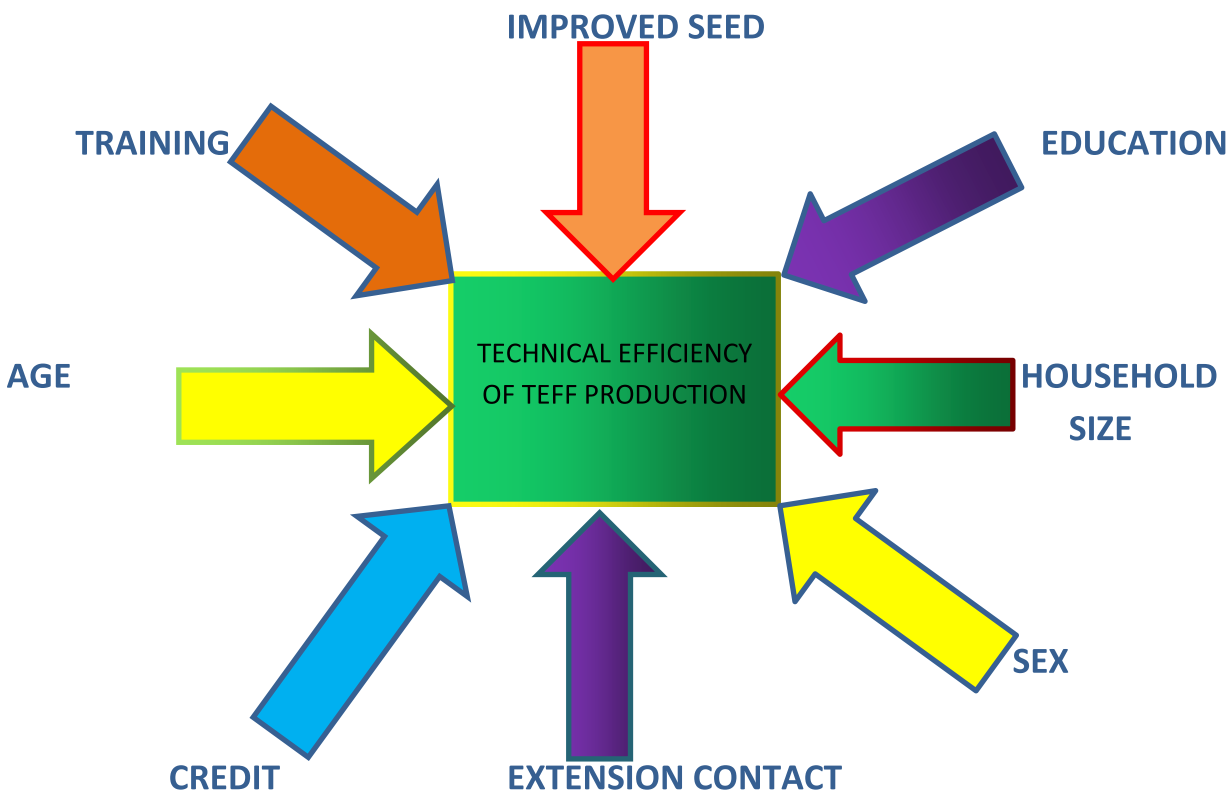

Figure 1 Conceptual Framework

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

The research is conducted in Silti District, Silte Zone, Central Ethiopia South Region .The district has two part, Silti woreda and Misrak Silti woreda located in 84 km far from Hosana, 26 Km from Werabe and 160 km from Addis Ababa.According to a study published in 2022 by Bedassa and colleagues, the population distribution in Silte Zone of the Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia is:

Dega: 21.3% , Weynedega: 27.8% and Kola: 50.9%

According to a study published in 2021 by Berihun and colleagues, the distribution of soil types in Silte Zone of the Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia is

Nitisols: 35.2% ,Luvisols: 28.7% ,Vertisols: 22.5% and Cambisols: 13.6%

The main production system in the study area is agriculture on the production of cereals (such as sorghum, maize and teff), fruits and partialy vegetables. In addition to farming, they are engaged in small scale farm to receive additional income such as keeping small number of livestock ,Chat and Honey production.

