ECONOMIC EFFICIENCY OF SMALLHOLDER FARMERS IN MAIZE PRODUCTION IN GUDEYA BILA DISTRICT, OROMIA NATIONAL REGIONAL STATE, ETHIOPIA

M.Sc. THESIS

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By

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DEDICATION

I dedicate this thesis manuscript to my father Tesema Edosa whom I lost in October 2016. God let your soul rest in peace.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this Thesis is my own work. I have followed all ethical principles of scholarship in the preparation, data collection, data analysis and completion of this Thesis. All scholarly material that is included in the thesis has been given acknowledgment through citation.

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BIOGRAPHICAL SKETCH

The author was born in Abayyi-Dale rural Kebele, Gudeya Bila District, East Wollega Zone of Oromia National Regional State in April 1994. He attended his elementary school education at Zangi Elementary School. The author completed secondary and preparatory education at Gudeya Bila Secondary and Preparatory School. After completion of his preparatory school education, he joined Wollega University Shambu Campus in October 2012 and graduated with Bachelor of Science Degree in Agricultural Resource Economics and Management in June 2015.

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ACRONYMS AND ABBREVIATIONS

AE	Allocative Efficiency
ATA	Agricultural Transformation Agency
CRS	Constant Return to Scale
CSA	Central Statistical Agency
DEA	Data Envelopment Analysis
EE	Economic Efficiency
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GBWOANR	Gudeya Bila Woreda Office of Agriculture and Natural Resource
MOARD	Ministry of Agriculture and Rural Development
MOFED	Ministry of Finance and Economic Development
NGOs	Non-Governmental Organizations
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
SDPRP	Sustainable Development and Poverty Reduction Plan
SE	Scale Efficiency
SFA	Stochastic Frontier Analysis
SPF	Stochastic Production Frontier
TE	Technical Efficiency
TLU	Tropical Livestock Unit
UNDP	United Nations Development Programme
USDA	United State Department of Agriculture

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ABSTRACT

Agriculture in Ethiopia is characterized with low productivity. To improve this problem either introduction of modern technologies or improving the efficiency of farmers is an important. Improving efficiency of the farmer has received the greatest attention as it is more cost effective than introducing new technologies. The aim of this study was to analyze levels of technical, allocative and economic efficiency of smallholder farmers and factor affecting efficiency levels of farmers in maize production in the study area. To meet the stated objectives primary data were collected using structured questionnaires from 154 randomly selected sample households during the 2017/18 production year. Stochastic production frontier model was used to estimate technical, allocative and economic efficiency level where as Tobit model was used to identify factors affecting efficiency level. The mean technical, allocative, economic efficiency were 71.65%, 70.06% and 49.89%, respectively. Thus the results reveal exists considerable levels of inefficiencies in maize production in study area. The Tobit model results revealed that education levels, family size, farm size, frequency of extension contact, uses of credit and participation in off/non-farm activities had a significant positive effect on technical efficiency. Livestock holding and participation in off/non-farm activities had positive effect and distance of maize plot from home were found to had negative effect on allocative efficiency while education levels, family size, uses of credit, extension contact and participation in off/non-farm activities were found to had positive effect and distance of maize plot from home is negative influence on economic efficiency. The result indicated that there exists a room to increase the efficiency of maize producers in the study area. For realizing significant economic efficiency gains policies and strategies of the government should be directed towards increasing farmer's education and livestock holding, promoting off/non-farm activities, facilitating credit and extension service.

Key words: Cobb-Douglas, stochastic frontier, Tobit

1. INTRODUCTION

1.1. Background of the Study

Agricultural sector plays crucial role in Sub Saharan Africa as, it is reflected on its high share in GDP, employment generation and prioritization in the development agenda (FAO, 2016). Likewise, the economy of Ethiopia is based on agriculture, which accounts for 36.3% of GDP and over 70% of exports earning (UNDP, 2018). It also generates employment of 73% to the total population and supplies 70% of the raw-material requirements of local industries (UNDP, 2016).Nevertheless, it remains rain-fed and majority of smallholder farming engaging on less than a hectare of land (ATA, 2016). FAO (2016) reported that total value of agricultural output has grown markedly over the past decade due to area expansion. However, gap between actual agricultural production and potential for increasing its productivity still persists (FAO, 2015).

Ethiopia had adopted Agricultural Development-Led Industrialization in order to boost and sustain smallholder agriculture since 1990s as a national strategy (MoFED, 2003).With the adoption of this development strategy, MoARD (2010) inferred that the country has designed and implemented different poverty reduction strategies including the Sustainable Development and Poverty Reduction Plan (SDPRP) and the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP).The first Growth and Transformation Plan (GTP –I) is also settled in the country gave special interest to agriculture that aimed to alleviate poverty (NPC, 2015).

More recently the second Growth and Transformation Plan (GTP –II) also made agricultural growth as its core growth program at the national level and to maintain it as a source of economic growth. Besides this fact, agriculture remains the main economic growth and development option in Ethiopia which is estimated to increase at annual average growth rate of 8% during GTP II period (NPC, 2015).Despite such strategies and policies, the sector is characterized by its low productivity, which is attributed to limited access to agricultural inputs such as fertilizer and improved seeds ,inefficiency resource use , limited access to finance, agricultural markets and poor land management (MOARD, 2010; USDA, 2015; ATA, 2016).Increasing agricultural production is vital for enhancing the development of agriculture, ensuring food security, providing inputs for industrial sector, stimulating export earnings, GDP and getting better income and living condition of the people agriculture in Ethiopia (MoFED, 2013). This can be achieved through promoting the use of improved agricultural technologies or improving the efficiency of production of cereal crops in Ethiopia (Sinafikeh *et al.*, 2010; Yu; Nin-Pratt, 2014).

Maize is the most important staple cereal crop supplying over 40% daily calorie intake and consumed directly as human food in different forms in rural Ethiopia (ESA, 2014). It is also being the most important cereal crops in terms of availability and utilization of improved agricultural technologies such as fertilizer, improved seeds, pesticides, herbicides and better farm management practices than other cereal crops after 2002 of SDPRP (Sinafikeh *et al.,* 2010; CSA, 2014).The rapid growth in population and urbanization increase the demand for more food as well as for industrial in Ethiopia. Consequently, maize remains a strategic crop to meet this demand (Tsedeke, *et al.*, 2015). It is particularly important for poor households as they mix maize flour with teff to make the national staple injera, and the cost of maize is half that of wheat and teff. (WB, 2018).

In Ethiopia, maize grows under a wide range of environmental conditions between 500 to 2400 meters above sea level. Maize is cultivated in different parts of Ethiopia, mainly Oromia, Amhara, Southern Nations and Nationalities Peoples and Tigray regions and it is the first most important cereal crop in East Wollega Zone (MOA, 2013). Maize is the major staple food crops both in terms of area planted and volume of production obtained in 2016/2017 production year. From the total grain cultivated areas 12.57 million ha, 81.27% of ha were covered by cereals which produce 87.41% of the total production of 290.38 million quintal. The same source showed that, from the total area of cereals allocated maize covered 20.89% producing 30.91% quintals with the yield of 36.74 quintal per hectare (CSA, 2017).

Maize is produced by 5.36 million smallholders in Oromia region and occupies 1.14 million hectare of land with an output and productivity of 43.62 million quintal and 38.26 quintal/hectare respectively. The same report indicate in East Wollega zone there were 65,801 smallholders producing 6.04 million quintals of maize on 135,191.93 ha of land with yield of 44.67 quintal per hectare during 2016/2017 production year.

As far as the study area is concerned, among the cereals grown maize is the major crop in terms of volume of the production (266648.4 of quintal) and area (7534.6 ha of land) with productivity of 35.39 Qt/ha during 2016/2017 which is lower than regional productivity. Thus, having adequate knowledge and information on the level and determinants of the smallholder farmer's technical, allocative and economic efficiency is believed to be instrumental for policy design and formulation.

1.2. Statement of the Problem

Similar to most developing countries Ethiopia is one of the struggler in terms of agricultural production in the face of ever rising population growth rate that unable to meet reliable food security (Nsiah and Bichaka, 2017). To address this, it needs boosting of agricultural productivity and improves living standard of farmers either through use of modern inputs technology or decreasing the present level of inefficiency of farmers (Getachew, 2017; Alelign, 2017; Shehu, 2013). As far as maize concerned its yield levels in Ethiopia are still very low caused by institutional, social and economic factor, risk issue and suboptimal crop management (EEA, 2017). In addition, maize yields are inevitably affected by weather condition, limited input, limited a favorable policy, quality of seed varieties and limited techniques of production (CSA, 2017; Alemu, 2005).

Ethiopian government initiated agricultural extension programs, improved seed, fertilizer application, which had given the main concern to maize over long periods of time and the opportunity of achieving dramatic growth in productivity (Samuel, 2006; David *et al., 2011*). Despite recent progress made by improved technologies in the country maize productivity remains below its potential. Thus, it is not sufficient to meet national requirement of production by introducing yield-enhancing agricultural technologies in areas where there is inefficiency in existing knowledge of production (Asefa, 2011, Tura *et al.,* 2010).Furthermore eliminating existing inefficiency among farmers can be more cost effective than introducing new technologies as a ways of rising agricultural output and farm household income (Tefaye and Beshir, 2014).Thus it is possible to raise productivity through improving efficiency by using existing resource base and available technology. Consequently if farmers' managerial and technical skills are not in place may result in increases in their inefficiencies in production (Jema,2008).Moreover production under improved technology involves substantial inefficiencies due to poor extension, education, credit, and input supply systems (Arega and Rashid, 2005).Therefore identifying levels of efficiency and factor that affect level of efficiency is very essential for policy issue to deal with problem of maize producer households.

In line with this several efficiency studies have been conducted in different part of Ethiopia. However much of them are limited to technical efficiency which does not full represents overall efficiency (Geta *et al*., 2013; sorsie *et al.,* 2015; Kitila and Alemu, 2014; Tsegaye and Ernst, 2015).Although, the analysis of technical efficiency of maize farming is important, there was limited empirical research done so far particularly on the estimation of other efficiencies such as allocative and economic efficiency in Ethiopia (Gosa and Jema, 2016; Mustefa *al*, 2017; Kifle, 2017). According to those researchers there is mixed results of the different efficiency analyses and although they identify factors affect the inefficiency level of farmers, these factors are not uniformly and identical in all places at all time.

Since social development is dynamic their study is restricted to only one district not represents other district. Therefore, policy suggestion drawn from some of the above empirical works may be inconsistent in designing area specific policies to be well-matched with its socio-economic as well as agro ecologic conditions. Consequently increase in farming inefficiency affect yield and as such policy makers need to take a close look (Fantu, 2011). As far as the author is concerned, there is no similar empirical works that has been undertaken to estimate the level of technical, allocative and economic efficiency and factors that affect efficiency of smallholder maize producer in the study area. Therefore, this study intended to fill this information and knowledge gaps in Gudeya Bila district where such type of work has not been conducted for efficiency of maize production.

1.3. Research Questions

This research attempted to answer the following research questions:

1. What are the levels of technical, allocative and economic efficiency of smallholder maize producers in the study area?
2. What are the factors that affect technical, allocative and economic efficiency of smallholder maize producers in the study area?

1.4. Objectives of the Study

1.4.1. General objectives

The general objective of the study was to analyze economic efficiency of smallholder farmers in maize production in Gudeya Bila district of East Wollega Zone.

1.4.2. Specific objective

The specific objectives of the study were the following:

1. To measure the levels of technical, allocative and economic efficiency of smallholder maize producers in the study area.
2. To identify the factors that affect technical, allocative and economic efficiency of smallholder maize producers in the study area.

1.5. Significance of the Study

It is clearly fact that for resource poor farmers such as Ethiopia, efficient utilization of resource is a major means to obtain maximum output. As such, efficiency study will play a great role in generating valuable information regarding to inefficiency in production. Attainment of technical, allocative and economic efficiency is necessary in order to validate the magnitude of the gains that could be obtained by improving performance in agricultural production with a given improved technology. This research result benefits agricultural experts, development planners, other researchers and ultimately the smallholder farmers in the study area.

The study would generate information on various problem related to socio-economic and institutional challenges in maize production practices of smallholder farmers in Gudeya Bila district. In other words, specific farm efficiency study help to verify the level to which farmers are using the existing technologies efficiently; the potential for raising output with the existing technology; and ultimately the opportunity to raise productivity by improving efficiency. Finally it can be used as reference for further investigation of smallholder farmer's efficiencies at a wider level.

1.6. Scope and Limitation of the Study

This research used cross-sectional survey as in opposition to time series data primarily due to lack of repeated measurement, cost and time implications. In addition, the result of cross-sectional data does not show inter temporal differences in efficiency levels of households. Moreover, farmers in the study area do not keep records they might face recalling problems of the past events and most probably they may give wrong information during the survey time. Given the time element and financial resource constraints it is difficult to relax the study beyond one district. Farmers in the study area produce different types of crops, this study focused only on maize and other crops were not included. Furthermore, the scope of the study was limited on the economic efficiency of the smallholder maize producers of the study area.

1.7. Organization of the Thesis

The remaining part of the thesis is presented as follows. The second chapter deals with review of literature which includes theoretical, conceptual of economic efficiency and empirical studies made on efficiency in both abroad and within Ethiopia. Brief description of the study area, types and sources of data, sampling design, data collection and methods of data analysis are presented in chapter three. The fourth chapter deals with results and discussion of descriptive and econometric model results. Summary, conclusion and recommendations based on the results of the study are presented in chapter five.

2. LITERATURE REVIEW

In this chapter, a review on concepts and definition of efficiency and efficiency measurements approach, models of measuring production efficiency, empirical studies on efficiency, and conceptual framework of the study are discussed briefly.

2.1. Concepts and Definition of Efficiency

Efficiency is considered to be one of the most important issues in the production process. It is a commonly used term in economics. Farrell (1957) proposed measure of efficiency, which consists of two components: technical efficiency and price (allocative) efficiency. These two measures are then combined to give a measure of total economic efficiency. TE enables us to compare observed and optimal level of output and inputs of a production unit (Coelli, 1995). Hence, TE which measures the ability of a farm to obtain maximum output from a given set of inputs (output-oriented measures); or use the minimum feasible amount of inputs to produce a given level of output (input-oriented measures). It is measured by comparing the observed output against the feasible (frontier) output (Fried *et al*., 2008).Lovell (1993) defines the efficiency of a production unit in terms of a comparison between observed and optimal values of its output and input. The comparison can take the form of the ratio of observed to maximum potential output obtainable from the given input, or the ratio of minimum potential to observed input required to produce the given output. In these two comparisons the optimum is defined in terms of production possibilities, and efficiency is technical. According to Kumbhakar and Lovell (2003) technical efficiency is achieved when the firm is able to produce a maximum level of outputs given a certain level of inputs or minimize inputs given a certain level of outputs.

On the other hand, AE is the ability of farmers to use inputs in optimal proportion for a given input price. AE measures the ability of a farm to use inputs in optimal proportions given their respective prices and the production technology. Allocative inefficiency arises when inputs of production are used in a proportion that does not minimize the costs of producing a given level of output. Economic efficiency is the product of technical efficiency and allocative efficiency. A firm that is both technically and allocatively efficient is said to be an economically efficient firm (Tutulmaz, 2014). Once again, TE and AE are then combined to give EE, which is sometimes referred to as overall efficiency (Coelli *et al.,* 1998).

The firm is more inefficient, when it is more distant from the frontier. Therefore, the frontier must be constructed first from the production, profit and cost available observations; to determine the efficiency level of the firm (Forsund *et al.,* 1980).A firm is allocatively efficient if production occurs in a sub-set of economic boundary of the production possibilities set which satisfies the firm's objectives. The location of this sub-set is determined by the prices faced and the goal pursued by the firms. It refers to the proper choice of inputs and products combination according to their price relation or the ability of the firm to maximize profit by equating marginal revenue product of inputs to their respective marginal costs. Economic efficiency combines both technical and allocative efficiencies (Farrell, 1957).

2.2. Efficiency Measurement Approach

Basically there are two approaches in measuring efficiency: input oriented and output oriented. The output oriented approach deals with the question "by how much output could be expanded from a given level of inputs?" Alternatively one could ask "by how much can input of quantities be proportionally reduced without changing the output quantity produced?" This is an input oriented measure of efficiency. However, both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli and Battese, 2005).

2.2.1. Input-oriented measure of efficiency

Input oriented measure of efficiency means the minimum amount of input required to produce a given amount of output. Farrell (1957) illustrated his idea using a simple example involving firms, which use two inputs, (X_1 and X_2) to produce a single output (Y), under the assumption of constant returns to scale. The constant returns-to-scale assumption permits representing the technology using a unit isoquant. In addition, Farrell also discussed the extension of his method so as to accommodate more than two inputs. Knowledge of the unit isoquant of fully efficient firm, represented by SS' in Figure 1, permits the measurement of technical efficiency. If a given firm uses quantities of inputs, defined by the point P, to produce a unit of output, the technical inefficiency of that firm could be represented by the distance QP, which is the amount by which all inputs could be proportionally reduced without a reduction in output. This is usually expressed in percentage terms of the ratio QP/OP which represents the percentage by which all inputs have to be reduced to achieve technically efficient production. The technical efficiency (TE) of a firm is most commonly measured by the ratio

$$TE_i = OQ/OP = 1 - QP/OP \qquad (2.1)$$

TE_i takes values between zero and one, and hence provides an indicator of the degree of technical inefficiency of the firm. A value of one indicates the firm is fully technically efficient. For example, the point Q is technically efficient because it lies on the efficient isoquant.

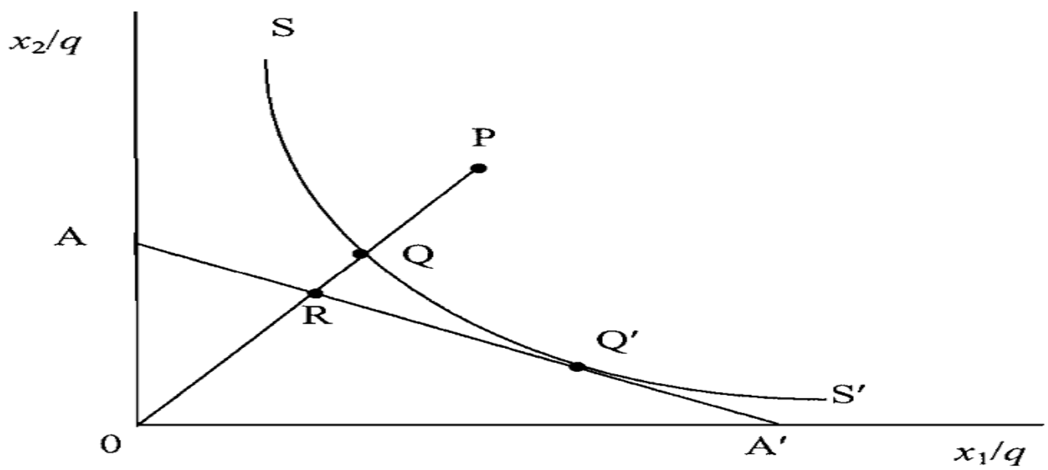

Figure 1. Technical and Allocative efficiency input approach.