3.2. Data Types, Sources and Methods of Data Collection

Both primary and secondary data as well as quantitative and qualitative data were employed for this study. The primary data were collected using structured questionnaire and focus group discussion. For this study structured questionnaire was designed and pre-tested. The feed-back from the pre-test was used to refine and modify the questionnaire. The process of primary data collection was done by enumerator, the Kebele development agents and the researcher. The enumerators were trained on data collection procedures. In the study cross-sectional household data of main harvest cropping season was used. Data for input (such as land, human labor, oxen labor, fertilizer, and seed amount) were used and output of teff production was collected from the specified period of time. Data on input use and outputs were collected in local units and converting into standard units. In addition, primary data was collected by interviewing the selected teff producing farmers and variables that cause variation in production efficiency like age, education, household size, extension contact, gender, and the like. In addition, socio-economic variables such as demographic data, credit access, livestock holding, wealth indicators and institutional data were collected. On the other hand, data related to teff production trend, input supply and extension services were collected to clarify and support analysis and interpretation of primary data

3.3. Sampling Technique and Sample Size Determination

In order to select sample households, three-stage sampling technique where combinations of purposive and simple random sampling techniques were used to select the district and sample household heads. Silte Zone, Silti district was purposively selected due to near our city and extent of teff production in Silte Zone. This information was obtained from Silte Zone Agricultural Office. In the first stage, select Silti district, Silti was selected purposively due to the major teff production part of the district. In the second stage, out of the total 20 rural , two kebele were selected by simple random sampling. In the third stage, 80 sample teff producing farmers were selected using simple random sampling technique from each selected kebele based on probability proportion to size sampling technique. The sample size for the study was determined based on Yamane (1967) since the population is homogenous in agro-ecology and production system. The simplified formula provided by Yamane is used to determine the required sample size at 90 % confidence level and 10 % level of precision.

. The simplified formula used to determine the sample size of the study was specified as follows.

$$n = \frac{N}{1 + N(e)^2}$$

Where: n=statistically acceptable sample size

N=Total size of target population

e=level of precision(error level) at 90 % confidence level (0.1).

Table 1. Sample distribution in selected kebele

No of kebele	Name of kebele	Household	Sample size
1	Dacha Gisila	220	44
2	Asano	180	36
Total		400	80

3.4. Method of Data Analysis

Descriptive statistics and inferential statistics along with econometric models were used to analyze the data. Descriptive statistics such as mean, standard deviation, frequency and percentage were employed to analyze the data collected on socio-economic, institutional and agro ecological characteristics of the sample households. The econometric analyses were following the data will be analyzed using stochastic frontier approach by using single stage estimation.

3.5. Selection of the Functional Form

Another issue surrounding parametric frontiers relates to the choice of functional form. Among the possible algebraic forms, Cobb-Douglas and the translog functions have been the most widely used functional forms in most empirical production analysis studies. Each functional form has its own advantage and limitations. Some researchers argue that Cobb-Douglas functional form has advantages over the other functional forms in that it provides a comparison between adequate fit of the data and computational feasibility. It is also convenient in interpreting elasticity of production and it is very parsimonious with respect to degrees of freedom. So, it is widely used in the frontier production function studies as stated in Hazarika and Subramanian, (1999).

The Cobb -Douglas production frontier functional form was fitted to estimate the level of technical in/efficiency of farmer's teff production in the study area. To summarize, the choice of this functional form is due to the fact that, first, the Cobb-Douglas has been the most commonly used production functional form in the specification and estimation of production frontiers in empirical studies in most efficiency especially farm efficiency studies in both developed and developing countries. Second, because of the logarithmic nature of the production function that makes econometric estimation of the parameters a very simple matter (in terms of analysis and interpretation). In addition, the Cobb-Douglas functional form is also convenient in interpreting elasticity of production and it is very parsimonious with respect to degrees of freedom. Therefore, that is why Cobb-Douglas functional form was used in this study. The technical efficiency of teff production in Silti district was measured by considering the output obtained per household head as the dependent variable. The output of teff from the 2024/25 production year was measured in quintals. The independent variables will the inputs (factors) of production used in the same production year. Accordingly the relevant inputs which were considered as follow:

Y = the total amount of teff produced in quintal by the i^{th} farmer;

X1= the total number of oxen-power used for teff production in oxen-days by the i^{th} farmer;

$X2$=the total labor (family and hired) in man-days used for teff production by the i^{th} farmer;

$X3$=the total quantity of teff seed in kilogram used for teff production by the i^{th} farmer;

$X4$ = the total amount of fertilizer in kilogram applied for teff production by the i^{th} farmer;

$X5$= the total area covered by teff in hectares of the i^{th} farmer;

The Cobb-Douglas form of stochastic frontier production is stated as follows;

$\ln Y=\beta 0+\sum_{j=1}\beta j \ln Xij+Vi-Ui$

Where: For ith farmer, Y is the total quantity of teff produced, x is the quantity of input j used in the production process including Oxen labor, Human labor, land, quantity of seed and quantity of fertilizer; Vj is the two-sided error term and Uj is the one-sided error term (technical inefficiency effects).

The inefficiency model was estimated as the equation given below.

$\ln Y=\delta 0+\sum_{n=1}^{9} \delta nZni$

Zi is the variable in the inefficiency model

The technical inefficiency (ui) could be estimated by subtracting TE from unity. The function determining the technical inefficiency effect is defined in its general form as a linear function of socio -economic and management factors.

It can be defined in the following equation:

$Ui= \delta 0 + \sum_{k=1}^{9} \delta kZ_{jk}$

Where,

ui is the technical inefficiency effect,

δk is the coefficient of explanatory variables,

The Zi variables represent the socio-economic characteristics of the farm explaining inefficiency of the i^{th} farmer. As a result the technical inefficiency was explained by the following determinants:

Zi1= Age of the household head (years);

Zi2= Sex of the household (a dummy variable. It takes a value of 1if male, 0 otherwise;

Zi3= Household size (total numbers of family member who lives in one roof);

Zi4 = Education (A continuous variable It takes a value of 1 if literate, 0 otherwise);

Zi5 = Number of livestock measured by TLU;

Zi6= Training (A dummy variable. It takes a value of 1 if yes, 0 otherwise);

Zi7 = Extension contact (frequency of extension service during the farming season);

Zi8 = credit (A dummy variable It takes a value of 1 if user,0 otherwise);

Zi9= Improved seed (A dummy variable. It takes a value of 1 if yes, 0 otherwise).

3.6. Definition of Input and Inefficiency Variables and their Hypotheses

Output (Y): This is the dependent variable of the production function. It is the total amount of teff produced expressed in terms of physical output of teff in quintal (Qt) of sample households.

3.6.1. Input variables

Oxen (X1): Primarily oxen are used as a source of drought power in teff production process in the study area. It refers to the number of drought power used for different activities in teff production and it was measured in oxen-days (ODs). Here, one oxen-day is equivalent to eight hours in order to aggregate the ODs used for different oxen-driven activities that include plough, and threshing.

Labor (X2): This represents the total labor (family, exchange and hired) utilized in various farm activities (plough, sowing and fertilizer application, weeding, harvesting and threshing). The record was done by the type of person participated on the given activity by categorizing as children, man and woman. Thus, labor inputs for major activities were converted into man equivalent. The man-equivalent was computed by taking into account the age and sex of the laborer and using standard conversion factor reported by Strock et al. (1991) as indicated in . Then the total man -equivalent used by each sample farmer was included in the production function by converting into man-days. It was measured in man-days (MDs) where eight hours is equivalent to one man-day.

Seed (X3): It refers to the quantity of teff seed used in kg by the household head. Farmers mainly use local and improved teff seed in production.

Fertilizer (X4): Farmers commonly apply Di-Ammonia Phosphate (DAP) and UREA for teff production in the study area. Farmers used it in equal amount. The rate of application of this productivity enhancing input clearly matters to maximize teff yield. Its unit of measurement is kg.

Area of land covered by teff (X5): This refers to the physical unit of land area under teff crop cultivation expressed in hectare (ha). It includes all plots (that is, plots of land owned and/or cultivated through different land use arrangements such as renting-in, leasing and/or sharecropping) of land under teff production for each household.

3.6.2. Definition of inefficiency variables and hypothesis

Based on previous studies and socio-economic conditions of the study area, the following factors were expected to determine efficiency differences among sample farmers.

Age : Age of household head in years is hypothesized to reflect experience and physical strength of the farmer on efficiency. However the farmer become less efficient as he/she gets older and his ability to manage farming activities are expected to decrease. Younger farmers are tending to be more open and likely exposed to methods and techniques (Evaline et al., 2014 ; Bwala et al., 2015 ; Biam et al., 2016). Hence, in this study age was hypothesized to have negative effect on technical efficiency.

Sex of the household head : is a dummy variable representing the sex of household head taking a value of 1 for male headed households and 0 for female headed households. Even though women play a substantial role in agricultural activities, there are still tasks that are not used to be done by women. Besides, female headed households may also have to perform additional tasks such as taking care of children and therefore they may have to allocate their time between these tasks and actual farm activities (Fantu et al., 2011; Hazell, 2013). Hence, male headed households was expected to be more efficient than female headed households.

Household size : It is total numbers of family member who lives in one roof (number of people living together and utilizing scarce resources) measured in adult equivalent. Empirical studies by Musa et al. (2014), Mburu (2014) and Kabir et al. (2015) showed that family size are positively affect the efficiency level of the farmer. Thus, family size was expected to have a positive influence on technical efficiency of farmers in the study area.