Source: Coelli *et al.* (1998)

AA' represents by the slope of isocost line, is also known, allocative efficiency (AE) of the firm operating at point P could be measured as the ratio:

$$AE_i = OR/OQ \qquad (2.2)$$

Since the distance RQ represents the reduction in production costs that would occur if production were to occur at the allocatively (and technically) efficient point Q', instead of at the technically efficient, but allocatively inefficient, point Q. This indicates the irrespective of the slope of these two parallel lines (determined by the input price ratio) the ratio RQ/OQ represents the proportional reduction in costs of production associated with movement from Q to Q' (Farrell, 1957).The total economic efficiency (EE) is defined to be the ratio:

$$EE_i = OR/OP \quad (2.\ 3)$$

2.2.2. Output-oriented measure of efficiency

The output oriented measures of technical efficiency addresses the question: "By how much can output quantities be proportionally expanded without changing the input quantities used." This means the maximum attainable amount of output produced from a given level of vector inputs used. In the output-oriented perspective, efficiency is evaluated keeping inputs constant. Output oriented measures can be illustrated by considering the case where production involves two outputs (q_1 and q_2) and a single input (x_1). Figure 2 below shows the output-oriented approach of efficiency measurement using a production possibility curve that shows the possible combination of two outputs (q_1 and q_2) one can produce given input X and the level of technology. Knowledge of the fully efficient production possibility curve as well as the revenue line makes it possible to measure and interpret the level of EE.

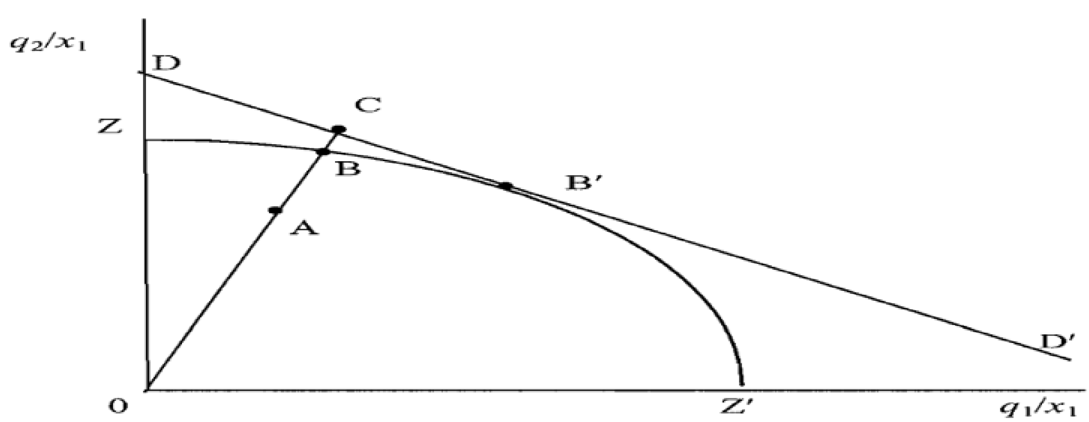

Figure 2.Technical and allocative efficiency output approach.
Source: Coelli *et al.* (1998)

The line ZZ' is the unit production possibility curve and point A corresponds to an inefficient farm. The inefficient point ‘A’ lies below the curve ZZ', which represents the upper bound of production possibilities (Coelli *et al*., 1998).In Figure 2, above the distance AB represents technical inefficiency (the technical inefficiency is the ratio; AB / OB).That is the amount by which outputs could be increased without requiring extra inputs. Therefore a measure of output-oriented technical efficiency is the ratio.

$$TE = OA/OB \tag{2.4}$$

The allocative efficiency (AE) of the firm operating at point F could be measured as the ratio:

$$AE = OB/OC \tag{2.5}$$

Additionally, we can define overall economic efficiency as the product of these two measures.

$$EE = OA / OC = (OA / OB) * (OB / OC) = TE * AE \tag{2.6}$$

Thus in Figure 2, if DD' has a slope equal to the ratio of price of outputs, B' is the optimal method of production, for this point represents 100% technical and allocative efficiencies (Coelli *et al.,* 1998).

2.3. Models of Measuring Production Efficiency

Lovell (1993) provides a tremendous introduction to model of measuring production efficiency. Two major methods are data envelopment analysis (DEA) and parametric models, which involve mathematical programming and econometric methods, respectively.

Frontier production functions have been applied to farm-level data in many developed and developing countries (Coelli *et al.,* 1998). Despite these wide arrays of applied work, the extent that empirical measures of efficiency are sensitive to the choice of methodology remains a matter of debate (Thiam *et al.,* 2001).None of the proposed methods of measuring efficiency relative to an estimated frontier is perfect. However, they all offers substantially better measures of efficiency than simple partial measures, such as output per unit of labour or land (Coelli, 1995).The following reviews focus mainly on these two broad categories of frontier models.

2.3.1. Non-parametric frontier models

One of the methods of efficiency measurements is the non-parametric method. The DEA frontier is both non-parametric and non-stochastic since it does not impose any a priori parametric restrictions on the underlying frontier technology (because it does not necessitate any functional form to be specified) and doesn't require any distributional assumption for the inefficiency term. Therefore, the model avoids the imposition of unwarranted structures on both the frontier technology and the inefficiency component that might create distortion in the measurement of efficiency (Fare *et al.,* 1985). The non-parametric deterministic frontier is based upon Farrell's original approach of piecewise linear convex isoquant such that no observed points lie to the left or below it (Farrell, 1957). This work has been extended by Charnes *et al.* (1978) and was called Data Envelopment Analysis (DEA). Charnes *et al.* (1978) proposed a model which had an input-oriented constant return to scale (CRS) model of DEA .CRS assumption is only appropriate when all firms are operating at an optimal scale. In case of different constraints, may cause a firm to be not operating at optimal scale. The use of the CRS specification when not all firms are operating at the optimal scale the results in measure of TE which are confounded by scale efficiency (SE). The shortcoming of scale efficiency is that the value does not indicate whether the firm is operating in an area of increasing or decreasing returns to scale (Coelli *et al.,* 1998). These methods can also accommodate multiple-output farms and can also be applied to almost any industry (Coelli, 2002).

The advantage of non-parametric approach is that no functional form is imposed on the data (Forsund *et al.,* 1980; Murillo, 2004). According to Coelli (1995), it is a mathematical programming approach used for considering optimum solution relative to individual units or firms rather than assuming that a solution applies to each DMU.Particularly, the main criticism of DEA is that it assumes all deviations from the frontier are due to inefficiency and because of this, non-parametric frontier methodology may overstate inefficiencies and hence outliers may have profound effect on the magnitude of inefficiency (Licwelgn and Williams, 1996). Since a standard formulation of DEA creates a separate linear program for each decision making units, large problems can be computationally intensive (Coelli. *et al.,* 1998). Alelign (2017) and Endrias *et al.* (2013) was used DEA approach to measure efficiency level of smallholder farmers. An alternative method or approach to the solution of the noise problem has been widely adopted. Thus, the next section reviews various issues pertaining to parametric frontiers that are classified as deterministic and stochastic frontier methodologies.

2.3.2. Parametric frontier models

The parametric approach is the one which there is a function including explicit parameters. In the case of a parametric function, many econometrical techniques and non econometrical ones permit to estimate the production or the cost frontiers parameters: the least squares method or the maximum likelihood method. The parametric frontier model may further be categorized into deterministic and stochastic frontier models. The basic difference between the two types of models is the deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for the statistical noise and inefficiency components.

2.3.2.1. Deterministic frontier model

The deterministic frontier model uses econometric techniques to estimate the parameters of the pre-specified functional forms. Aigner and Chu (1968) considered the estimation of the parametric frontier production function of Cobb-Douglas form. According to them the model is defined as follows.

$$\ln Yi = \ln Xi\beta - ui \qquad i = 1,2,\ldots\ldots N \qquad (2.7)$$

Where, $\ln Yi$- the natural logarithm of the (scalar) output for the i^{th} firm

XiVectors of input quantities used by the i^{th} firm

$\beta = \beta o, \beta 1, \ldots\ldots \beta_k$ β is a((k + 1)) column vector of unknown parameters to be estimated.

ui - is a non-negative random variable associated with technical inefficiency.

Therefore, the ratio of the observed output for the i^{th} firm, relative to the potential output, defined by the frontier function, given the input vector, x_i, is used to define the technical efficiency of the i^{th} firm.

$$TEi = \frac{Yi}{\exp(\mathrm{X}i\beta + \mathrm{v}i)} = \exp(-ui) = \frac{Yi}{Yi*} \tag{2.8}$$

The criticisms of the above deterministic frontier model is that no account is taken of the possible influence of measurement errors and other noise upon the frontier is embedded in the one-sided component (Coelli *et al.,* 1998). As a consequence, outliers can have profound effects on the estimates and any shortcoming in the specification of the model could translate into increased inefficiency measures (Greene, 1993).Deterministic frontiers may be estimated using corrected ordinary least squares or modified ordinary least squares. Unbiased estimates of the slope parameters in both estimation procedures are obtained using OLS followed by a correction of the intercept. In corrected ordinary least squares, using the largest positive observed residual while modified ordinary least squares modifies the intercept using the mean of the assumed one-sided distributed disturbance term (Kumbhakar and Lovell, 2003).

Efficiency measures for all deterministic frontiers are then calculated relative to the common family of frontier. Hence the estimated frontier is the "best practice" frontier of the sample and not the "absolute" frontier (Forsund *et al.,* 1980). Thus, the deterministic approach assumes all deviations from the frontier to be due to inefficiencies and it ignores the possibility that a firm's performance may also be affected by factors entirely outside the control of the producers. Thus, the deterministic method will sum-up the effect of exogenous shocks together with measurement error and inefficiency. Timmer (1971) developed the probabilistic frontier as a solution to the outliers in the above deterministic estimation approaches. Timmer imposed a Cobb-Douglas structure and estimated the parameter using linear programming by discarding the outliers until the parameter value stabilizes. The deterministic model considers that any deviation from the frontier is due to inefficiency. Hence when there is high random error on the data, the inefficiency estimates was exaggerated as compared to other models, which take into account random errors.

2.3.2.2. Stochastic frontier model

The stochastic frontier production function was independently proposed by (Aigner *et al.,* 1977; Meeusen and Von den Broeck, 1977).The original specification involved a production function specified for cross-sectional data which had an error term with two components, one to account for random effects and another to account for technical inefficiency. This model can be expressed in the following form:

$$Y_i = f(X_i;\beta) + vi - ui \tag{2.9}$$

Where, V_i = random error term of the model, and other variables are defined as in equation 2.7.The technical efficiency of a farmer, which can be predicted using the frontier program, which calculates the maximum likelihood estimators, is between 0 and 1. The maximum likelihood estimates of the parameters of the frontier model are estimated, the variance parameters are expressed in terms of the parameterization

$$\gamma = \frac{\delta^2{}_u}{\delta^2 s} \tag{2.10}$$

$\delta^2 u$ – is the variance parameter that denotes deviation from the frontier due to inefficiency

$\delta^2 v$ – is the variance parameter that denotes deviation from the frontier due to noise.

$\delta^2 s -$ is the variance parameter that denotes the total deviation from the frontier.

Where, $\delta^2 s = \delta^2 v + \delta^2 u$ and the γ parameter has a value between 0 and 1. A value of γ of zero indicates that the deviations from the frontier are due entirely to noise, while a value of one would indicate that all deviations are due to technical inefficiency.

Battese and Coelli (1998) pointed out that in the prediction of farmers level technical efficiencies which the best predictor of $\exp(Ui)$.The explanatory variables used for the inefficiency effects in the stochastic frontier model are defined as follows:

The best prediction of firm level efficiency $\exp(-Ui)$ can be obtained by:

$$E\left[\exp\left(\frac{-ui}{ei}\right)\right] = \frac{1-\left(\delta v + \frac{\gamma ei}{\delta v}\right)\exp\left(yei + \frac{\delta^2 s}{2}\right)}{1-\phi\left(\frac{\gamma ei}{\delta v}\right)} \tag{2.11}$$

Where $\delta v = \sqrt{\gamma(1-\gamma)\delta^2 u}$

$ei = \ell n(Yi) - xi\beta$

ϕ – is the density function of a standard normal random variables

The random error, vi accounts for measurement error and other factors, such as the effects of weather, strikes, chance, etc., on the value of the output variable, together with the combined effects of unspecified input variables in the production function. Aigner *et al.* (1977) assumed that the Vi were independently and identically distributed (i.i.d) normal random variables with mean zero and constant variance δ^2 . ui that were assumed to be independent and identically distributed truncated or half-normal random variables.

Mostly, empirical, production efficiency studies in agriculture are treated by using stochastic frontier model. As noted by Coelli *et al*. (1998), the stochastic frontier is considered more suitable than DEA in agricultural applications, especially in developing countries, where the data are likely to be heavily influenced by the measurement errors and the effects of weather conditions, diseases, etc. Stochastic frontier approach (SFA) used in this study because of above advantages over nonparametric approaches.

Stochastic frontiers take into account stochastic error by decomposing the error term into stochastic and inefficiency components. In Stochastic Frontier Analysis (SFA), the error term is decomposed by parameterizing the distribution of the inefficiency term (Fried *et al*., 2008). However the need for imposing an explicit parametric form for the underlying technology and explicit distributional assumption for the inefficiency term are the main weaknesses of this approach (Coelli, 1995). It is worth nothing that ui in the normal -truncate normal case is not constrained to be positive (e.g., for a cost function) or negative (e.g., for a production). Thus estimates generated from the normal-truncated normal case might reveal a distribution pattern for u which would be quite similar to an exponential distribution (Stevenson, 1980).Stochastic frontier approach entail a prior specification of the most popular functional forms such as Cobb-Douglas and Translog production function, which have been most commonly used in the empirical estimation of frontier models by agricultural economists. Cobb-Douglas production function is a special form of the Translog production function where the coefficients of the squared and interaction terms of input variables are assumed to be zero. Besides The Cobb-Douglas production function imposes a severe prior restriction on the farm's technology by restricting the production elasticity to be constant and the elasticity of input substitution to unity (Wilson, *et al*., 1998; Coelli, 1995; Coelli *et al*., 2005). While, Translog production function, unlike Cobb-Douglas production function is suitable for the estimation of second order functional form which helps to account the effect of input interaction on output. However, as oppose to Cobb-Douglas, Translog production function is susceptible to the problem of serious multicollinearity (Headey *et al*., 2010).

According to Coelli (1995), the Cobb-Douglas functional form has most attractive feature which is its simplicity. Moreover, Translog production function is more complicated to estimate having serious estimation problems. One of the estimation problems is as the number of variable inputs increases, the number of parameters to be estimated increases rapidly. Another problem is the additional terms require cross products of input variables, thus making a serious multicollinearity and degrees of freedom problems. Even though Cobb-Douglas model assumes unitary elasticity of substitution, constant production elasticity and constant factor demand; if the interest is to analyze the efficiency measurement and not analyzing the general structure of production function, it has adequate representation of technology and insignificant impact on measurement of efficiency (Coelli *et al*., 2005). When farmers operate in small farms, the technology is unlikely to be substantially affected by variable returns to scale (Coelli, 1995).Moreover, Cobb-Douglas production function has been employed in many researchers dealing with efficiency in Ethiopia (Hassen, 2016; Kitila and Alemu; Kifle, 2017; Gosa and Jama, 2016; Solomon, 2014; Musa, 2013 etc...). As a result of taking the advantages and disadvantages of both functional forms in to consideration the appropriate functional form that better fit the data was selected after testing the null hypotheses using the generalized likelihood ratio test. Hence, in this study Cobb-Douglas production function was employed for maize producing smallholder farmers based on the test statistic of log likelihood ratio (LR).

2.4. Stochastic Frontier Efficiency Decomposition

The measurement of technical, allocative and economic efficiencies can only handled, stochastic frontier framework, through the efficiency decomposition technique. The stochastic decomposition methodology was proposed by Bravo-Ureta and Rieger (1991), which was an extension of the model introduced by Kopp and Diewert (1982) to decompose cost efficiency into technical and allocative efficiency measures. Stochastic efficiency decomposition is generally based on the duality between production and cost functions.

Bravo-Ureta and Rieger (1991) utilize the level of output of each firm adjusted for statistical noise, observed input ratios and the parameters of stochastic frontier production function to decompose overall efficiency into technical and allocative efficiencies. The parameters of the SFPF are actually used to derive the parameters of dual cost function. Let redefined in its original form of Aiger *et al*. (1977) and Meeusen and Van den Broeck (1977) as:

$$\ln(Y_i) = f(X_i, \beta_i) + vi - ui \qquad (2.12)$$

If v_i is now subtracted from both sides of equation, we obtain:

$$(Y_i^*) = f(X_i, \beta_i) - ui = Y_i^* - v_i \qquad (2.13)$$

where $(Y_i^*)$is the i^{th} firm's observed output adjusted for the statistical noise captured by v_i ,X_i is the vector of input quantities used by the i^{th} ; β is a vector of unknown parameters to be estimated;$f(X_i, \beta_i)$denotes functional relationship (Cobb-Douglas); and v_i is a non-negative variable representing the inefficiency in production. The adjusted output Y^* is used to derive the technically efficient input vector xi. The technically efficient input vector for the i^{th} firm, X_{it}, is derived by simultaneously solving equation (2.12) and the observed input ratio $\frac{x1}{xi} = ki$ where ki is equal to observed ratio of the two inputs in the production of Y^*. The technically efficient input vectors form the basis for deriving the technical efficiency measures by taking ratios of the vector norms of the efficient and observed input quantities while the adjusted output is used to derive allocative and economic efficiencies employing the dual cost frontier function that is analytically derived from the stochastic frontier production function.

2.5. Approaches to Identifying Efficiency Factors

In efficiency analysis, it is not only the level of efficiency that is important, but it is important to identify socioeconomic, demographic, institutional factors and farm characteristics. In order to identify efficiency factors there are two estimation approaches. The first approach advocate 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:

$$\mu i = \delta Zi + wi \qquad (2.14)$$

Substitute this into the stochastic production function, the resulting equation is

$$\text{Yi} = \text{f}(\beta\text{i, xi}) + \text{vi} - (\delta\text{izi}) + wi \qquad (2.15)$$

μi – is inefficiency effects of the i^{th} firm

Zi – is a (1xm) vector of variables associated with the technical inefficiency effects;

δ – is an (mx1) vector of unknown parameter to be estimated; and

wi – is error term which unobservable random variables that are assumed to be independently distributed, as an alternative, the technical inefficiency effects are assumed to be independent non-negative truncations of normal distributions with unknown variance $\delta^2 u$ and means $Zi\delta$ .Thus the means $\exp(\mu i) = E(Zi\delta + wi) = Zi\delta$ may be different for different farmers, but the variances are assumed to be the same. 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 second 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 ordinary least square methods or Tobit regression. This hypothesis is introduced to avoid the bias included in the first stage, according to which the efficiency level is independent of those variables while in the second stage, they are considered as dependent. As Kumbhakar and Lovell (2000) asserts, this method can be used for the non-parametric approach and for the parametric approach as well. The regression done in the second stage is possible thanks to the OLS method or a Tobit model to take into account the truncated characteristic (between 0 and 1) of the dependent variable (efficiency). Therefore, this study used the two stage estimation approach due to the measurement procedure of the overall economic efficiency.

2.6. Empirical Studies on Efficiency

Efficiency analysis has been considered by different researchers both from abroad as well as within the country. Most studies have specified the Cobb-Douglas type production function and commonly estimated parameters by using the MLE procedure. Summary of some of these empirical studies on efficiency in agricultural production are given.

2.6.1. Empirical studies on efficiency abroad

Ntabakirabose (2017) conducted study on an economics analysis of the factors influencing maize productivity and efficiency among farmers in Rwanda. The study was based on the cross sectional data collected in July 2015. Multi-stage sampling procedure was applied to the population of maize farmers from the area under study and 168 respondents. A Stochastic production frontier model was used to estimate technical, allocative and economic efficiency levels, whereas Tobit model was used to identify factors affecting efficiency levels. The study result indicated that the mean technical, allocative, and economic efficiency score for the sampled farms were 51.78%, 63.17%, and 54.17 % respectively. It was found that improved seeds, land size, organic manure, labor and chemical fertilizer positively and significantly influenced maize productivity. Factors such as access to credit, extension services, work experience in maize production and family income were found to be statistically significant influence of the technical efficiency in the study area. However, household head age and distance to market showed a negative and significant effect on technical, allocative and economic efficiency of the maize farms.

Mburu *et al*. (2014) conducted study on analysis of economic efficiency and farm Size of wheat farmers in Nakuru District, Kenya by using Cobb Douglas stochastic frontier model to measure level of technical, allocative and economic efficiency and Tobit models to identify factors affecting efficiency of farmers. results indicate that the mean technical, allocative, and economic efficiency indices of small scale wheat farmers are 85%, 96%, and 84%, respectively.. The number of years of school a farmer has had in formal education positively and distance to extension advice is negatively affect technical and economic efficiency. Farm size and main occupation of the farmers have positive and negative influence on the allocative efficiency levels respectively.

Abdulai*, et al.* (2013) undertakes study on the technical, allocative and economic efficiency of maize production in northern Ghana by using the stochastic frontier model. The study found that conventional inputs such as farm size, seed, fertilizer, labour and weedicides were statistically significant and had positive effects on maize output. The mean estimates were 85.1%, 87.8% and 74.7% for technical, allocative and economic efficiencies respectively. Production in the study area exhibited increasing returns to scale. With regarding to the determinants study fond that experience, agricultural extension service and gender had negative relation to technical inefficiency. The study also found that Land, seed and weedicides would be allocatively efficient by increasing their use by 26.6%, 10.52% and 39.9% respectively to reach the point at which their marginal value product equals marginal factor cost.

Nargis and lee(2013) undertake study efficiency analysis of rice production in north-central region of Bangladesh by using data envelopment analysis the study revealed that on average the farms technical, allocative and economic efficiencies were 0.93, 0.82 and 0.69.Their existing technical, allocative and economic inefficiencies were 7%, 18% and 31%, respectively. In addition, a second stage Tobit regression showed that the variation was also related to farm-specific attributes such as education, household size, seed type, extension services, irrigation, and sources of energy posively where as land tenancy is negatively affect to technical efficiency. Seed type is negatively affect and land tenancy is positive affect allocative efficiency. Sources of energy and irrigation machine types affect positively while seed types is negatively affect to economic efficiency rice production.

Etim and Okon (2013) identifies sources of technical efficiency among subsistence maize farmers in Uyo, Nigeria using the stochastic frontier production function which incorporates a model for the technical efficiency effect. Farm-level survey data from 110 traditional maize farmers were obtained using well structured questionnaire. The results reveals that the mean efficiency of 0.71. Results further reveal that land, labour, inorganic fertilizer and planting materials were found to have positive and significant impact on production. Other variables which were identified as sources of technical efficiency and which have positive impact on technical efficiency include age, credit and access to market and technical assistance have negative impact on technical efficiency.

2.6.2. Empirical study on efficiency in Ethiopia

Mustefa *et al*. (2017) conducted study on economic efficiency in maize production in Ilu Ababor Zone of Oromo Regional state using cross sectional data collected from randomly selected 240 sample households. Authors uses Cobb-Douglas production function using stochastic production frontier approach to estimate the efficiencies levels, whereas Tobit model is used to identify determinants that affect efficiency levels of the sample farmers. The estimated results showed that the mean technical, allocative and economic efficiencies were 81.78%, 37.45% and 30.62% respectively. Education level, soil fertility of the sample household was the most important factor that found to be positive and significant affect the level of technical efficiency. Whereas, land fragmentation and affect the level of technical efficiency negatively. Education level, livestock ownership affects level of allocative efficiency positively. Besides, land fragmentation and frequency of extension contact were important factors that affect allocative efficiency of farmers negatively in the study area. The results also further revealed that education level and extension contact was the most important factor that found to be positively and negatively affect economic efficiency respectively.

Study conducted by Kifle (2017) in Bako Tibe district, Oromia National Regional state, from Ethiopia 124 randomly selected sample household using Stochastic Frontier Production Function (SFPF) to estimate the level of Technical Efficiency (TE), Allocative Efficiency (AE) and Economic Efficiency (EE) and Tobit model used to identify factors affecting these efficiencies . The mean of TE, AE and EE were 82.93%, 66.03% and 54%, respectively. The mean of TE and AE implies that there exists possibility to increase production by 17.07% without using extra inputs and decrease cost of inputs by 33.97%, respectively. The result revealed high inefficiency among maize producers. The Tobit model results revealed that age, off/non-farm activities, sex, amount of land owned and perception on agricultural policy had a significant effect on TE. Education, frequency of extension visit, perception on agricultural policy and livestock holding had significant effect on AE while age, off/non-farm activities, sex, land owned, credit utilized and perception on agricultural policy had a significant effect on EE.

Gosa and jema (2016) conducted study on technical, allocative, and economic efficiencies of smallholder sorghum farmers and identifying factors that determine them in Habro district by using Cobb-Douglas production function using stochastic production frontier approach to estimate technical, allocative and economic efficiency levels, and use Tobit model identify factors affecting efficiency levels of the sample farmers. The study found that the mean technical, allocative and economic efficiencies of sorghum farmers 74, 44 and 32%s, respectively. Results of the Tobit model revealed that age, sex and farm size affect technical efficiency positively and significantly, while experience and land fragmentation affect technical efficiency negatively. The result also indicates that experience and education have positive and significant effect on allocative efficiency while age and sex were found to have significant negative effect. The result of the study also shows that farm size has a positive and significant effect on economic efficiency whereas land fragmentation and extension contact affect economic efficiency negatively and significantly.

Tsegaye and Ernst (2015) investigate if there are potentials of maize productivity gains in Jimma zone, Ethiopia by improving the technical efficiency of the farm households in Seka Chekorsa wereda by using 53 maize producing farmers. According to their finding around 60% of maize producing farmers were operating at a technical efficiency level of more than 80%. While for some 40% of the farm households between 10 to 20% and the inefficiency. Livestock ownership, the number of years farmers participated in the agricultural extension program and access to infrastructures had positive effect on the level of technical efficiency. However, education had unexpected sign to technical efficiency.

Sorsie *et al.* (2015) estimated technical efficiency of maize production in Ethiopia by using stochastic production frontier model shows that the scores of technical efficiency range from 3 to 96% with an average technical efficiency of 77%. The estimated mean technical efficiency score for the sample is 77% indicating that on average only 77% of potential output was achieved using the farmer's production inputs and available resources. According to the researchers results for the technical inefficiency model indicate that ages of households, access to credit, planting improved seed varieties, received extension services, irrigate the crop and perform soil protection practices negatively related to inefficiency. Off- farm income positively related to technical inefficiency.

Sisay *et al.* (2015) conducted study on technical, allocative and economic efficiency using a parametric stochastic frontier model fit Cobb-Douglas production function. He used 385 household heads and interviewed using a structured questionnaire during 2013/2014 production year. The results show that the mean technical, allocative and economic efficiency score was found to be 62.3, 57.1 and 39%, respectively, indicating a substantial level of inefficiency in maize production. By using two limit Tobit model technical, allocative and economic efficiency of maize production are positively and significantly influenced by the size of household, education level of household head, the size of livestock holding, extension service frequency of contacts, cooperative membership and use of mobile cell-phone whereas total landholding size of the household head have negative and influence.

A study undertaken by Geta *et al.* (2013) in southern Ethiopia with the objective of assessing productivity and technical efficiency of smallholder maize producer farmers, based on the data collected from 385 randomly selected farmers in Wolaita and Gamo Gofa zones of Southern Nations, Nationalities and Peoples Region (SNNPR) of Ethiopia, indicated that technical efficiency range between0 and 1.The results of DEA model indicate that the average technical efficiency was found to be about 0.40. This indicates that if the average farmer in the sample was to achieve the technical efficiency level of its most efficient counterpart, then the average farmer could realize 60% cost savings. By using two limit Tobit regression they found that important socio economics factors that significantly and positively affected the technical efficiency were agro-ecology, oxen holding, farm size and use of high yielding maize varieties. Socio-economic variables age, family size and education affect technical efficiency of maize producer negatively. Input variables human labor, chemical fertilizer, availability of oxen, planting method, use of hybrid maize has a significant and positive effect on maize production.

Musa (2013) conducted on economic efficiency maize production of smallholder farmers in Arsi Negelle district using randomly selected 138 sample households Cobb-Douglas production function was fitted using stochastic production frontier approach to estimate technical, allocative and economic efficiency levels, whereas Tobit model was used to identify factors affecting efficiency levels of the sample farmers. The estimated results showed that the mean technical, allocative and economic efficiencies were 84.87%, 37.47% and 31.62% respectively which indicates the significant inefficiency in maize production in the study area. The discrepancy ratio (γ), which measures the relative deviation of output from the frontier level due to inefficiency, implied that about 79.06% of the variation in maize production was attributed to technical inefficiency effects. Among factors hypothesized to determine the level of efficiencies, education was found to significantly determine allocative and economic efficiencies of farmers positively while frequency of extension contact had positive relationship with technical efficiency and it was negatively related to both allocative and economic efficiencies. Credit was also found to significantly influence technical and economic efficiencies positively and distance to market significantly affects technical efficiency negatively.

The above reviewed literature indicated that the existence of efficiency differentials among smallholder farmers in different place at different time period and most of the works was interested in analyzing technical efficiency alone. Moreover, these studies also showed efficiency differentials due to variation of source of inefficiency. Study on economic efficiency of smallholder agriculture are limited and the findings or conclusions of some of them are not consistent with one another because of different socio economic, agro ecological nature, farming system and other factor. Therefore, policy implications drawn from some of the above empirical works may not allow in designing area specific policies to be compatible with its socio-economic as well as agro-ecologic conditions. Therefore, this study intends to fill these gaps. Moreover, the stochastic frontier approach is adopted to study efficiency of different agricultural sector. Hence, this study adopted the most widely applicable method of estimating efficiency of maize production in Gudeya Bila district of eastern Wollega, Oromia.

2.7. Conceptual Framework

The conceptual framework is performed which represents how various factors inter-relate to influence maize efficiency the study area. This figure 3 was guide this research study.

Production involves transformation of input to output. In crop production, inputs include land, seeds, oxen power, labour and fertilizer, which are all combined in different ratios to produce outputs. Productivity improvements can be achieved in two ways. One can either improve the state of the technology by inventing new technology which leads to an upward shift in the production frontier or alternatively one can improve efficiency of the farmers to use the existing technology more efficiently. This would be represented by the firms operating more closely to the existing frontier. Therefore, it is evident that increase in productivity achieved through either technological progress or efficiency improvement so that the policies required to address these two issues are likely to be quite different (Coelli, 1995).

The efficiency with which the inputs are transformed into outputs does not only depend on inputs used but also on the decision-making practices that the farmer uses to combine these inputs. Decision-making practices are influenced by farm and farmer characteristics, which together with the inputs determine the quality and quantity of outputs produced. Efficiency of production was determined by the crowd of socio-economic and institutional factors (Jema, 2008). The measurement of efficiency difference is due to heterogeneity of conditions and the diversity of environments in which farmers operate does not have to be unique. It is likely to vary across Demographic, Socio-economic, institutional factors and farm characteristics (Mechri, *et al*., 2017; Croppenstedt and Demeke, 1997).The efficiency differentials among farmers are determined by these demographic, farm characteristics, socio-economic and institutional factors (Battese and Coelli, 1995; Kwabena and Victor, 2014). The factors related to demographic include age, sex and family size of household. The factors related to the socio-economic include livestock holding, education and off/non-farm activities. The institutional factors include use of credit and extension service and distance to the market. farm size, soil fertility and distance to farm are farm characteristics. Farm specific variables such as educational level, family size and farm size were significant factors implicated for the observed variations in efficiency (Omojola *et al*., 2014).Extension and credits are important policy and institutional variables that positively influence efficiency (Tchale, 2009)

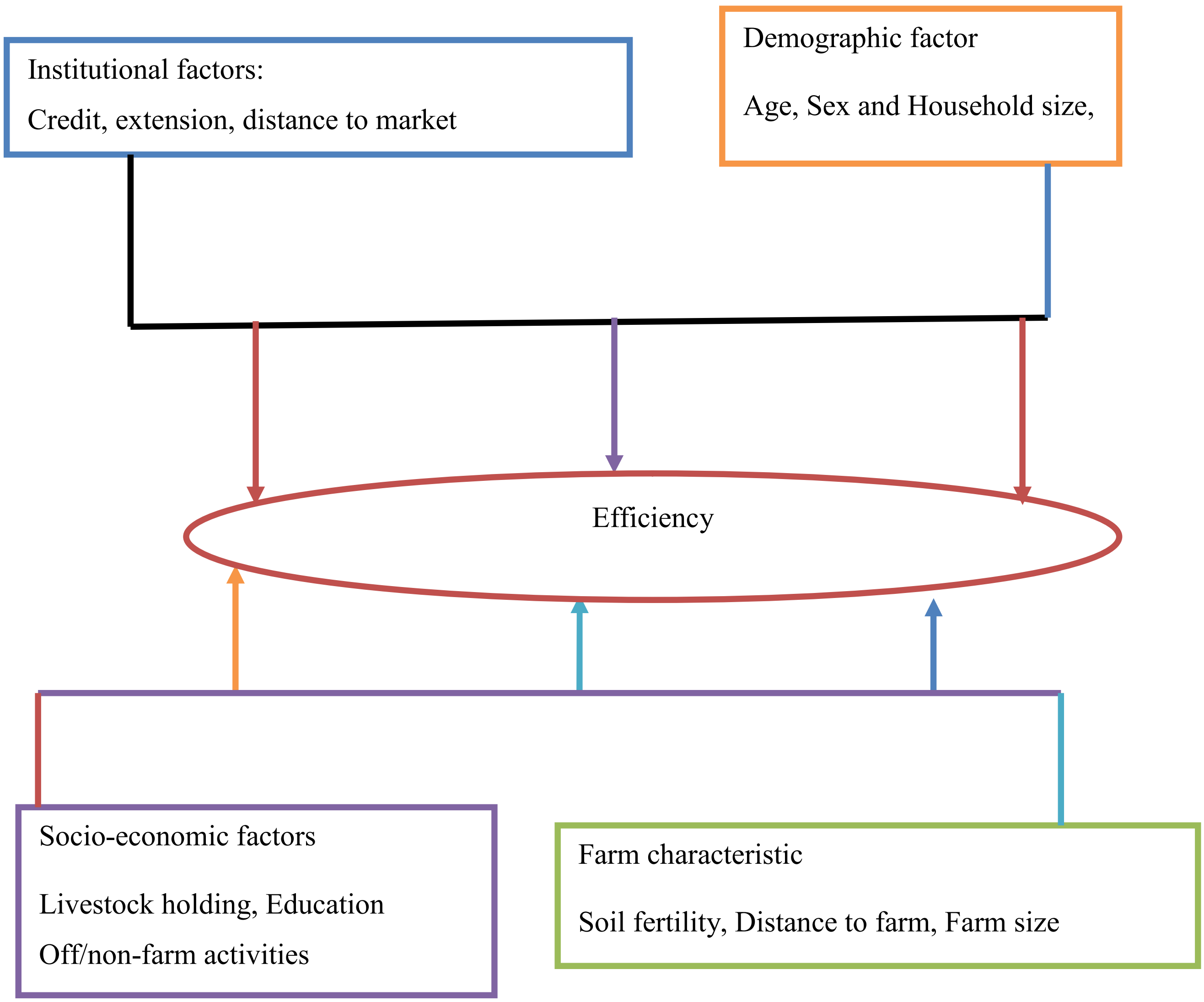

Figure 3.Conceptual framework of the study

Source: Adopted Alelign (2017); Omojola *et al.* (2014) and illustrated based on the literature review.

3. RESEARCH METHODOLOGY

In this chapter, description of the study area, types and sources of data, sampling method and sample size determination, methods of data collection, methods of data analysis and definitions of variables hypothesized on economic efficiency of maize production are presented.