Education of the household head : It is continues variable which is the year of schooling of the household head. This is used as a proxy variable for managerial ability of the decision making unit (household head). It is assumed that through education, the quality of labor is improved and he/she become active to adopt new technologies. Access to education together with increased experience could guide to better management of farm activities. The role of education toward improving farmers` efficiency is now widely accepted, in that it enables them to understand the socioeconomic conditions governing their farming activities and learn how to collect, retrieve, analyze and disseminate information. A lot of empirical studies showed that education is one of the most recognized factors in determining the efficiency level of the farmers in the world and resulted that education determined efficiency positively (Ali and Khan, 2014; Hailemariam, 2015; Ouedraogo, 2015). Hence, in this study education was expected to have positively related with teff production efficiency

Livestock size : It is the total number of livestock owned by farmers measured in tropical livestock unit. The variable used as proxy for wealth, farmers with more livestock units, which can readily be converted to money can be able to buy modern inputs than those that own fewer livestock units. Moreover, families with more animals are more likely to have larger protein intake than those with fewer animals, which helps improve their working efficiency (Mekonnen et al., 2015; Bwala et al, 2015). Therefore, in this study livestock number was expected to have positively relation with technical efficiency of teff production.

Training : Training is an important tool in building the managerial capacity of the household head. Household heads that got training related with crop production and marketing or any related agricultural training were hypothesized to be more efficient than those who did not receive training. It is dummy variable having value equal to 1 if the household got training at least one day in the cropping season and zero otherwise. Many empirical studies showed that training found to be affect efficiency positively (Beyan, 2013; Awol, 2014; Birhan, 2015). Hence, in this study training was expected to have positive effect on technical efficiency.

Number of Extension contact : This is used as a proxy measure for access to extension services and defined as the number of time the extension agent visited the farmer during stated production season. Extension workers may play a central role in informing, motivating and educating farmers about available technologies. Hence, it may have a positive impact on efficiency levels of teff producers through improvement of their managerial ability and general agronomic practices (Abba, 2012; Krishnan and Patnam, 2014; Hailemariam, 2015; Chandrasekhar and Nikita, 2015). Hence, in this study number of extension contact was expected to have positively related with teff production efficiency

Credit : This is dummy variable that represents amount of credit received for farm related purposes by the farmer in the production year. Since farmers in developing countries have not sufficient working capital to run agricultural activities unlike developed countries, farmers need to have that potential to engage in such business. Hence, credit is an important source of financing the agricultural activities of smallholder farmers and this is supported by empirical studies conducted by farin et al. (2010), Gebregziabher (2012) and Biam et al. (2016) amount of credit is positively related to level of technical efficiency of crop production. Hence, in this study credit was expected to have positively related with teff production efficiency.

Improved seed : It is dummy variable which have the value of one if the farmer is used improved seed; and zero otherwise. This argues that, improved seed of teff is enhancing productivity and quality of the output. The empirical studies by Sultan and Ahmed (2014) and Mukete et al. (2016) indicated that improved seed are important variable to maximize efficiency. Hence, in this study improved seed was expected to have positively related with technical efficiency.

Table 2. Summary of definition, measurement and hypothesis of inefficiency variables

Variable	Definition	Measurement	Expected sign with sign with Technical efficiency
Dependent			
Efficiency index	Technical efficiency in teff production		
Independent			
Age	Age of household head	Year	–
Sex of the household	Sex of the household head, having a value of 1 for male and 0 otherwise	Dummy	+
Household size	total numbers of family member who lives in one roof	Adult equivalent	+
Education	It takes 1 if literate,	Continuous	+

	0 otherwise		
Livestock size	Number of livestock	TLU	+
Training	Farmers received training on related activities having a value of 1 if yes, 0 otherwise	Dummy	+
Extension contact	Frequency of extension service during the farming season	Number	+
Credit	It takes 1 if user, 0 otherwise	Dummy	+
Improved seed	It takes 1 if yes, 0 otherwise	Dummy	+

4. RESULTS AND DISCUSSION

The chapter has been divided into two main sections. The first section deals with the results of descriptive analysis pertaining to socio-economics, demographic characteristics and various agricultural activities undertaken by sample household heads. In the second section, the econometric results related to level of technical efficiencies realized and factors affecting technical efficiency in teff production have been presented and discussed.

4.1. Descriptive Results

The descriptive statistics presented in this section is comprised of various sub section. The discussion is included demographic and socio economic characteristics; institutional support; rate of input use and description of variables used in SPF

4.1.1. Demographic and socio-economic characteristics of sample households

Household size: Total numbers of individuals within the household determine the availability of labor power needed in the farm production. Family labor plays an important part in the success of a small- scale farming practices in that the farmer does not need to spend too much money on labor costs. In the study area, average household size for the sample farmers was about 4.2 adult equivalents per household. According to table (3), the largest household size was being 7 while the smallest size was 2 adult equivalents per household with standard deviation 1.30

Age of the household head: it is one of the important factors which determine the farming experience of the farmer. Age of household is important to study such a long period phenomenon, related with the change in farm size and extent of subdivision. All these contribute in determination of individual farm efficiency. The survey result showed in table(3), the average age of the sample household heads was 51.86 years. Their age ranged from 22 to 73 years with standard deviations of 12.18.

Education status of the household head: Education enhances the acquisition and utilization of information on improved technologies by farmers. Education together with increased experience could guide farmers to better manage their farm activities. Education upgrades the ability and changes the attitude of person in a given society. Educated farmers were expected to adopt new agricultural technologies and had better managerial skill. Therefore, table 3 revealed that about 30% and70% of the sample household heads were illiterate and literate respectively.

Sex of the household head: The survey result in table 3 indicated that 29% percent of households are female-headed. It is understood that female-headed households face greater challenges in the agricultural production and marketing compared with their male-headed counterparts. This is due to the fact that female household heads in the rural Ethiopia hold various tasks including collecting of fire wood from the field, fetching water, childrearing and household management obligations.

Table 1. Demographic and socio-economic characteristics of sample households

Variable	Min	Max	SE	Mean
Age of household head	22	73	12.18	51.86
Family size of household head	2	7	1.30	4.23
Dummy variable	Response	Frequency	Percent	
Education status of HH	Literate	56	70	
	Illiterate	24	30	
Sex of HH	Male	57	71	
	Female	23	29	

Source: Own Survey,2016

4.1.2. Institutional support

Extension service: In order to give effective extension service to the farmers, the region assigned DAs in each Kebele. The DAs are agricultural streams such as, crop production, animal husbandry and natural resource management. In this study, 86% of the sample respondents reported that they have been receiving extension services out of which 66.6% received advice about teff production. The extension workers also visit farmers on different intervals. Some farmers are being visited more frequently while others have got no chance at all to be visited by extension workers. The survey result indicated that, the average frequency of extension contact of sample households was 2.45 times with standard deviation of 0.78 (Table 4).

Credit: There exist both formal and informal lending institutions to provide credit. The formal sources of credit in the study area are Microfinance Association(MFA) and local cooperatives, whereas friends, relatives, traders, and the like are informal sources from which farmers could get credit. As far as the access to credit is concerned, from either source when they are in need of it provided that they fulfill the requirements set by the lending institutions.

On the study area 80% of the farmer use access to credit and the rest had not use access to credit. This indicates that majority of the sample farmers were use access to credit.
(Table 4).

Training: An appropriate training given to the farmers may improve productivity by enhancing their management capacity. In the study area, farmers were getting training from surrounding research centers and other governmental and nongovernmental organizations. Among the sample farmers, 71% of farmers were trained on different teff related aspect and the rest had not received any training on the subject matter previously. This indicates that majority of the sample farmers were received (Table 4)

Table 2. Institutional characteristics of the sample household

Variable	Min	Max	SE	Mean
Frequency of extension contact	1	4	0.78	2.45
Dummy variable	Response	Frequency	Percent	
Access to credit	Yes	64	80	
	No	16	20	
Training	Yes	57	71	
	No	23	29	
Total		80		

Source: Own Survey,2016

4.1.3. Resource basis

4.1.3.1. Ownership of livestock by sample household heads

Livestock have diverse functions for the livelihood of farmers in mixed farming system. They provide food in the form of meat, milk, and non-food items such as draught power and manure as inputs into crop production. In addition, they were source of cash income and act as a store of wealth and play a determinant role in social status within the community and buffering risk. The survey result showed that, the average number of livestock in the sample household heads was 4.60 . Their livestock ranged from 2 to 12 with standard deviations of 2.27(Table 5).

4.1.3.2. Level of oxen power utilization by sample household heads

Oxen were the only sources of traction power in the area. Shortage of draught power limits the area that can be cultivated. Shortage of oxen power leads to poor land preparation and delayed completion of the operation. Poor land preparation leads to poor plant establishment, heavy weed infestation and low yields. The number of draught animals determines the amount of land that can be cropped, the types of crop grown, total crop production and yield (Mburu et al., 2014). Larger holding of oxen permit a greater area of land to be cultivated (Ogada et al., 2014). Oxen power was found as an important factor of production in the study area. Oxen power utilization by sample households Average oxen power used by the sample households in teff production was 4.08 oxen days with standard deviation of 0.88.(Table5).