3.1. Description of the Study Area

This study was carried out in Gudeya Bila district, which is one of the 17 districts located in the East Wollega zone of Oromia National Regional State in the Western part of Ethiopia. It encompasses agro-ecologies of highland, mid-altitude and lowland with proportion of 17.6% and 55.8%and 26.6%, respectively. The district is bordered by Jima Ganeti and BakoTibe districts in east, Guto Gida and SibuSire districts in west, Abe Dongoro district in north and Gobbuu Sayyoo district in south. It is located at 104 from the zonal capital and 274km from Addis Ababa, capital of Ethiopia to west. It lies between 37^0 01' 28"N latitude and 9^0 17'23" S longitudes. Altitude ranges between 500 to 3500 meters above sea level (GBWOANR, 2017) According to CSA (2013) population projection, the district has a total estimated population of 71629 of whom 49.2% are men and 50.8% are women; and 86.85% of its population is rural dwellers.

Rivers and streams are also found in this district. Some of the rivers are Gibe, Meki and Dokonu. Moreover, the temperature of the district varies between 11^0C to 23^0C. The district experienced an annual average rainfall of 1400 to 2000 mm with its rainy season occurs between May to September and the dry season last from October to April. The farming system in the district is mainly mixed crop-livestock production. Most farmers in the district undertake both crop production and livestock rearing activities. Agriculture is mainly characterized by rain-fed production system. Maize is one of the major cereals grown in the district. Apart from maize, the major crops grown in the district include sorghum, wheat, and teff, barley, and Niger seed. There are also a large number of livestock: 39373 cattle, 13699 small ruminants, and 3702 equines (GBWOANR, 2017)

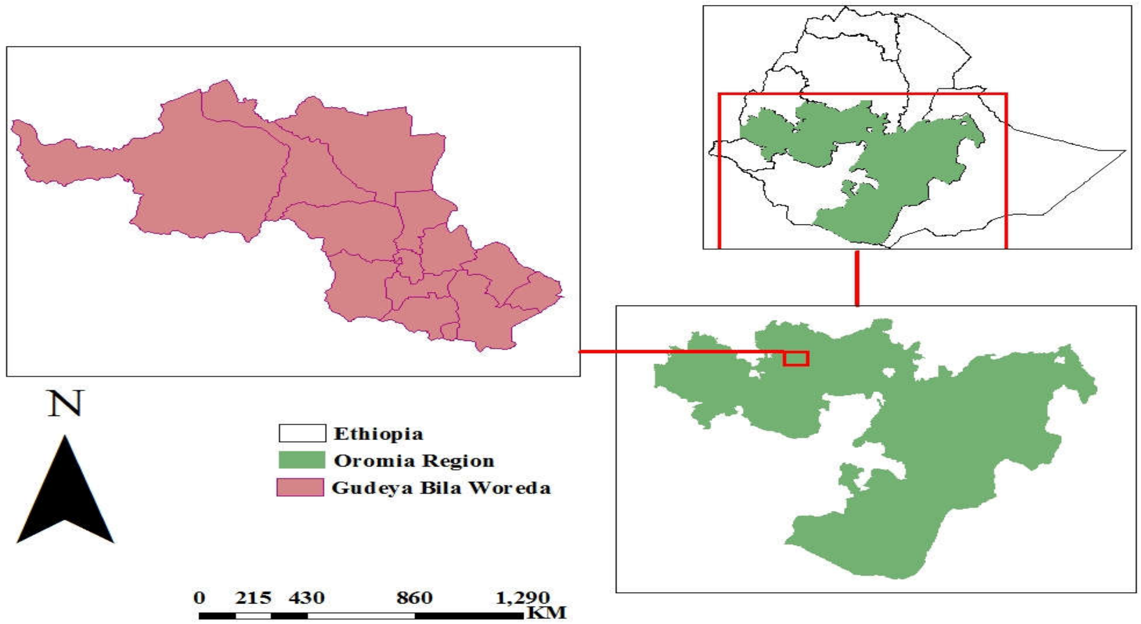

Figure 4. Map of the study area.
Source: ETHIO- GIS 2018 output

From the total area of the district 82041.84 ha the land use constitutes 34525 ha of cultivated land, 4504.76 ha of grazing land,10039 ha of forest land, 12595.9 ha of land allocated for homesteads and 20377.184 ha of land is used for different purposes. As far as extension service is concerned three development agents were assigned for the extension service in the each 13 kebele. The total development agent available during 2017 was 39. Credit service is mainly from two micro-finance institutions Oromia Credit and Saving Share Company and Wasasa (GBWOANR, 2017). Moreover in the study district, there are 24 primary schools, 3 secondary school, and 2 preparatory high schools.

3.2. Sampling Techniques and Sample Size Determination

Two stages random sampling technique was used to select sample household for this study. In first stage out of 13 kebeles exist in the district three kebeles namely Darbas, Tibe, and Haro Gudisa were randomly selected. In second stage 154 samples household were selected by simple random sampling by lottery method from three kebeles household taking into account probability proportional to the size of maize producers in each sample kebeles. Accordingly, 154 households were selected for survey. The sample size was determined based on the following formula given by Yamane (1967).

$$n = \frac{N}{1 + (e^2)N} \qquad (3.1)$$

Where, n is sample size, N is number of maize producing households in the district which is 8765 and e is the desired level of precision which was taken to be 8%.

Table 1.Total number of households and sample households in the study area.

Name of kebele	Total number of households	Sample proportion (%)	Sample
Darbas	379	33	51
Tibe	173	15	23
Haro Gudisa	608	52	80
Total	1160	100	154

Source: Own computation (2018)

3.3. Type, Sources and Methods of Data Collection

This research is basically relied on quantitative and qualitative types of data collected from both primary and secondary sources. To address the stated objectives of the study, primary data was collected from 154 households with information collected at household level using structured questionnaire and also focus group discussions obtained from maize dominant farmers.

Structured questionnaire was used to collect primary data from sample respondent. The data collected include household level output of maize and the inputs used in the production process and the socioeconomic, demographic, institutional and farm-specific characteristics, input price, cost of input incurred during maize production period such as amount and cost of labour used, rental cost of land, cost of oxen used, and cost seed and fertilizer (detail relevant information are obtained by Appendix 9). Prior to collecting data the study area was visited to know the means of livelihood of the communities. The questionnaire was first pilot tested to ensure clarity, reliability and validity, and consistency of the sequence each question and then translated into Afaan Oromoo for enumerator orally. Enumerators who are capable of speaking the local language as well as English were selected to collect the data. Then, the selected enumerators were trained by the principal investigator on the techniques, mechanism and moral duties of collection of information from the survey. This involves explanation of all questions in detail, objective of the study, the ethical consideration while asking each question. This ensures the enumerators to understood all the questions, well behaved and there by minimizes enumerators' bias and alternative errors. Then the questions were asked through face to face contact with smallholder households' by aid of trained enumerators under close supervision of the researcher.

Focus Group Discussion also was made on issues related to production efficiency among maize dominant farmers. This discussion helps to understand the strengths and weakness through arguing on answers and raising questions of some selected maize dominant farmers to get pertinent information. The minimum group composition was six and the maximum was eight. This makes ease of generation of general information in the district. Besides to primary data, this study used secondary data collected from different journal, internet, published research, and bureau of agriculture of the district.

3.4. Methods of Data Analysis

In this study, both descriptive and econometric models were used to analysis the data collected from sample farm households. Descriptive statistical tools such as minimum, maximum, mean, standard deviations, percentage and frequencies were used to describe households, farm characteristics, distribution of technical, allocative and economic efficiency levels, and production cost and input used for maize production.

In econometric estimation method Stochastic frontier approach was employed to estimate level of technical, allocative and economic efficiency and Tobit model was used to identify factors that affect the efficiency level of the maize farmers using Stata13 software. The detailed econometric models specifications for analysis of efficiency level and its determinant discussed below.

3.4.1. Efficiency measurement

The main objective of this section was to describe efficiency analysis by specifying production frontier using Cobb-Douglas stochastic model. Stochastic frontier model was employed to estimate parameters of production function and level of efficiency. The stochastic frontier is the most appropriate technique for efficiency studies. This is because of the fact that this technique accounts for measuring inefficiency factors and technical errors occurring during measurement and observation (Coelli, 1998). So as to take into account effects of these errors, stochastic frontier model was used in this study.

According to Coelli (1995), the Cobb-Douglas functional form has most attractive feature for is its simplicity. Even though Cobb-Douglas model assumes unitary elasticity of substitution, constant production elasticity and constant factor demand; the interest is to analyze the efficiency measurement and not analyzing the general structure of production function. Hence, it will have adequate representation of the technology and insignificant impact on measurement of efficiency (Coelli *et al.*, 2005). Besides, according to Coelli (1995), in smallholders farming, the technology is unlikely to be substantially affected by variable returns to scale and therefore it is better to use Cobb-Douglas production function than Translog function. The alternatives such as translog production functions also have their own limitations such as being susceptible to multicollinearity and degrees of freedom problems. As a result of taking the advantages and disadvantages of both functional forms in to consideration the appropriate functional form (Cobb-Douglas) that better fit the data was selected after testing the null hypotheses using the generalized likelihood ratio test.

Following Aigner *et al.* (1977) and Meeusen and van Den Broeck (1977), the SPF model is defined as:

$$Y_i = f(X_i;\beta) + v_i - u_i \tag{3.2}$$

Where Y_i measures the quantity of output of the i^{th} farm, X_i is the vectors of explanatory variables used by the i^{th} farmer. The β is the vector of unknown parameters. The functional specification $f(X_i;\beta)$ is a suitable production function (eg. Cobb-Douglas). The disturbance term v_i is intended to capture the effects of the stochastic noise and it is assumed to be v_i ~N (0, δ^2). The disturbance, ui, captures the technical inefficiencies. Technical efficiency (TE) of an individual firm is estimated as the ratio of the observed output to the corresponding frontier output.

Output input data was transformed into linear specification form by using natural logarithm since Cobb Douglas is not linear in parameters the model used for this study is specified in the following form:

$$\ln Y_i = \beta_0 + \sum_{j=1}^{6} b_j \ln X_{ij} + e_{ij} \qquad (3.3)$$

Where

$\ln -$ Denotes the natural logarithm

j – Represents the number of inputs used to produce maize in the study area.

$i -$ Represents the i^th^ maize producers in the sample

Yi-is observed maize output of the i^th^ farmer in 2017/2018 production season.

x_{ij} Denotes j^{th} farm input variables such as seed(kg) ,land allocated for maize crop (ha) , amount of NPS used by sample household (kg), amount of urea used by sample household (kg), pair of oxen power used for maize production by sample household (oxen-day), labor used by sample household (man-day) in maize production of the i^th^ farmer.

$\beta o, bj$ – Stands for the vector of unknown parameters to be estimated

$ei -$Is a composed disturbance term made up of two elements $(v_i - u_i)$. The random error $v_i -$accounts for the stochastic effects beyond the farmer's control, measurement errors as well as other statistical noises and u_i captures the technical inefficiency. The variance parameters are presented as $\delta^2 = \delta^2{}_v + \delta^2{}_u$. According to Aigner *et al.,* (1977), the symmetric component (vi) is assumed to be independently and identically distributed as $N(0, \delta^2 v)$ .On the other hand, ui is non-negative half normal or truncated random variable with zero mean and constant variance $\delta^2 u$.

Aigner *et al.* (1977) proposed the log likelihood function for the model in equation (3.3) assuming half normal distribution for the technical inefficiency effects u. They expressed the likelihood function using λ parameterization, λ where is the ratio of the standard errors of the non-symmetric to symmetric error term $\left(i.e. \lambda = \frac{\delta u}{\delta v} \right)$.However, Battese and Corra (1977) proposed that the γ parameterization, where $\gamma = \frac{\delta^2 u}{(\delta^2 v + \delta^2 u)}$ to be used instead of λ .The reason is that could be any non-negative value while γ ranges from zero to one and better measures the distance between the frontier output and the observed level of output resulting from technical inefficiency. However, there is an association between γ and λ. According to Bravo and Pinheiro (1997) gamma (γ) can be formulated as $\left(\gamma = \frac{\lambda^2}{1+\lambda^2} \right)$.Hence, by following Battese and Corra (1977) the log likelihood function of the model is specified as:

$$\ln(L) = -\frac{N}{2}\left[\ell n\left[\frac{\pi}{2}\right] + \ell n\delta^2 \right] + \sum_{i=1}^{N} \ell n\left(1-\phi\left[\frac{\varepsilon i\sqrt{\gamma}}{\delta^2}\right]\sqrt{\frac{\gamma}{1-\gamma}}\right) - \frac{1}{2\delta^2}\sum_{i=1}^{N} \varepsilon i^{\,2} \qquad (3.4)$$

Where:

$L -$ Represent likelihood function

$\varepsilon i = \ln Y - xi\beta -$ Represent composed error term;

$\mathrm{N} -$ Represent the number of observations;

ϕ – Represent the standard normal distribution

δ^2,$-$Represent the variance of parameters of the model and

$$\gamma = \frac{\delta^2 u}{\delta^2} \qquad (3.5)$$

γ Parameter has a value between zero and one. When it is zero, it indicate that technical inefficiency effects are absent in the data. The implication is that the estimated SFA model reduces to a simple OLS regression since all variation is due to random noise. When is closer to one, the model indicates that most of the variation in output is due to technical inefficiency and therefore, confirms the appropriateness of SFA technique to evaluate the data.

Minimization of the function on equation (3.4) with respect to the parameters $(\beta, \delta^2, \gamma)$ and solving simultaneously the first partial derivatives of the function by equating to zero produces the efficient maximum likelihood estimates of the parameters. The (γ) parameter is used to test whether the technical inefficiency affects output or not. Similarly, the significance of δ^2 indicates whether the conventional average production function adequately represent the data or not.

The production function could also be estimated through an alternative form, called dual, such as cost or profit function. Assuming that the production function in equation (3.3) is self- dual (eg. Cobb-Douglas), the dual cost function of the Cobb-Douglas production function can be specified as: the cost frontier function is also specified as;

$$\ln C_i = \beta_0 + \sum_{i=1}^{n} (\alpha_j \ln w_j + a_j \ln Y^*) \tag{3.6}$$

Where i refers to the i^th^ sample farmer; j is number of input; Ci is the minimum cost of maize production; Wj denotes input prices; Y* refers to farm output which is adjusted for noise vi and α's are parameters was estimated. Sharma *et al*. (1999) suggests that the corresponding dual cost frontier of the Cobb Douglas production functional form in equation (3.2) can be rewritten as:

$$Ci = C(Wi,\ Yi^*,\alpha) \tag{3.7}$$

Where i refers to the i^{th} sample household; Ci is the minimum cost of production; Wi denotes input prices; Y^* refers to farm output which is adjusted for noise V_i and $\alpha's$ are parameters to be estimated. The economically efficient input vector of the i^{th} household X_{ie} is derived by applying Shepard lemma (as cited in Arega and Rashid, 2005) and substituting the firms input prices and adjusted output level, a system of minimum cost input demand equation can be expressed as:

$$\frac{\partial ci}{\partial wn} = x^e(Wi, Yi, \alpha) \tag{3.8}$$

Where n is the number of inputs used. The observed, technically and economically efficient costs of production of the i[th] farm are then equal to $W^{'}Xi$, $W^{'}Xit$ and $W^{'}Xie$ respectively.

The minimum cost is derived analytically from the production function, using the methodology used in Arega and Rashid (2005). Given input oriented function, the efficient cost function can be specified as follows:

$$\min_{X} \sum C = \sum_{j=1}^{6} w_j X_j \qquad (3.9)$$

Subjects to

$$Y^{*} = \hat{A} \prod X_j^{\beta j} \qquad \text{Where } \hat{A} = Exp(\hat{\beta} 0)$$

The solution for the problem in the above equation is the basis for driving dual cost frontier. Substituting the input demand equations derived using shepherd`s lemma (3.9) and Yield adjusted for stochastic noise (predicted value of yield) in the minimization problem above, the dual cost function can be written as follows:

$$C(Yi^{*}, W) = HYi^{*\mu} \prod_j W_j^{\alpha_j} \qquad (3.10)$$

$$aj = \mu \hat{\beta}_n \quad \mu = (\sum_n \hat{\beta}_n)^{-1} \quad H = \frac{1}{\mu}(\hat{A} \prod_n \hat{\beta}_n^{\beta_n})^{-\mu}$$

According to (Sharma *et al.,* 1999), the explained cost measures enable to estimate AE and further EE.

We can define the farm–specific technical efficiency in terms of observed output (Yi) to the corresponding frontier output (Yi*) using the existing technology.

$$TE_i = \frac{W^{'}Xit}{W^{'}Xi} = \frac{Y_i}{Y^{*}} \qquad (3.11)$$

The farm specific economic efficiency is defined as the ratio of minimum observed total production cost (C*) to actual total production cost (C).

$$EE_i = \frac{W^{'}Xie}{W^{'}Xi} = \frac{C^{*}}{C} \qquad (3.12)$$

Following Farrell (1957), the AE index can be derived from Equations (3.11) and (3.12) as Follows:

$$AE_i = \frac{W^{'}Xie}{W^{'}xit} = \frac{EE_i}{TE_i} \qquad (3.13)$$

As stated in Greene (1980) different hypotheses were tested using the generalized likelihood ratio test: $LR = -2[L(HO) - L(H1)]$ where L (H0) and L (H1) are the values of log likelihood functions under the null and alterative hypothesis, respectively. The decision rule is the null hypothesis is rejected when the calculated chi- square is greater than the critical chi-square with degree of freedom at 5% level of significance.