Table 3. Resource Basis characteristics of the sample household

Variable	N	Min	Max	Mean	Std. Deviation
Oxen power	80	2	5	4.08	0.88
Total number of livestock unit	80	2	12	4.60	2.27

Source: Own Survey,2016

4.1.4. Description of production function and input variables

4.1.4.1. Labor availability

Family labor was the main source of labor for performing various farming activities for smallholder farmers. In the study area, it has been observed that there was a sort of labor division in various farm works between family members. Ploughing and planting were types of activities belonging to male whereas food preparation and childcare were left to female. In most of other cases than these both female and male worked together. In this specific study, labor availability of the sample household was calculated in man equivalent to examine the effect of variation in labor availability among the households. Because of differences in capacity and ability of performing a given activity between sex and different age groups labor force were standardized to a similar unit (man equivalent). The minimum and maximum level of labor (man-day) used were 10 and 40 man-days, respectively (Table6)

4.1.4.2. Average size of cultivated land holding by sample household heads

An attempt was made to study the size of cultivated land holding by sample household heads of Silti district. To mitigate the challenge of land shortage, young farmers usually shared land with their parents and relatives during marriage or obtained land use access through sharecropping and renting in land. The average land area allocated to teff production (both owned and rented land) was approximately 0.38 ha and ranged from 0.20 ha to 0.65 ha with a standard deviation of 0.11.(Table 6).This part present summary statistics results of production variables (both the physical inputs used in the production of teff output) used for analysis in the stochastic production frontier model. The result of analysis for output variable indicates that on average a household produced 5.49 Qt of teff output that ranges from 3 Qt to 8 Qt with standard deviation of 1.21 among the sample farmers in 2016 production year . This indicates the large variability of output among the farmers. The average seed input (both improved and local seed) sown by teff producers in the study area during a given production year was 21.88 kg and which ranges from 14 to 33 minimum and maximum quantities of seed, respectively. Regarding fertilizer type, farmers in the study area commonly using DAP and Urea fertilizer. The summary result indicates the mean rate of fertilizer application of 30.10 Kg and which ranges from 20 Kg to 41 Kg minimum and maximum application rate, respectively. The use of oxen power in teff production activities like plowing and threshing in the study area is usual. The result indicated that the mean number of oxen power used was 4.08 oxen days, with the maximum and minimum of 2 and 5 pair of oxen days per season respectively. (Table 6).

Table 4. Descriptive statistics of input variables used in production function estimation

Variables	N	Min	Max	Mean	Std. Deviation
output(Qt)	80	3.00	8.00	5.49	1.21
Amount of fertilizer(kg)	80	20.00	41.00	30.10	4.93

Seed(kg)	80	14.00	33.00	21.88	2.87
Family labor(man day)	80	10.00	40.00	26.58	6.36
Oxen power(pair oxen day)	80	2.00	5.00	4.08	0.88
Cultivated land size(ha)	80	0.20	0.65	0.38	0.11

Source: Own Survey,2016 E.C

4.2. Econometric Results

4.2.1. Maximum likelihood estimation of parameters

The maximum-likelihood estimates of parameters of the stochastic production frontier and inefficiency effect models ,stochastic production frontier model permits to consider production of teff in the study area with Cobb-Douglas stochastic production was tested and found to be best to fit the data. It was used to estimate efficiency of farmers and to identify factors determining the inefficiencies in teff producing farmers. Estimation of parameters was carried out with a one-stage procedure under the assumption of normal/half-normal distribution of the error terms. This approach leads us to the final estimates of parameters of the five explanatory variables of the frontier function; and nine explanatory variables which influence the mean efficiency of teff producing farmers. The ML estimates of the parameters of the frontier production functions and inefficiency effects are presented in Table 7. The Maximum Likelihood estimates of the parameter of SPF functions together with the inefficiency effects model are presented in Table 7 below. Out of the total five variables considered in the production function, three (seed ,labor and oxen power) had a significant effect in explaining the variation in teff production among farmers. The coefficients of production function variables were positive. The coefficients of oxen power and labor were significant at 1% level of significance , and the coefficient of seed was significant at 10% level of significance. This informs that they were significantly different from zero and hence these variables were important in explaining teff production in the study area. The positive production elasticity with respect to seed, oxen and labor imply that as each of these variables increase, teff output will increase. On average, as the farmer increases area allocated to teff, amount of seed , labor and oxen power for the production of teff by 1% each, he/she can increase the level of teff output by 0.05, 0.04 and 0.94 percent, respectively.