3.4.2. Determinants of efficiency

After estimating the level of technical, allocative and economic efficiency from stochastic frontier model they was regressed using a two limit Tobit model on farm specific explanatory variables that affect in efficiency level. The Tobit model was used because the efficiency scores lie within a double bounded range of 0 to 1. Estimation with (OLS) regression of the efficiency score would lead to a biased parameter estimate since OLS regression assumes normal and homoskedastic distribution of the disturbance and the dependent variable (Greene, 2003).Following Gujarati (2004) Tobit regression is specified as:

$$y_i{}^* = \delta o + \delta_m Z_{im} + \mu \qquad (3.14)$$

Where $y_i{}^* -$ latent variable representing the technical, allocative and economic efficiency scores of ith farm

$m-$ the number of factors affecting efficiency

$\delta -$ a vector of parameter to be estimated

$Z_{im} -$represents farm specific factors affecting efficiency of ith farm

$\mu -$ error term that is independently and normally distributed with zero mean and variance δ^2

Denoting y_i as observed variables,

$$y_i = \begin{cases} 1 & if \;\; y_i^* \geq 1 \\ y_i{}^* & if \;\; 0 < y_i{}^* < 1 \\ 0 & if \;\; y_i{}^* \leq 0 \end{cases} \qquad (3.15)$$

Following Maddala (1999), the likelihood function of this model is given by:

$$L(\beta,\sigma / y_i L_{1j,} L_{2j}) = \prod_{y_{j=l_{1j}}} \varphi\left(\frac{L_{1j} - \beta^{'} X_j}{\sigma}\right) \prod_{y_{j\equiv y_j^*}} \frac{1}{\sigma} \phi\left(\frac{y_j - \beta^{'} X_j}{\sigma}\right) \prod_{y_{j=l_{2j}}} 1 - \varphi(\frac{L_{2j} - \beta^{'} X_j}{\sigma} \quad (3.16)$$

Where L_{1j} = 0(lower limit) and L_{2j}=1(upper limit) are normal and standard density functions.

The Tobit regression model coefficients do not directly give the marginal effects of the associated independent variables on the dependent variable. But their signs show the direction of change in the dependent variable as the respective explanatory variables change (Amemiya, 1984).In a two-limit Tobit model, each marginal effect includes both the influence of explanatory variables on the probability of the dependent variable to fall in the uncensored part of the distribution and on the expected value of the dependent variable conditional on it being larger than the lower bound. Thus, the total marginal effect takes into account that a change in explanatory variable will have a simultaneous effect on the probability of being efficient and value of efficiency scores in maize production.

McDonald and Moffitt (1980) proposed useful decomposition techniques of total marginal effects. Based on the likelihood function of the model stated in equation (3.17), the total marginal effect divided into the three marginal effects as follows:

1. The unconditional expected value of the dependent variable:

$$\frac{\partial E(y)}{\partial x_j} = [\varphi(Z_u) - \varphi(Z_L)] \frac{\partial E(y^{|*}}{\partial x_j} + \frac{\partial[\varphi(Z_U) - \varphi(Z_L)]}{\partial x_j} + \frac{\partial(1 - \varphi(Z_U)}{\partial x_j} \quad (3.17)$$

2. The expected value of the dependent variable conditional upon being between the limits:

$$\frac{\partial E(y^*)}{\partial x_j} = \beta_k \left[1 + \frac{\{Z_L \varphi(Z_L) - Z_U \varphi(Z_U)\}}{\{\varphi(Z_U) - \varphi(Z_L)\}}\right] - \left[\frac{\{\phi(Z_L) - \phi(Z_U)\}^2}{\{\varphi(Z_U) - \varphi(Z_L)\}^2}\right] \quad (3.18)$$

3. The probability of being between the limits:

$$\frac{\partial[\varphi(Z_U) - \varphi(Z_L)]}{\partial x_j} = \frac{\beta_m}{\sigma}.[\phi(Z_L) - \phi((Z_U)] \quad (3.19)$$

Where φ (.) = the cumulative normal distribution, ϕ(.) = the normal density function, $Z_1 = -\beta X / \sigma$ and $Z_U = (1 - \beta X) / \sigma$ are standardized variables that came from the likelihood function given the limits of y^*, and σ = standard deviation of the model.

3.5. Definition of Variable and Hypotheses

3.5.1. Production function variables

Maize output: This is the dependent variable of the production function which was measured in quintals of maize produced in 2017/2018 production period by sample household.

Inputs: Are explanatory variables of production functions and defined as follows:

Seed (SEED): This continuous variable refers to the quantity of improved seed used in kg for maize production by each sample household in 2017/2018 production season. During survey period sample respondent used improved seed such as BH661, Shone and Limmu for maize production during 2017/2018 production year.

Land (LAND): This continuous variable refers to the physical unit of land (owned, shared and rented) allocated to maize production measured in hectare in 2017/2018 production season by sample household.

NPS and Urea fertilizer (NPS, UREA): In this study, it was not possible to aggregate mineral fertilizers (Urea and NPS) into one variable as due to price variations. If price were used to aggregate fertilizers, the resulting efficiency estimates would have been biased. This is because the resulting difference in economic efficiency would not be only due to input variations but also price variations. Due to this fact, Urea and NPS were not aggregated into one variable in the analysis. Therefore the amount of NPS fertilizer (NPS) measured in kg and amount of urea fertilizer measured in kg by each sample household for maize production during the 2017/2018 production season were considered as input variable separately.

Oxen power (OXEN): This continuous variable which refers to the number of oxen power used for different farming activities for maize production was measured in pair of oxen days (one oxen-day is equivalent to eight working hours).

Labor (LABOR): This continuous variable which represents the aggregate labor (family labor, exchange labor and hired labor) used for maize production such land preparation, ploughing, planting and different agronomic practice in the production season by sample farmers. It was measured in man days (eight hours are equivalent to one man day) and converted to homogenous variable using the standard set by Storck *et al*. (1991).

3.5.2. Input prices

The input prices that were used to estimate the cost frontier function. These variables were assumed to be positively related to the total variable cost of maize production. The amount that was paid by farmers (22.48birr per kg) to purchase seed was recorded mean price. The unit price for land was estimated using the local average rental cost in the area, which was 3000 Birr/Ha. For labor, the average wage rate for hired labor, 40 Birr/man-day, was used. Oxen power was estimated as the amount of cash paid for the rental per oxen day and the mean price used from this survey was 70 birr per oxen-day. As far as NPS and urea are concerned, the current market values of 12.02 and 10.11 Birr/kg were used respectively.

3.5.3. Efficiency variables and hypothesis

After a detailed review of previous studies and the existing condition in the study area, demographic, socioeconomic, and institutional and farm characteristics that are expected to affect efficiency level of sample farmers in the study area are hypothesized below.

Age of household head (AGEHHD): It is a continuous variable which refers to the age of the household head measured in years. It is believed that age can serve as a proxy for experience. Age of household related positively to efficiency (Kifle, 2017). In this case farmers with more years of experience are expected to be more efficient. However, as the farmer gets older his labor productivity is expected to decrease. Fantu *et al. (*2011) found negative effect of age on efficient. Therefore it is hypothesized the effect of age of household head to efficiency of maize producer is positive in this study.

Sex of the household head (SEX): This is a dummy variable that takes a value of 1 if the household head is male and zero, otherwise. It is hypothesized that male headed households are more efficient than female headed households in maize production. This is because, male household heads are more exposed to farming operations; they have better practical experiences in farming operations and would probably use inputs optimally than females do. This hypothesis is supported by Fantu *et al. (*2011).

Education level (EDUC): This variable measured in continuous years of formal schooling of the household head. This because farmers with greater years of formal education tend to be more efficient in maize production probably due to their enhanced ability to acquire knowledge of production ,which make them produce closer to the frontier output. Study by Mustefa *et al*. (2017) and Solomon (2014) indicated that education had positive effect on efficiency. Therefore in this study it was hypothesized that education determines efficiency level of the maize producer sample farmers positively.

Family size (FMSIZE): This variable is measured as number of family size in one household measured in man equivalent during 2017/2018 farming year. In this study, family size is hypothesized to affect efficiency level of the farmers positively. This is because, as labor is the main input in crop production, a farmer that has available labor in family could carry out important maize practices timely. Therefore, family size could have positive effect in raising the farmers' production efficiency. This hypothesis is in line with (Sorsie *et al*., 2015; Tefaye and Beshir, 2014).

Farm size (FRMSIZE): This is measured as the area of cultivated crop (own, shared or rented) during 2017/18 production year in hectares under the household management. It is hypothesized that as the farm size increases the efficiency of the farmer decrease. This is because; Households with larger area of cultivated land have the less management attention. Total area cultivated had a negative effect on efficiency (sisay *et al* 2015; Lemessa *et al*., 2017).

Livestock ownership (LIVSTK): This variable measures the total livestock holding of the farmers in 2017/2018 production year measured in tropical livestock unit (TLU). It is hypothesized that livestock owned determine efficiency level of farmers positively. This is because importance of livestock in the crop production system as source of draft power, income, inputs purchase and manure. Increase in the number of livestock owned increase the efficiency of farmers (Tsegaye and Ernst, 2015; Rao and Bealu, 2015).

Fertility of the maize land (FERTY): This is measured as a dummy variable that takes a value of 1 if a household perceive his plots as fertile and 0, otherwise. Farmers are asked to categorize their land as fertile, or less fertile as they are estimated to approximately known the fertility status of their maize land. This variable is hypothesized to determine efficiency positively. This is because the fertile plot is more productive than less fertile plots. Fertility of maize land was found to relate positively to efficiency (Mustefa *et al*., 2017).

Distance to nearest market (DISMRKT): It is a continuous variable and defined as the distance of farmers from nearest market measured in kilometer. When farmers are sited far from nearest market, there would be limited access to input and market information. Therefore, it is hypothesized that higher distance from the nearest market would have negatively affect efficiency of maize production in these studies. Distance from nearest markets reduces efficiency (Ermias *et al.*, 2015; Getachew, 2017).

Distance of maize plot from home (DISPLOT): This is measured as the distance of maize plot from homestead measured by walking minute required. It is hypothesized that distance of maize plots was negatively related to efficiency. This is because; those plots far away from home will receive less management attention by the farmer. This hypothesis is supported by (Tefaye and Beshir, 2014; Kinde, 2005).

Extension contact (EXTEN): This variable measured as a continuous variable refers to frequency of contacts with extension workers in 2017/2018 production period. This variable is hypothesized as those farmers who have more frequent contacts with development agents are likely to be more efficient. This is because they are get advice in terms that increases their knowledge of their production. Study done by Sisay (2015) and Kifle (2017) indicated that extension contact had a positive and significant relationship with efficiency of maize farmers.

Credit use (CREDIT): This variables measured as dummy variable which represents whether the farmer have used credit or not during 2017/2018 the production season. If the farmer has used credit takes a value of one and zero, otherwise. It is hypothesized that farmers who have used the credit are more efficient than others. This is because, using the credit is an important source of financing and it enables the smallholder farmers to purchase agricultural inputs in time that would increase their efficiency. Credit was found to relate positively to efficiency (Kinde, 2005; Sorsie *et al.,* 2015).

Participation in Off /non-farm activities (OFF/NFRM): This variable is measured as a dummy variable that takes a value of 1 if a farmer is engaged in off /non-farm activities and 0 otherwise. It is hypothesized that farmers participating in off/non-farm activities are more efficiency than others. This is because those farmers engaged on Off/non-farm activities could obtain additional income that could be used for the purchase of agricultural inputs that would improve efficiency of maize producers. Participation in off/ non-farm activities were found to relate positively to efficiency (Getachew and Bamlaku, 2014).

Table 2.Summary of hypothesized variables of production function

Notation	Variable	Measurement unit	sign
SEED	Seed used for maize production	Kilograms	+
LAND	Area of land used for maize production	Hectare	+
NPS	NPS Fertilizer used for maize	Kilograms	+
UREA	Urea Fertilizer used for maize	Kilograms	+
OXEN	Oxen power used for maize	Oxen-days	+
LABOR	Labor used for maize production	Man-days	+

Own computation (2018)

Table 3.Summary of efficiency variable and their expected sign

Notation	Variables	Measurement	sign
AGEHHD	Age of household head	Years	+
SEX	Sex of household head	Dummy	+
EDUC	Education level of household head	Years	+
FMSIZE	Total number of household	ME	+
FRMSIZE	Total cultivated land	Hectares	-
LIVSTK	Total livestock holding	TLU	+
FERTY	Fertility status of maize plot	Dummy	+
DISPLOT	Distance of home to maize plot	Minute	-
DISMRKT	Distance to nearest market	Kilometer	-
CREDIT	Uses of credit	Dummy	+
EXTEN	Frequency of extension contacts	Numbers	+
OFF/NFRM	Off/non-farm activities	Dummy	+

Own computation (2018)

4. RESULTS AND DISCUSSION

This chapter has two sections. The first section presents results of the descriptive statistics and the second section deals with econometric results from the stochastic frontier model and Tobit models.

4.1. Descriptive Results

Before embarking on presenting and discussing the results obtained from the econometric model, it was better to present demographic, socio-economic, farm characteristics and institutional factor; input and output information of the sample farm households.

4.1.1. Demographic and socio-economic feature

Sex and marital status of the respondent: With regards to the sex of respondents, survey result shows that about 20.78% of the sample households were female headed and the remaining 79.22% were male headed. Female headed households face greater challenges in the agricultural production activities as compared with their male headed counterparts 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 from the far distance rivers, child caring and household management. In addition, they have farm management tasks that increase the burden. Such multiple tasks combined with less resource accesses and ownership would likely lead to more frequent and perhaps severe economic and social shocks that in turn decrease their efficiency. The survey result showed that the total number of married widowed and divorced households were 120, 27 and 7 respectively. Females became head of households, when they were divorced or widowed, take responsibility and starting farming in addition to homemaking role.

Table 4.Sex and marital status of the respondents

Variable		Number farmers	Percent
Sex	Female	32	20.78
	Male	122	79.22
Marital status	Married	120	77.9
	Divorced	7	4.5
	Widowed	27	17.5
	Total	154	100.0

Source own survey (2018)

Family size: Family labor plays an important part in the success of a smallholder farming practices in that the farmer does not need to spend too much money on labor costs. The average family size of the sample households was found to be 6.25 with the minimum of 2 and maximum of 13. In the study area, the average family size was about 3.61 man equivalents per household. The largest family size was 7.8 while the smallest was 0.8 man equivalents per household.

Table 5.Age, household structure and education level of sample households

Variables	Minimum	Maximum	Mean	Std. Deviation
Education level	0	12	4.29	3.14
Age	26	64	42.13	9.14
Family size in number	2	13	6.25	2.35
Family size in man equivalent	0.80	7.80	3.61	1.31

Source: Own survey (2018)

Educational level and age of household head: Education is a means to develop the quality of labor through improving the managerial skill hence increases efficiency of farmers. Education could guide farmers to better manage their farm activities. Education level of the households measured in years of schooling indicates that the average level of education is 4.29.The education level of the respondent ranges from zero (illiterate) to grade 12(Table 5). Regarding age, the average age of the sample household heads was about 42.13 years with minimum of 26 and maximum of 64 years.

4.1.2. Livestock ownership of the respondent

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. The survey result signifies that 1.23% sample households had no livestock, while 2.58% owned number of livestock above 15.01 to 20.91 TLU. On the other hand 41.56% of the household had number of livestock within the range of 1 to 5 TLU (Table 6).This implies that about 97.33% of total households own up to a maximum of 15 TLU.Livestock ownership of sample household ranges from 0 to 20.91 with a mean and standard deviation of 6.13 and 3.65 respectively.

Table 6.Distribution of sample households under various tropical livestock units

TLU ranges	Frequency	Percent
0	2	1.23
1-5	64	41.56
5.01-10	68	44.15
10.01-15	16	10.39
15.01-20.91	4	2.58
Total	154	100.0

Source: Own survey (2018)

Oxen were the only sources of traction power in the area. Shortage of oxen power leads to poor land preparation and delayed completion of the farm operation. Poor land preparation leads to poor plant establishment, heavy weed infestation and low yields. Table 7 shows that 20.1% of the farm households have oxen of three and more. About 52.6% of the farm households have pair of oxen. While 24.7% have a single ox and 2.6% have no ox at all. Conventionally, land preparation is done using a pair of oxen, but the result indicates that 27.3% of the sample households cannot independently plough their farm using own oxen. The available option for those who have no pair of oxen in the study area is to exchanges with other or rent oxen from other households. Oxen ownership of sample household ranges from 0 to 6 with a mean and standard deviation of 2.03 and 1.01 respectively.

Table 7.Number of oxen owned by households.

Numbers of oxen	Number of farmers	Percent
0	4	2.6
1	38	24.7
2	81	52.6
3	14	9.1
4 and above	17	11
Total	154	100

Source: Own survey (2018)

4.1.3. Participation in off/non-farm activities

Farmers in the study area are engaged in various off/non-farm activities in parallel with the main farming activities. This may be due to the returns they obtain from off/non-farm supplements the agricultural activities. Some of these activities are: handicraft, petty trade and selling of local drinks. The income they desperately need to obtain from such off/non-farm activities may substantiate the low income that is usually obtained from farming activities. In this study, 53.25% of them participated in various off/non-farm activities while 46.75% are not participated in any of the above off/non-farm activities (Table 18).

4.1.4. Input and farm characteristics

Land utilization and availability: Land is the most important factors of production for the rural people of the country in general and the study area in particular. Farmers use most of their land for crop production. Ethiopian agricultural production is very much related to the existing landholding system to generate a livelihood for smallholder farmers (Grover and Temesgen, 2006). Survey result shows the mean land owned by the farmers in the study area was 1.57 ha.As shown in Table 8, about 20.1% of sample farmers owned land not more than 0.5 ha whereas 19.5% of sample farmers had more than two ha of land. The mean size of cultivated land size was 1.46 ha in which about 11% farmers cultivate less than 0.5 ha, while 20.1% of farmers cultivate land which was more than 2 ha.

Table 8.Distribution of the sample farmers by cultivated and owned land size

	Owned land		Cultivated farm size	
Size(ha)	Number	Percent	Number	Percent
<=0.5	31	20.1	17	11
0.501-1	42	27.3	48	31.2
1.01-2	51	33.1	58	37.7
>2	30	19.5	31	20.1
Total	154	100	154	100.0
Average owned land in ha	1.57			
Average cultivated land in ha	1.46			

Source: Own survey (2018)

Farm characteristics: The number of ploughing can indicate an intensity of land preparation that helps for proper germination of the seed and it was expected to have a direct impact on productivity. On average, sample households ploughed their maize land 3.72 times with minimum of 2 times and maximum of 5 times during 2017/2018 production year.

Table 9.Ploughing frequency, farm factors and soil fertility

Variable	Min	Max	Mean	Std.devation
Ploughing frequency(number)	2	5	3.72	0.73
Number of plot(number))	1	4	1.19	0.48
Distance of maize plot from home (minute)	2	75	12.92	10.92

	Response	Number	Percent
Fertility status Soil	Fertile	63	40.91
	Medium	91	59.09

Source: Own survey (2018)

The result also indicate the mean number of plots allocated for maize crop was 1.19 allocated minimum of 1 and maximum of 4 plots in different location .On average distance between the plot under maize crop and the farmer’s home were 12.92 minutes ranging from minimum of 2 minutes up to a maximum of 75 minute(Table 9).Regarding to farmers perception on soil fertility the result of the survey showed that 40.91% of respondents classified their maize farm as “fertile’’ class in fertility status and the remaining respondents graded is as “ medium fertile ” based on their perception. Thus, farmers at least perceive that they did not allocate infertile land for maize production for the main rain season of 2017/18 production year.

Labor: Farmers produce maize by using labor intensive technologies. Family, exchange and hired labor are used for performing different farming operations such as land preparation, ploughing, planting, fertilizer application, weeding and cultivation, harvesting, threshing and transporting for maize production in the study area. The survey result indicated that the majority of the sample households 55.2% used only family labor. Exchange labor was the additional source of labor supply to household labor, 35.7% of the sample households used both family and exchange labor. As shown below, family labor was dominantly used for maize production (Table 10).

Table 10.Types of labor used for maize production

Types of labor used by household	Frequency	percent
Family labor	85	55.2
Both family and exchange labor	55	35.7
Both family and hired labor	11	7.1
Family, exchange and hired labor	3	1.9
Total	154	100.0

Source: Own survey (2018)

4.1.5. Institutional support

4.1.5.1. Extension service

In order to give effective extension service to the households, the district assigned three development agents in each kebele. However the extension workers didn’t visit farmers equally in the study area. Even though some farmers are being visited more 98.05% have got chance to visited by extension worker while only 1.95% of them have not got chance at all to be visited by extension workers during 2017/2018 of production year. The survey result indicates that, the average frequency of extension contact of sample households was 11.30

times with standard deviation of 9.60 with minimum of zero (no contact) to a maximum of 48 times. (Table 12)

4.1.5.2. Uses of credit

In the study area there are both formal and informal lending institutions to gives credit. The formal sources of credit in the study area are Oromia Credit and Saving Share Company (OCSSCO) and Wasasa. Where local money lender, friends and relatives are informal sources of the credit. However, the process to use credit from the formal institutions was not as easy as the informal institutions. For instance, in the case of OCSSCO and Wasasa farmers were asked to form a group of five to acquire credit. If any one group of members not pays back the group can pay the repayment amount. As shown table 11 out of the total 63.64% sample households who had credit uses, 17.50%, 35.70% of them get their credit from formal source Wasasa and OCSSCO respectively. While the other 10.44% respondents get it from informal sources like local money lender, friend and relatives. The credit user's farmers reported that they used the money to purchase agricultural inputs such as seed, NPS, urea and chemicals. Credit users also reported that they used the credit to buy livestock and food items.

Table 11.Distribution of credit source among sample households

Credit source	Total Sample household	
	Frequency	Percent
Wasasa	27	17.50
Oromia Credit and saving share company	56	35.70
local money lender ,friend, and relative	16	10.44
Total	98	63.64

Source: Own survey (2018)

4.1.5.3. Distance to the nearest market

Market is one of the basic institutions for the purchase of different farm input and to sell their outputs. The mean distances of the nearest market to the farmers was 3.55 km and is ranging between 0.83 km and 10 km.

Table 12.Institutional characteristics of the sample households

Dummy Variable	response	Frequency		Percent
Credit	Yes	98		63.64
	No	56		36.36
Continuous variables	Minimum	Maximum	Mean	Std.devation
Extension Contact	0	48	11.30	9.60
Distance to nearest the market	0.83	10	3.55	1.94

Source: Own survey (2018)

4.1.6. Asset ownership of household

The ownership of asset can be used as a proxy for wealth status of the households. People living in different areas own different assets, based on the socio-economic and cultural values of these assets in their areas. The major assets owned by sample households which contribute to maize production efficiency are presented as follows: As table 13 show that 76% of household head have iron sheet house while 24% of the them live in grass roofed house. As far as radio and mobile ownership is concerned, 44.2%, and 59.7% of sample households owned radio and mobile while 55.8% and 40.3% have no radio and mobile respectively.

Table 13.Asset ownership of sample households

Variable	Owned		Do not own	
	Number	percent	Number	percent
Iron sheet Ownership	117	76	37	24
Radio Ownership	68	44.2	86	55.8
Mobile Ownership	92	59.7	62	40.3

Source: Own survey (2018)

4.1.7. Major crops production and their area coverage

Crop production is major activities in the study area. The major crops grown in the areas include maize, teff, niger seed, sorghum, wheat, and barley. On average, sampled households allocated 0.80 hectare of cultivated land for maize production. Next to maize teff and niger seed were crops that took the lion’s share of the farmer`s total cultivated land covering 0.34

and 0.18 ha of land, respectively. The sample households also allocated 0.06 of the total cultivated land for wheat. Moreover, sorghum and barley were crops that took certain share of households total cultivated land covering, 0.03 and 0.02 ha, respectively. Table 14 also demonstrates the average production of major crops in quintals. Given the variation in productivity among crops, sampled farmers on average got 23.05 quintals of maize, which were 75.39% of the total major crop production. The total average production of teff and wheat was 2.68, 2.14 quintals, which was 8.75%, 7% of the total major crop production. Sampled households on average also got 1.61, 0.68 and 0.38 quintals of sorghum, Niger seed and barley which was tooks some share of 5.27%, 2.25% and 1.27% respectively.

Table 14.Average crops production of various crop output by sample households

		Area(ha)		Production(Qt)	
Crop type	No. farmer	Mean	percent	Mean	percent
Maize	154	0.80	54.95	23.05	75.39
Teff	104	0.34	23.66	2.68	8.79
Niger seed	64	0.18	12.52	0.68	2.25
Wheat	34	0.06	4.45	2.14	7.00
Sorghum	29	0.03	2.54	1.61	5.27
Barley	12	0.02	1.41	0.38	1.27

Source: Own survey (2018)

4.1.8. Maize Production constraints:

Soil factors were the major problem that farmers were facing in the study area followed by crop disease (American Gerry) and poor land preparation. About 24.7% of respondents reported soil factor was the problem that they were facing whereas 16.9% were facing maize disease (especially American Gerry). Additionally according to information obtained from FGD American Gerry is a recently occurred disease that affects the yield of their maize crop that needs the immediate control of disease. In addition to this, 15.6% and 13.6% of the respondent faces poor land preparation and seed productivity problem respectively in the study area. Farmers also reported that there was labour shortage during peak agricultural production seasons.

Table 15.Maize production constraints

Variables	Frequency	Percent
Soil factor	38	24.7
Seed productivity problem	21	13.6
Weed infestation	11	7.1
Poor land preparation	24	15.6
Shortage of oxen	9	5.8
Labor constraint	15	9.7
Shortage of land	10	6.5
Maize disease	26	16.9
Total	154	100.0

Source: Own survey (2018)

4.1.9. Descriptive statistics of variables used in the model

This section present summary statistics results of production variables used for analysis in the stochastic production frontier model, cost frontier and in Tobit model.

Descriptive statistics of production function variables: On average, sample farmers obtained 23.05 quintal of maize. The average land area allocated to maize production (owned shared and rented land) by household was 0.80 ha and ranged from 0.23 ha to 2.5 ha. The amount of seed that sampled households used were 16.34 kg on average. Like other inputs, human labor and oxen power inputs were also important, given a traditional farming system in the study area. Sampled households, on average, used 69.58 man equivalent labor and 18.61 oxen days for the production of maize during 2017/18 production season. Sample farmer households also on average, used 70.64 kg and 135.06 kg of NPS and urea respectively.

Table 16.Descriptive statistics of variables used in production function

Variables	Unit	Mean	Std.devation	Minimum	maximum
OUTPUT	Quintal	23.05	14.63	3	70
SEED	Kilogram	16.34	9.94	4	65
LAND	Hectare	0.80	0.49	0.23	2.5
NPS	Kilogram	70.64	45.57	15	250
UREA	Kilogram	135.06	84.53	25	400
OXEN	Oxen-day	18.61	10.05	5	49
LABOR	Man-day	69.58	37.47	15.6	195.5

Source: Own survey (2018)

Descriptive statistics of variables used to estimate the cost function: As presented in table 17 the mean and standard deviation of each variable used in the cost function along with their involvement to the total cost of cultivation are discussed as follows. On average total cost of Birr 9104.48 was required to produce 23.05 quintal of maize. Among the various factors of production, the cost of labor and land accounted for the highest share 2783.65 birr and 2400.04 respectively. Following the cost of labor and land, cost of urea, oxen and NPS takes, 1365.94 1303.30, 849.36 respectively out of total cost of cultivation. Among other input cost of seed took the smallest share 367.56 birr, out of the total cost of maize cultivation.

Table 17. Descriptive statistics of variables used to estimate the cost function

Variables	Unit	Mean	Std. Deviation	Percentage share of total cost
OUTPUT	Quintal	23.05	14.63	-
Total cost of output	Birr	9104.48	6182.29	-
Cost of seed	Birr	367.56	225.99	4.03
Cost of land	Birr	2400.04	1435.66	26.36
Cost of NPS	Birr	849.36	553.16	9.32
Cost of urea	Birr	1365.94	895.04	15.00
Cost of oxen	Birr	1303.30	724.46	14.31
Cost of labor	Birr	2783.65	1515.46	30.57

Source: Own survey (2018)

Descriptive statistics of variables included in efficiency model: Total of 12 variables were hypothesized to affect efficiency of maize producers, out of them four were dummy variables and eight of them are continuous variables. Table 18 illustrate summary of these variables.

Table 18.Summary of efficiency model variables

Variables	Mean	Std.devation	percentage of mean with dummy=1	Percentage of mean with dummy=0
AGEHHD	42.13	9.13		
EDUC	4.29	3.14		
FMSIZE	3.61	1.31		
FRMSIZE	1.46	0.86		
LIVSTK	6.12	3.65		
DISPLOT	12.92	10.97		
DISMRKT	3.55	1.94		
EXTEN	11.30	9.60		
CREDIT			63.64	36.36
SEX			79.22	20.78
FERTY			40.91	59.09
OFF/NFRM			53.25	46.75

Source: Own survey (2018)

4.2. Econometric Model Outputs

This section presents the econometric model outputs of the production function; efficiency scores and factor that affect technical, allocative and economic efficiency of smallholder farmers in maize production in the study area.

4.2.1. Hypothesis testing

In SPF method it is possible to test various hypotheses using maximum likelihood ratio test, which were not possible in non-parametric models. Therefore, the following tests were carried using the generalized Likelihood Ratio (LR) which includes tests of model selection, inefficiency effect, and coefficients of determinants.

The first hypothesis test was functional form that can better fit to the data at hand was selected by testing the null-hypothesis that Frontier model specification for the data is Cobb-Douglas production function(i.e. coefficients of all interaction terms and square specifications in the Translog functional forms are equal to zero ($Ho = bij = 0$)). The test was made based on the value of likelihood ratio (LR) statistics which can be computed from the log likelihood values of both the Cobb-Douglas and Translog functional forms. Then, the value was compared with the upper 5% critical value of the χ^2 at the degree of freedom equals to the difference between the numbers of explanatory variables used in both functional forms (in this case degree of freedom=21). In other words, the degree of freedom is the number of interaction terms and square specifications in the Translog case restricted to be zero in estimating the Cobb-Douglas functional form. The log likelihood functional values of both Cobb-Douglas and Translog production functions were -44.01 and -30.26 respectively. The LR value computed therefore was 28.72 and this value is lower than 32.67 the upper 5% critical value of the χ^2 at the degrees of freedom equal to 21. This shows that the coefficients of the interaction terms and the square specifications of the input variables under the Translog specifications are equal to zero. As a result the null hypothesis the Cobb-Douglas functional form best fits the data was accepted for this study.

The second hypothesis was testing for the existence of the inefficiency component of the total error term of the stochastic production function. In other words, we have to decide whether the average production function (without considering the non-negative random error term) best fits the data. We can carry out the test for the null hypothesis that the inefficiency component of the total error term of the stochastic frontier specification equals to zero ($\gamma = 0$) against the alternative hypothesis that inefficiency component is greater than zero ($\gamma > 0$). If the null hypothesis is accepted (i.e. one-sided error term is equal to zero) then the stochastic model is identical to the average response function indicating that there is no inefficiency problems within the maize producing farmers. The likelihood ratio statistic computed (using one-sided generalized likelihood ratio test of ($\gamma = 0$) from the values of log likelihood functions under both the average response function and full frontier function given the specification of the Cobb-Douglas production function was 14.08. The value is higher than the χ^2 critical value for the upper 5% at the degree of freedom equal to one. The higher LR value reveals the existence of inefficiency or one-sided error component in the model. Hence, the hypothesis that those maize producers in the study area are technically efficient is strongly rejected. As a result, the production behavior of maize producers of the study area can better be represented by the stochastic production function than the average response function.

The third test conducted was whether the technical efficiency levels were better estimated using a half normal or a truncated normal distribution of μ . If null hypothesis is accepted half normal distribution is correct specification distributional assumption. The results indicated that the half normal distribution was suitable for the sample households as the calculated LR value of was 0.66 less than the critical χ^2 value of 3.84 at 5% significance level with degree of freedom equal to 1.

Table 19.Generalized likelihood ratio test of hypotheses for parameters of stochastic production frontier

Hypothesis	Degree of freedom	LH0	LH1	LR	Critical χ^2	Decision
$Ho:\beta_7=\beta_8=\beta_{27}=0$	21	-44.01	--30.26	28.72	32.67	Accept Ho
$H_1:\beta_7\neq\beta_8\neq\beta_{27}\neq0$						
$Ho:\gamma=0$	1	-51.05	-44.01	14.08	3.84	Reject Ho
$H_1:\gamma\neq0$						
$Ho:\mu=0$	1	-44.01	-43.68	0.66	3.84	Accept Ho
$H_1:\mu\neq0$						
$Ho:\delta_1=\delta_2=\delta_{12}=0$	12	-44.01	-29.35	29.32	21.0261	Reject Ho
$H_1:\delta_1\neq\delta_2\neq\delta_{12}\neq0$						

Source: Own computation (2018)

The fourth hypothesis tested was that all coefficients of the inefficiency effect model are simultaneously equal to zero. $Ho=\delta_0=\delta_1=\delta_2=\delta_3....=\delta_{12}=0$) against the alternative hypothesis, which states that all parameter coefficients of the inefficiency model are different from zero. If null hypothesis is accepted the explanatory variables in the inefficiency effect model do not contribute significantly to the explanation of the technical inefficiency variation for the maize producers. This hypothesis was tested by calculating the LR value using the value of the log likelihood function under the stochastic frontier model (without explanatory variables of inefficiency effects Ho) and the full frontier model (with variables that are supposed to determine inefficiency level of each farmer, $H1$). The LR value obtained was 29.32 which is much higher than the critical χ^2 value at the degree of freedom equal to the number of restrictions equal to be zero (in this case the coefficient of the inefficiency effect model 12). Therefore, the null hypothesis is rejected in favor of the alternative hypothesis that explanatory variables associated with inefficiency effects model are different from zero.

4.2.2. Estimation of production and cost functions

The ML estimates of the parameters, of the SPF specified in equation (3.3), were obtained using the Stata13 computer program. These results together with the standard OLS estimates of the average production function are presented in Table 20.

Table 20.Estimation of the Cobb-Douglas frontier production function

Variables	MLE	
	Coefficients	Std. Err
Constant	1.0135*	0.5325
LN(SEED)	0.2804***	0.0951
LN(LAND)	0.3110***	0.1032
LN(NPS)	0.0742	0.0706
LN(UREA)	0.0867	0.0688
LN(OXEN)	0.1395	0.0860
LN(LABOR)	0.1423*	0.0800
$\delta^2 = \delta_v^{\ 2} + \delta_u^{\ 2}$	0.2453***	0.0526
$\lambda = {}^{\delta u}/_{\delta v}$	2.54***	0.1107
Gamma (γ)	0.866	
Log likelihood	-44.01	
Return to scale	1.0341	

Note:* and *** refers to 10% and 1% significance level, respectively.

Source: Own computation (2018)

From the total of six variables considered in the production function, three inputs (land, seed and labor) had a significant effect in explaining the variation in maize yield among farmers. The coefficients of the production function are interpreted as elasticity. If there is a one percent increase in the size of land, amount of seed and amount of labor would increase maize production by 0.311%, 0.2804%, 0.1423% respectively, suggests that maize production was responsive to land, seed and labor in the study area. Hence, the increase in these inputs would increase production of maize significantly as expected. Moreover one percent increase in amount of land would result in 0.311% increase in maize production, keeping other factors constant. Alternatively, this indicates maize production was more responsive to land. Return to scale of all input used in production process is the measure of total factors productivity (Niagara *et al.*, 2009). The scale coefficient was calculated to be 1.0341, indicating increasing returns to scale (Table 20). This implies that there is potential for maize producers to continue to expand their production because they are in the stage I of the production surface where resource use is believed to be underutilized. In other words, a percent increase in all inputs proportionally would increase the total production by 1.0341%. This is in line with finding of Abdulai *et al*. (2013) found that maize production in northern Gana exhibit increasing return to scale but. The diagnostic statistics of inefficiency component reveals that sigma squared (δ^2) 0.2453 was statistically significant at 1%. This indicates goodness of fit, and the correctness of the distributional form assumed for the composite error term. The ratio of the standard error of $u(\delta u)$ to standard error $v(\delta v)$ known as lambda (λ), was 2.54.Depending on the value of lambda gamma value is derived using the formula $\left(\gamma = \frac{\lambda^2}{1+\lambda^2}\right)$ the gamma (γ) was 86.6%. It also shows that about 86.6% of the variations in output of maize are caused by technical inefficiency. The remaining 13.4% variation was due to random noise that is beyond the control of the farmers.

The dual cost function which was derived analytically from the stochastic production function is given as follows basis for computing allocative and economic efficiency:

$$\ln Cmi = 2.66 + 0.0299\ln w_1 + 0.3195\ln w_2 + 0.0089\ln w_3 + 0.1641\ln w_4 + 0.0775\ln w_5 + 0.0145\ln w_6 + 0.4755\ln Y^*$$

Where $lCmi$ is minimum cost of maize production; w_1 refers to the price of seed per kg, w_2 is cost of land per ha; w_3 is cost of NPS per kg ; w_4 is cost of urea per kg ; w_5 is cost of oxen per day; w_6 is cost of labor per day Y^* is output adjusted for any statistical noise; i^{th} refers to the i^{th} sample household.