Table 5. Maximum likelihood estimate for Cobb-Douglas production function variable Maximum likelihood estimate

	Maximum likelihood estimate		
Variable	Coefficient.	SE	z -Value
lnArea	-0.32	0 .59	-0.54
lnLabor	0 .04*	0 .01	3.34
lnOxen	0 .94*	0 .09	10.70
lnSeed	0 .05**	0 .02	1.85
lnFertilizer	0 .02	0 .01	1.59
constant	-0.99	0 .89	-1.13
Log likelihood	-52.16		
Mean technical efficiency	0.78		
Total sample size	80		

*,** represents significant at 1% and 10% probability level respectively.

Source: frontier model result, 2016 E.C

Performance Level: Since the score is 0.78, it reflects that, on average, the units are performing at 78% of the ideal or benchmark efficiency level.Inefficiency Indicator: This means there is a 22% inefficiency in converting inputs into outputs; in other words, for every unit of output that is theoretically possible, 22% of resources are being wasted or not utilized effectively.

4.2.3. Determinantof technical efficiency

The focus of this analysis was to provide an empirical evidence of the determinant productivity variability/inefficiency gaps among smallholder teff farmers in the study area. the study investigated farm and farmer-specific attributes that had impact on smallholders` technical efficiency. The driving force behind measuring farmer's efficiency in teff production is the identification of important variables/determinants with which to work for development in order to improve the existing level of efficiency. The determinants of technical inefficiency/efficiency in a given period vary considerably depending on the socio-economic conditions of the study area particularly pertaining to managerial characteristics and other related factors. Before discussing the significant factors which influencing efficiency in teff production, it is important to see how efficiency are interpreted. The result in the table 8 is presented in terms of efficiency and hence the negative sign shows the increase in the value of the variable attached to the coefficient means the variable positive contribute toefficiency level or conversely it contributes negative to inefficiency levels. Thus any negative coefficient happens to reduce inefficiency which implies its positive effect in increasing or improving the efficiency of the firm and vice versa. Accordingly, the negative and significant coefficients of extension contact, total livestock and credit indicate that improving these factors contribute to increase technical efficiency. Whereas, the positive and significant variable such as household size, affect the technical efficiency negatively that is increases in the magnitude of these factors aggravate the technical inefficiency level. The implications of significant variables on the technical efficiency of the farmers in the study area were discussed here under.

Table 6. Maximum-likelihood estimates of technical inefficiency determinants

Variable	Coefficient	SE	Z-Value
Constant	3.25*	0.97	3.35
Sex	-0.02	0.22	-0.09
Age	-0.01	0.01	-1.13
Household Size	0.27*	0.09	2.92
Education	-0.25	0.22	-1.14
Improved Seed	-0.08	0.24	- 0.33
Training	-0.03	0.26	-0.12
Credit	-0.52**	0.26	-2.02
Extension Contact	-0.49*	0.14	- 3.55
TLU	-0.13*	0.04	-2.96
Log likelihood	-52.16		
Total sample size	80		

*,** represents significant at 10% and 5% probability level respectively.

Source: frontier model result, 2016 E.C

The inefficiency index is a quantitative measure used to assess how inefficient a certain process, organization, or system is compared to an optimal or benchmark standard. The derivation of the inefficiency index can vary depending on the context, but generally follows these steps

Define the Output and Input: Determine what outputs (goods, services, or results) and inputs (resources, time, money) are relevant to the process being evaluated.Establish a Benchmark: Identify or calculate the ideal or maximum output that could potentially be achieved with given inputs. This can be based on historical data, industry standards, or theoretical models.MeasureActual Performanc**e**: Collect data on the actual outputs produced with the inputs used in the process.Calculate Efficiency Ratio: The efficiency ratio is calculated by dividing the actual output by the benchmark output:

Efficiency Ratio=Actual Output /Benchmark Output

Derive the Inefficiency Index: The inefficiency index is typically calculated as:

Inefficiency Index=1−Efficiency Ratio

This formula shows how much less efficient the process is compared to the benchmark. If the efficiency ratio is less than 1, the inefficiency index will be positive, indicating inefficiency.Interpret the Results: The resulting inefficiency index provides insights into how far the current performance is from the optimal level, prompting identification of areas for improvement. the inefficiency index is derived by comparing actual performance against an established benchmark and calculating how much of the potential efficiency is not being realized.

Household size : There is statistically significant and negative relationship between household heads and technical efficiency of teff production at 10% level of significance. The result indicated that as household size of farmers increases their technical efficiency level decrease. This may be due to the reason that The number of household is increase the ability to work is decrease and the household number is contest each other. The empirical studies by Musa et al. (2014), Mburu (2014) and Kabir et al. (2015) .

Credit: In this study, amount of credit affected technical efficiency of farmers positively and significantly at 5% level of significance. The empirical studies conducted by Gebregziabher et al. (2012), Musa et al.(2014) and Biam et al. (2016) found positive and significant relationship between credit and farmers` technical efficiency which was in line with this study Amount of credit increases farmers' efficiency because it temporarily solves shortage of liquidity/working capital. In this study, amount of credit was hypothesized in such a way that farmers who get more amount of credit at the given production season from either formal or informal sources were expected to be more efficient than those who get less amount of credit. .

Number of Extension contact: in this study number of extension contact affected technical efficiency of farmers positively and significantly at 10% level of significance. Hence, it may have a positive impact on technical efficiency levels of teff producers through improvement of their managerial ability and general agronomic practices (Abba, 2012; Krishnan and Patnam, 2014; Hailemariam, 2015; Chandrasekhar and Nikita, 2015).

Livestock size : in this study livestock number affected technical efficiency of farmers positively and significantly at 1% level of significance. It is the total number of livestock owned by farmers measured in tropical livestock unit. The variable used as proxy for wealth, farmers with more livestock units, which can readily be converted to money can be able to buy modern inputs than those that own fewer livestock units. which helps improve their working efficiency (Mekonnen et al., 2015; Bwala et al, 2015).

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Teff is one of the dominant crops and its productivity is low in the study area. This means that it is possible to obtained additional output from existing inputs used, if resource are properly used and efficiently allocated. The aim of this study was to determine the level of technical efficiency of smallholder teff producers and identify factors affecting technical efficiency of smallholder farmers in teff production of Silti district, Silte Zone, Ethiopia. Technical efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource poor.

The main objective of this study was measuring technical efficiency level of farmers and identifying those factors which affect technical efficiency of teff production in Silti district of Central Ethiopia State. Data were collected for the 2016/17 E.C production season by interviewing a total of 80 sample teff producing farmers using a structured questionnaire that encompasses question related to demographic characteristics, inputs and output, institutional and farm specific characteristics. Three- stage sampling technique was employed for selecting the respondents. Data were analyzed using both descriptive statistics and econometric model. The stochastic frontier production function of the Cobb-Douglas functional form was found to be best fitted the data to estimate the level of individual technical efficiency.

Cobb-Douglas functional form constitutes five input variables in frontier function and nine explanatory variables in an inefficiency model. The estimated stochastic production frontier model indicated that seed, labor and oxen power is significant determinants of teff output. The positive coefficient of these parameters indicates that increased use of these inputs will increase the production level to a higher extent. Hence, given that these inputs are used to their maximum potential, introduction and dissemination of these inputs will increase the production level of teff in the study area. The estimated result of the Cobb -Douglas production frontier indicated that significant proportion of the variation in the stochastic frontier production function being due to technical inefficiency. This implies that presence of chance for improvement of farmers' productivity through better technical efficiency. The mean technical efficiency level of farmers in teff production was 0.78. This indicates that production can be increased by 22 percent of the potential in those farmers who grow teff through better use of the available resources, given the current state of technologies

Accordingly, the results of technical efficiency effects model showed; extension contact, household size, livestock and credit found to be the major determinants of efficiency level of the farmers in teff production. The negative coefficients of credit, extension contact and total livestock in inefficiency model means that these factors positively affect efficiency of the farmers in the area where they are significant. While, the positive coefficients of household size in inefficiency model indicated that these factors determine efficiency negatively.

5.2. Recommendations

Based on the findings of the study or result of econometrics analysis, the necessary recommendations are forwarded to the concerning body

- ❖ The implication of this study is that, technical efficiency of the farmers can be increased through better allocation of the available resources especially: seed, oxen power and labor.
- ❖ The amount of credit received was found to positively and significantly influence household technical efficiency level. But Smallholder framers in the study area have financial constraints. This could imply that households needed external financial sources to solve their own financial constraints. Therefore, Microfinance Association(MFA) have mandated to provide relatively high amount of credit for farmers should be encouraged and strengthen to deliver more than this and also harmonization loan delivery with the time input required and loan payment plans with harvesting seasons. In addition to this the regional government should intervene to strength the operation of rural saving and credit institutions at village level and creates awareness for those farmers to improve their saving habits so as to improve their asset formation.

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