4.2.3. Technical, allocative and economic efficiency score

The mean technical efficiency level of 71.65% varies from 30.54% to 93.53% shows that maize producing farmers have an opportunity to efficiently utilize resources and hence they could increase the current maize output by 28.35% using the existing technology. In other words, it implies that on average sample households in the study area can decrease their inputs (seed, land, NPS, urea, oxen and labor) by 28.35 % to get the output they are currently getting. This shows that there is a wide difference among farmers in their level of technical efficiency.

Table 21.Summary statistics of efficiency score of sample households

Variables	Observation	Mean	Std.devation	Min	max
TE	154	0.7165	0.1471	0.3054	0.9353
AE	154	0.7006	0.1297	0.2855	0.9462
EE	154	0.4989	0.1307	0.1856	0.8396

Source: Own computation (2018)

The mean allocative efficiency of farmers in the study area was 70.06% and ranges from 28.53% to 94.62% indicating that on average, maize producer households can save 29.94% of their current cost of inputs if resources are efficiently utilized. This shows that there is enormous opportunity to increase the efficiency of maize producing households by reallocation of resources in cost minimizing way. The most allocative inefficient farmer would have an efficiency gain of 69.82% derived from $(1 - 0.2855 / 0.9462) * 100$ to attain the level of the most allocatively efficient household.

As illustrated in the above table 21, mean economic efficiency level of sample households was 49.89% with minimum and maximum efficiency scores of 18.56% and 83.96% respectively. The mean economic efficiency shows that an economically efficient household can reduce his/her maize production cost by 50.11%.It can also inferred that if households in the study area were to achieve 100% economic efficiency, they would experience substantial production cost saving of 50.11%. This shows that there is a need to improve their level of economic efficiency. The result also implies that if the farmer with an average level of economic efficiency were to reach the level of the most economically efficient household, then he/she could experience a cost saving of 40.55% derived from ($(1-0.4989\ /\ 0.8393)*100$).Likewise, the most economically inefficient farmer would save cost of 77.89% derived from ($(1-0.1856/0.8396)*100$) to attain the level of the most economically efficient farmer.

The mean levels of efficiencies are comparable with the results from other similar studies in Ethiopia. For example, level of efficiency is Sisay *et al.* (2015) obtained technical, allocative and economic efficiency of 62.3, 57.1 and 39% respectively in south-western Ethiopia and Mustefa *et al* (2017) obtained mean technical, allocative and economic efficiencies 81.78%, 37.45% and 30.62% respectively. Also Arega and Rashid (2005) found the mean technical, allocative and economic efficiencies of 68, 83 and 56% respectively for traditional maize producers and 78, 77 and 61% respectively for hybrid maize producing farmers in Eastern Ethiopia. However Geta *et al.* (2013) obtained of low level of average technical efficiency 40% of maize producing farmers in Southern Ethiopia.

4.2.4. Distribution of technical, allocative and economic efficiency scores

Figure 5, 6, and 7 below present distribution results of technical, allocative and economic efficiency scores of sample smallholder farmers in the study areas. In a sense, around 28.6% of the technical efficient farmers were failing on the range of between 70% and 79.99% followed by 26.6% between the range of 80% and 89.99%. Out of the total sample households, only 5.8% have technical efficiency class between 90%-100%. This implies that about 94.2% of the households can increase their production at least by 10% and it suggests that out of total sample household less numbers of the maize producers in the study area are operating close to the frontier.

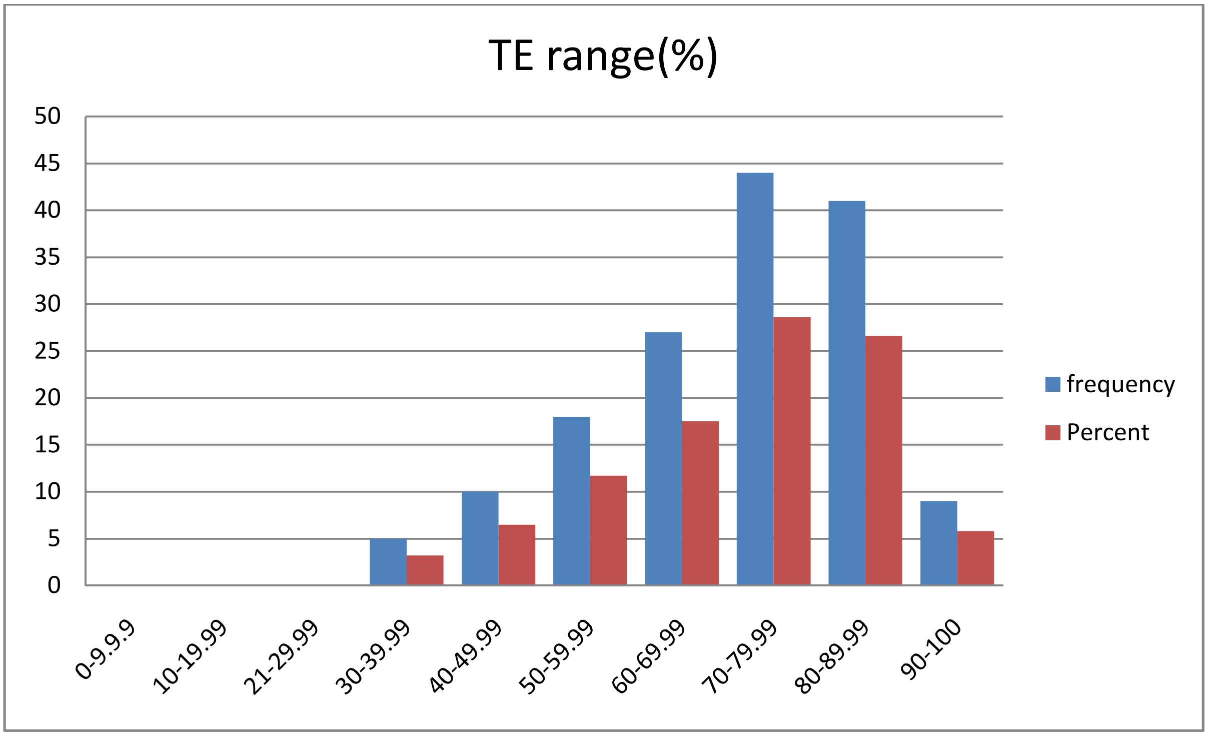

Figure 5.Distribution of technical efficiency scores (%)
Source: Own computation (2018)

The distribution of allocative efficiency revealed that, 44.2% of the sampled maize producers were in the range of between 70%-79.99%. Households in this group can save at least 20% of their current cost of inputs by behaving in a cost minimizing way. Followed by 18.2% range from 60%-69.99%.Only 1.3% of the total sample households had an AE score that ranged between 90% and 100%. This shows that almost maize producing households (98.7%) can at least save 10% of their current input cost by reallocation of resources in cost minimizing way. Additionally 37.01% of sample household attained below the mean allocative efficiency level.

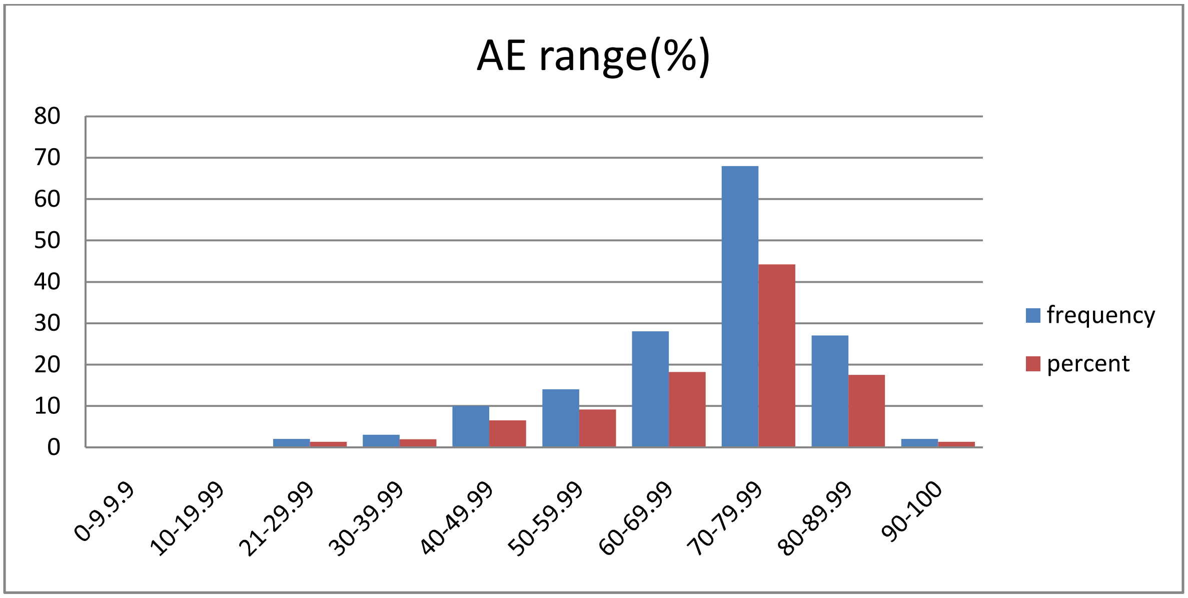

Figure 6.Distribution of allocative efficiency scores (%)
Source: Own computation (2018)

The distribution of EE scores implies that 29.9% of the farmers were performing between ranges of 60%-69.99% efficiency level. Households in this group can save at least 30% of their current cost of inputs by behaving in a cost minimizing way. Followed by 23.4% which ranges from 40%-49.99%.The model result also revealed that, 47.40% of the household farmers skewed to the left of the mean economic efficiency level. The low level of EE was the total effect of both technical and allocative inefficiencies. This also indicates the existence of substantial economic inefficiency in the production of maize during 2017/18 production year.

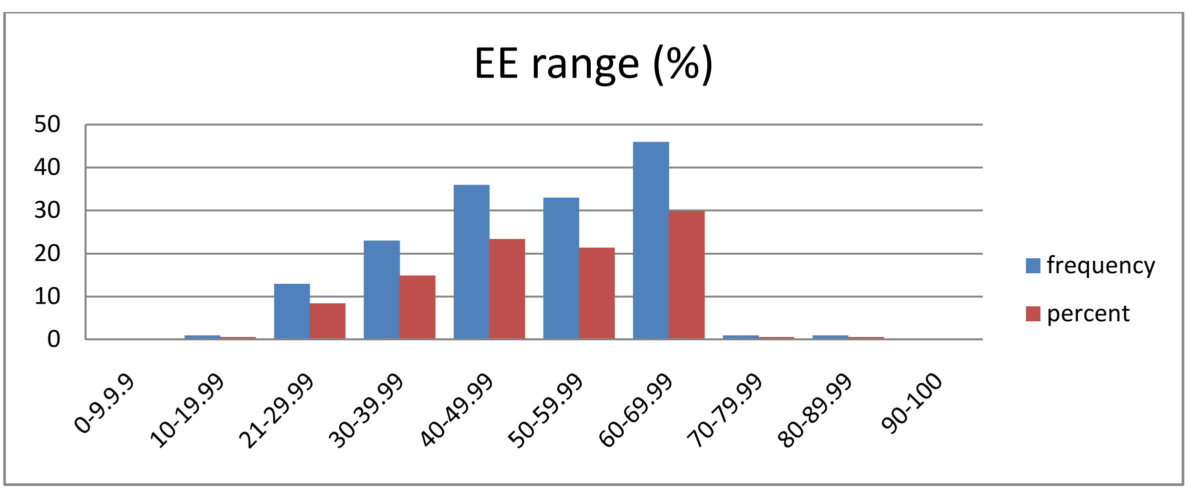

Figure 7.Distribution of economic efficiency scores (%)
Source: Own computation (2018)

4.2.5. Determinants of efficiency in maize production

After measuring levels of farmer efficiency in maize production finding out factors that affect efficiency of the farmers was the next most important step of this study. To see this end, the technical, allocative and economic efficiency estimates derived from the model were regressed on demographic, socioeconomic, institutional factor and farm characteristics variables that affect efficiency of farm households using two limits Tobit regression model (Table 22)

Table 22.Tobit model estimates for determinant of efficiency

	TE		AE		EE	
Variables	Coefficient	Std.Err	Coefficient	Std.Err	Coefficient	Std.Err
Constant	0.42413***	0.06792	0.70755***	0.06397	0.30214***	0.06173
AGEHHD	0.00104	0.00119	-0.00119	0.00114	-0.00040	0.00110
SEX	-0.01633	0.02638	-0.00227	0.02524	-0.00481	0.02437
EDUC	0.01223***	0.00337	-0.00452	0.00321	0.00542*	0.00310
FMSIZE	0.01691**	0.00821	0.00594	0.00792	0.01725**	0.00765
FRMSIZE	0.02556*	0.01335	-0.0047	0.01258	0.01358	0.01213
LIVSTK	-0.00388	0.00324	0.00596*	0.00313	0.00200	0.00301
FERTY	-0.01827	0.02148	0.03369	0.02059	0.01389	0.01988
DISPLOT	-0.00018	0.00100	-0.00207**	0.00096	-0.00164*	0.00092
DISMRKT	0.00663	0.00580	0.00522	0.00560	0.00820	0.00540
EXTEN	0.00435***	0.00113	-0.00105	0.00108	0.00208**	0.00104
CREDIT	0.06890***	0.02221	-0.0003	0.02121	0.04938**	0.02047
OFF/NFRM	0.05107**	0.02253	0.03816*	0.02165	0.05889***	0.02091
Loglikehood	91.95		100.61		105.89	

Note: *, **and *** significant at 10%, 5% and 1% level of significance, respectively

Source: Own computation (2018)

Table 23.The marginal effects of change in explanatory variables

	TE			AE			EE		
Variables	$\frac{\partial E(y)}{\partial X_j}$	$\frac{\partial E(y^*)}{\partial X_j}$	$\frac{\partial(\phi(Z_U - Z_L)}{\partial X_j}$	$\frac{\partial E(y)}{\partial X_j}$	$\frac{\partial E(y^*)}{\partial X_j}$	$\frac{\partial(\phi(Z_U - Z_L)}{\partial X_j}$	$\frac{\partial E(y)}{\partial X_j}$	$\frac{\partial E(y^*)}{\partial X_j}$	$\frac{\partial(\phi(Z_U - Z_L)}{\partial X_j}$
AGEHHD	0.00099	0.0008	0.00076	-0.00116	-0.00105	-0.00051	-0.00040	-0.00038	-0.00002
SEX	-0.01550	-0.01309	-0.01266	-0.00222	-0.00200	-0.00099	-0.00479	-0.00457	-0.00020
EDUC	0.01165	0.00991	0.00887	-0.00441	-0.00398	-0.00195	0.00539	0.00515	0.00025
FMSIZE	0.01611	0.01370	0.01226	0.00580	0.00523	0.00257	0.01714	0.01638	0.00082
FRMSIZE	0.02436	0.02071	0.01854	-0.00463	-0.00418	-0.00205	0.013503	0.01290	0.00065
LIVSTK	-0.00369	-0.00314	-0.00281	0.00582	0.00526	0.00258	0.00198	0.00190	0.00009
FERTY	-0.01743	-0.01485	-0.01297	0.03284	0.02953	0.01549	0.01381	0.01319	0.00060
DISPLOT	-0.00017	-0.00015	-0.00013	-0.00202	-0.00182	-0.00089	-0.00163	-0.00156	-0.00008
DISMRKT	0.00632	0.00537	0.00481	0.00510	0.00460	0.00225	0.00815	0.00779	0.00039
EXTEN	0.00415	0.00353	0.00316	-0.00102	-0.00092	-0.00045	0.00206	0.00197	0.00009
CREDIT	0.06597	0.05667	0.04453	-0.00030	-0.00027	-0.00013	0.04905	0.04673	0.00368
OFF/NFRM	0.04867	0.04144	0.03657	0.03728	0.03368	0.01634	0.05850	0.05577	0.00337

Note: Those computed marginal effects are $\frac{\partial E(y)}{\partial X_j}$ (total change), $\frac{\partial E(y^*)}{\partial X_j}$ (Expected change) and $\frac{\partial(\phi(Z_U - Z_L)}{\partial X_j}$ (Change in probability) for their respective significant coefficient of determinant are discussed in this study.

The Tobit model estimates and the respective marginal effects are provided in tables 22 and 23 respectively. The estimates of Tobit model showed that among the 12 total variables entered in the model, variables namely education level, family size, farm size, frequency of extension contacts, distance of maize plot from the home, livestock holding, credit and participation in off/non-farm activities were found to be statistically significant factors affecting the level of efficiency of smallholder farmers in maize production in the study area. The discussions about the significant variables are given below:

Education level: As expected, the sign of education was positive effect on TE and EE at 1% and 10% level of significance. This implies that more educated farmers are more technically and economically efficient than those who have relatively less education. This could be because; educated farmers have the ability to use information from various sources and can apply the new information on their farm that would increase outputs of maize. In general, more educated farmers were capable to identify, interpret and react to new information and improves their knowledge and managerial skill. Moreover, a one year increase in educational level of the household head increases the probability of the farmer being technically and economically efficient by 0.89% and 0.025% and change in the expected value of TE and EE by 0.99% and 0.51% with an overall increase in the probability and levels of TE and EE by 1.17 and 0.54% respectively. This result was consistent with the research done by Mburu *et al*. (2014) in Kenya, Emmanuel and Isaac (2014) in Zambia and Mustefa *et al. (*2017) in southwestern part of Ethiopia.

Family size: The coefficient of family size on both TE and EE is positive and statistically significant at 5% 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, because family labor is the main input in crop production as the farmer has large family size would manage crop plots on time and may able to use appropriate input combinations by using their own labor. Hence the farmers who had more available labor were better managers; therefore, they produced closer to their production frontier. Moreover, the computed marginal effect of family size showed that a one person change in the number of family in man equivalent would increase the probability of farmer being technically and economically efficient by 1.22 and 0.08% and change the expected value of TE and EE by 1.37%, and 1.64% with an overall increase in the probability and the level of efficiencies by 1.61 and 1.71%, respectively. This result is similar with the findings of (Sorsie *et al*., 2015; Tefaye and Beshir, 2014).

Farm size: The coefficient of farm size had positive relation with technical efficiency at 10% level of significance. Unexpectedly, the estimated result does not agree with the expectation. The link between efficiency and farm size has been the subject of much debate in the literature. Small farm size to have a positive impact on crop level efficiency because of its simplicity in management compared to the large farm size was reported by Lemessa, *et al*., 2017 in Ethiopia; Sisay *et al.,* 2015 in South-western Ethiopia and Omojola *et al*., 2014 in Nigeria.. On the other hand, Geta *et al.* (2013) found a positive relationship between these two variables because large land holding farmers are more likely to employ modern agricultural practices and hence could be more efficient due to its advantage of the economic scale associated with large farm size. This is mainly justified on the view that those farmers with large farm size can better diversify their crops and the better chance for maize to be planted on fertile soils and have the capacity to use compatible technologies that could increase the efficiency of the farmer. As a result, with increase farm size the technical efficiency of the farmer might increase. Moreover, a unit change in farm size would result in 1.85% change in the probability of a farmer being technically efficient and the expected value of TE by 2.07% with an overall increase in the probability and the level of efficiency by 2.44%. This finding was in line with results obtained by (Rao and Bealu, 2015; Gosa and Jema, 2016; Wudineh and Endrias, 2016).

Livestock holding: The coefficient for livestock holding (TLU) was positive and had a significant influence on AE at 10% level. The result reveal that having largest number of livestock holding helps to shifts cash constraint, provide manure and to satisfy all needs of farmers in the study area. Each unit increase in the value of TLU would increase the probability of a farmer being allocatively by 0.26% and the expected value of AE by about 0.53% with an overall increase in the probability and the level of efficiencies by 0.58%. This finding was consistent with the result obtained by (Getachew, 2017; Kifle, 2017).

Distance of maize plot from home: The coefficient distance of maize plot from farm household is negative and significant at 5% and 10% levels of significance on both AE and EE respectively. This relation may be because farmers living near the production site follow up whole day their maize plot that enables to better manage farms and save time of work which leads to better achievement of their efficiency. While, those farms plot far away from household residence will receive less management and the frequency of visits may reduce. This implies that as the distance of the plot from home increases the allocative and economic efficiency decreases. Unit change distance of plot from home would decrease the probability of a farmer being allocatively and economically efficient by 0.09 and 0.008% and the expected value of AE and EE decrease by 0.18 and 0.16% with an overall decrease in the probability and the level of efficiencies by 0.2 and 0.16%respectively. This is in line with (Ermias *et al*., 2015; kinde, 2005).

Frequency of extension contact: As expected the coefficient of frequency of extension contact was positive and significantly affected the level of technical and economic efficiencies at 1% and 5% level of significance respectively. Extension services are assumed to help in dissemination and adoption of new technologies. In addition, this extension services offer guidance to the farmers related to the use of various resources such as fertilizer and provide consultancy services in managing their scarce resources more efficiently. Each increase in the frequency of extension contact would increase the probability of a farmers being technically and economically efficient by 0.32 and 0.009% and the expected value of TE and EE by about 0.35 and 0.19% with an overall increase in the probability and the expected level of efficiencies by 0.42 and 0.2%, respectively. Abdulai*, et al. (*2013) found similar result in northern Ghana .This result is also consistent with research done by Hailemaraim (2015) and Musa (2013).

Credit use: The result also indicated that credit used had a positive sign and statistically significant effect on both TE and EE level at 1% and 5% level of significance. This suggests that on average households who use credit tend to exhibit higher levels of efficiency. This due to the reason that use of credit allows a household to enhance efficiency by removing money constraints which may affect their ability to apply inputs, implements farm management decisions on time.

Moreover, a change in the dummy variable representing the uses credit by the household ordered from 0 to 1 would increase the probability of the farmers being technically and economically efficient by about 4.45 and 0.37% and change the expected value of TE and EE by about 5.67 and 4.67% with an overall increase in the probability and the level of efficiencies by 6.59 and 4.9%, respectively. Hassen (2016) also found positive relationship between credit and efficiency of smallholder farmers in wheat production in South Wollo. Etim and Okon (2013) found similar result a positive relationship between credit and efficiency in maize farmers in Nigeria.

Participation in off/non-farm activities: In this study the coefficient of participation in off/non-farm activity was positive sign and statistically significant at 5%, 10% and 1% level of significance effect with respect to TE, AE, and EE respectively as expected. The reason is the income obtained from such activities could be used for the purchase of agricultural inputs and supplement financing of household expenditures which they cannot provide from the farm income hence increases their efficiency. Moreover, a change in the dummy variable representing the participation in off/non-farm activities by the household ordered from 0 to 1 would increase the probability of the farmers being technically, allocatively and economically efficient by 3.66, 1.63 and 0.34% and change the expected value of TE, AE and EE by about 4.14, 3.37 and 5.58% with an overall increase in the probability and the level of efficiencies by 4.87, 3.73 and 5.85%, respectively. This result is in line with the findings of (Kifle, 2017; Gizachew, 2018).Jema (2008) also found a positive relationship between off/non-farm and technical efficiency.

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

The difference between actual agricultural production and potential for increasing its productivity still persists in Ethiopia. To address this, it needs boosting of agricultural productivity and improves living standard of farmers either through use of modern inputs technology or decreasing the present level of inefficiency. Thus it is possible raise productivity through improving efficiency by using existing resource base and available technology. Thus this study was conducted to analyze technical, allocative and economic efficiencies and identifies factors that affect efficiency of smallholder maize producers in Gudeya Bila district, Oromia National Regional State, Ethiopia.

In this study, two stage random sampling procedure was used to select sample of 154 maize producer households for survey that represent total population. Both primary and secondary data were used. Primary data source were collected using structured questionnaire and focus group discussion. To support the primary data, secondary data from different sources were collected. Data analysis was carried out using descriptive statistics and econometric models. The Cobb-Douglas stochastic frontier model was used to estimate the production and cost functions. The estimated stochastic production frontier model indicated that three input land, seed, and labor were significant and positive determinants of production level of maize in the study area. The positive coefficient of these parameters indicated that increased use of these inputs would increase the production level to greater amount.

The stochastic frontier production function and self-dual cost function indicates that the average TE, AE and EE value of the sample households was 71.65%, 70.06% and 49.89% respectively. According to the Tobit regression model result education level of household head, family size, uses of credit, frequency of extension contacts, and participation in off/non-farm activities had positive significant effect on TE as expected. However coefficient of farm size is positive but not as expected. AE ability to use least cost combination of inputs to produce a given output was affected by livestock holding, participation in off/non-farm activities positively and significantly and negatively affected by distance of maize plot from home as expected. Finally, Education level, family size, credit uses, frequency of extension contact, and participation in off/non-farm activities had positive and significant effect on EE as expected and negatively affected by distance of maize plot from the home as expected. These factors have important policy implications in that to mitigate the existing level of inefficiency of households in the maize production and development programs should act upon these variables.

5.2. Conclusion

The main conclusion stemming from the analysis of the efficiency of maize production is that, maize producers in the study area are not operating at full TE, AE and EE levels and there exists the room to improve the level of technical, allocative and economic efficiency of maize producers in the study area. The implication is that, there will be substantial gain in increment in level of production or reduction in cost of production if continuing in efficiency of farmers for some time until the level of efficiency and productivity increases to sufficiently higher levels. Thus, the results of the study give information to policy makers on how to enhance efficiency level of maize producer household and specific determinant identified.

5.2. Recommendations

Given the importance of maize and the observed considerable room to improve the level of technical, allocative and economic efficiency of maize producers the following recommendations are drawn:

The result of the analysis showed that maize producers in the study area are not operating at full technical, allocative and economic efficiencies levels. Therefore intervention aiming to improve efficiency of farmers in the study area has to give due attention for resource allocation and utilization of resources in line with output maximization as there is big opportunities to increase output without additional technology.

The study results also revealed that there is a considerable variability in all efficiencies score of sample household in the production of maize in the study area. Therefore less efficient farmers increase their efficiency level by adopting the practices of relatively efficient farmers in the area.

Education level of household heads, measured in years of schooling affects technical and economic efficiency of maize farmer households positively. This indicates that education is fundamental in improving the technical and economic efficiency thereby increasing the performance of households. Hence, government and NGOs should have designed appropriate policy to provide adequate and effective basic educational opportunities to the rural population both formal and non-formal education, farmers training centers as farmer education and know how about the application of inputs and different farming system in the study area is seems crucial.

Family size (labor availability) positively and significantly affected technical and economic efficiencies of maize producer households. The result suggests that policy and strategy makers should encourage availability of labor force before introducing such labor intensive technology in the study area.

Given the mixed farming system in the study area, farmers with more number of livestock were relatively better in the allocative efficiency. Hence, there is a need to design appropriate policy and strategies for improving livestock production systems by solving the shortage of feed and health services which in turn will enhance the efficiency. As information obtained from FGD mixing of urea with straw started recently in the study area as additional source of feed to increase productivity of livestock so it should be encouraged and supported by livestock office that in turn increases efficiency of farmers.

The result of the study indicated that, frequency of extension contact of farmers with extension agents was the significant variable and had a positively effect on TE and EE level. Since, development agents had a crucial role to disseminate new production information, technologies and inputs from the research field to the actual farmers ground. Therefore, government and NGOs should have to intensify extension agents through providing practical attachment training with the current agricultural production so as to enhance the efficiency level. The other possible way is different agricultural technical vocational education and training colleges should specialize development agent by specific crop since it may be difficult to development agent to give advice for all crops at one specific production season. Other way may be as much as possible increases ratio of development agents to the number of farmers so as to increase the number of extensions contact.

This study provides evidence on the role of credit utilization in improving technical and economic efficiency positively through reducing financial constraints farmers face in purchasing inputs in maize production. Therefore, government should have to establish adequate rural finance institutions at affordable interest rate and facilitating the available micro-finance institutions such OCSSCO and Wasasa to assist farmers in terms of financial support is crucial to improve farmer's efficiency. Since most farmers fear the risk of repayment due to what they are planning to repay may be destroyed by climate change or other so that factor government and concerned bodies should have to create awareness on micro finance institution and training on loan repayment.

The study offers significantly and positive relationship between participation in off/non-farm activities and technical, allocative and economic efficiencies. This indicates that, rural development strategies should not only emphasize on increasing agricultural production but simultaneous attention should be given to promote off/non-farm activities and work diversification in the rural areas regarding to off/non-farm activities. There is also need for the government organizations to train farmers on off/non-farm entrepreneurship, so that they can earn profits from off/non-farm income generating activities through which they will acquire the needed farming capital thus helps to increase efficiency in maize production.

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7. APPENDICES

Appendix 1. Conversion factors for man equivalent and adult equivalent

Age group(year)	Man equivalent		Adult equivalent	
<10	0	0	0.6	0.6
10-13	0.2	0.2	0.9	0.8
14-16	0.5	0.4	1	0.75
17-50	1	0.8	1	0.75
>50	0.7	0.5	1	0.7

Source: Storck, *et al.1991*

Appendix2. Conversion factors used to estimate tropical livestock unit equivalents.

Animal category	TLU
Calf	0.25
Weaned Calf	0.34
Heifer	0.75
Steer(young bull)	0.80
Donkey (Young)	0.35
Donkey (adult)	0.7
Sheep and Goat (adult)	0.13
Sheep and Goat young	0.06
Caw and Ox	1
Mule/horse	1.1
Chicken	0.013

Source: Storck, *et al*., 1991

Appendix3.Technical efficiency score of the sample households

FI	TE	FI	TE	FI	TE	FI	TE	FI	TE
1	0.752942	36	0.840946	71	0.448358	106	0.846598	141	0.725886
2	0.794916	37	0.752926	72	0.710297	107	0.615613	142	0.524036
3	0.46697	38	0.792122	73	0.639746	108	0.529985	143	0.893343
4	0.645325	39	0.752384	74	0.852317	109	0.918592	144	0.680106
5	0.764643	40	0.822809	75	0.761192	110	0.708525	145	0.642821
6	0.702717	41	0.731083	76	0.391696	111	0.73817	146	0.826744
7	0.772344	42	0.681821	77	0.784936	112	0.712139	147	0.87286
8	0.773826	43	0.88365	78	0.65303	113	0.715037	148	0.465675
9	0.771504	44	0.816995	79	0.560686	114	0.856968	149	0.439697
10	0.838983	45	0.881128	80	0.625524	115	0.894692	150	0.414228
11	0.692093	46	0.86114	81	0.725426	116	0.733426	151	0.650112
12	0.638377	47	0.650559	82	0.516721	117	0.881893	152	0.813728
13	0.762465	48	0.629669	83	0.505958	118	0.379338	153	0.791225
14	0.905837	49	0.618478	84	0.891204	119	0.665877	154	0.563844
15	0.848505	50	0.630093	85	0.835592	120	0.305481		
16	0.632285	51	0.785262	86	0.753212	121	0.849769		
17	0.598746	52	0.615217	87	0.801148	122	0.38492		
18	0.792341	53	0.701818	88	0.608365	123	0.791813		
19	0.86535	54	0.70227	89	0.562652	124	0.783236		
20	0.869975	55	0.877923	90	0.531477	125	0.486335		
21	0.915278	56	0.558062	91	0.907505	126	0.643197		
22	0.680377	57	0.531054	92	0.91126	127	0.506405		
23	0.66395	58	0.697136	93	0.855341	128	0.697134		
24	0.88791	59	0.535865	94	0.731862	129	0.597303		
25	0.690472	60	0.616337	95	0.785409	130	0.411766		
26	0.924389	61	0.874529	96	0.813132	131	0.935346		
27	0.860244	62	0.764951	97	0.789501	132	0.716557		
28	0.904463	63	0.485188	98	0.866116	133	0.533031		
29	0.886851	64	0.49811	99	0.892493	134	0.305613		
30	0.87851	65	0.79189	100	0.902144	135	0.71803		
31	0.787264	66	0.709181	101	0.894717	136	0.462503		
32	0.806793	67	0.707327	102	0.781776	137	0.852579		
33	0.676701	68	0.896382	103	0.51071	138	0.593902		
34	0.783372	69	0.887448	104	0.789564	139	0.828033		
35	0.816272	70	0.782069	105	0.599705	140	0.830845		

FI=Farmers identification

Appendix4.Allocative efficiency score of the sample households

FI	AE	FI	AE	FI	AE	FI	AE	FI	AE
1	0.79624	36	0.680946	71	0.762595	106	0.778562	141	0.599784
2	0.316697	37	0.852815	72	0.785813	107	0.821669	142	0.354218
3	0.461561	38	0.782214	73	0.771752	108	0.841433	143	0.76625
4	0.675503	39	0.797579	74	0.618312	109	0.676671	144	0.63927
5	0.63368	40	0.742445	75	0.671371	110	0.783675	145	0.617275
6	0.716197	41	0.815318	76	0.853205	111	0.768951	146	0.726062
7	0.44269	42	0.787683	77	0.579145	112	0.772795	147	0.517677
8	0.41566	43	0.747622	78	0.705158	113	0.775767	148	0.765026
9	0.624224	44	0.521728	79	0.794416	114	0.751658	149	0.738434
10	0.331482	45	0.771327	80	0.770499	115	0.72361	150	0.755936
11	0.710848	46	0.662099	81	0.741582	116	0.807662	151	0.683805
12	0.561537	47	0.829007	82	0.800034	117	0.728878	152	0.657537
13	0.552965	48	0.799053	83	0.553488	118	0.919863	153	0.587308
14	0.769546	49	0.801576	84	0.695397	119	0.803581	154	0.756236
15	0.719589	50	0.816937	85	0.748463	120	0.880809		
16	0.473566	51	0.769088	86	0.805634	121	0.755482		
17	0.67538	52	0.816469	87	0.413265	122	0.82607		
18	0.644255	53	0.675531	88	0.818174	123	0.78778		
19	0.566203	54	0.848956	89	0.817243	124	0.756099		
20	0.285531	55	0.747376	90	0.809524	125	0.872534		
21	0.446603	56	0.781058	91	0.745029	126	0.690519		
22	0.437224	57	0.841479	92	0.72562	127	0.696234		
23	0.544214	58	0.797592	93	0.732894	128	0.757568		
24	0.94564	59	0.714004	94	0.780426	129	0.647679		
25	0.561549	60	0.647098	95	0.77015	130	0.675955		
26	0.635163	61	0.712477	96	0.764512	131	0.722738		
27	0.704437	62	0.634383	97	0.780611	132	0.64642		
28	0.68976	63	0.806168	98	0.725835	133	0.420581		
29	0.708041	64	0.709838	99	0.760802	134	0.677912		
30	0.715174	65	0.817286	100	0.764412	135	0.530273		
31	0.781756	66	0.585358	101	0.720316	136	0.662934		
32	0.772903	67	0.746293	102	0.792719	137	0.824973		
33	0.831392	68	0.674189	103	0.851375	138	0.419246		
34	0.794846	69	0.581765	104	0.775129	139	0.299785		
35	0.743462	70	0.76377	105	0.807753	140	0.456207		

FI: Farmers identification

Appendix5.Economic efficiency score of the sample households

FI	EE	FI	EE	FI	EE	FI	EE	FI	EE
1	0.599523	36	0.572639	71	0.341916	106	0.659129	141	0.435375
2	0.251747	37	0.642106	72	0.558161	107	0.50583	142	0.185623
3	0.215535	38	0.619609	73	0.493725	108	0.445947	143	0.684524
4	0.435918	39	0.600086	74	0.526998	109	0.621584	144	0.434771
5	0.484539	40	0.61089	75	0.511042	110	0.555253	145	0.396797
6	0.503284	41	0.596065	76	0.334197	111	0.567616	146	0.600268
7	0.341909	42	0.537059	77	0.454591	112	0.550337	147	0.45186
8	0.321648	43	0.660637	78	0.460489	113	0.554702	148	0.356253
9	0.481592	44	0.426249	79	0.445418	114	0.644146	149	0.324688
10	0.278108	45	0.679638	80	0.481965	115	0.647408	150	0.31313
11	0.491973	46	0.57016	81	0.537963	116	0.59236	151	0.44455
12	0.358472	47	0.539318	82	0.413395	117	0.642793	152	0.535056
13	0.421616	48	0.503139	83	0.280042	118	0.348939	153	0.464692
14	0.697083	49	0.495757	84	0.619741	119	0.535086	154	0.426399
15	0.610575	50	0.514746	85	0.62541	120	0.269071		
16	0.299429	51	0.603936	86	0.606813	121	0.641986		
17	0.404381	52	0.502305	87	0.331087	122	0.317971		
18	0.510469	53	0.4741	88	0.497748	123	0.623775		
19	0.489964	54	0.596196	89	0.459824	124	0.592204		
20	0.248405	55	0.656139	90	0.430244	125	0.424344		
21	0.408766	56	0.435879	91	0.676118	126	0.44414		
22	0.297477	57	0.446871	92	0.661228	127	0.352576		
23	0.361331	58	0.55603	93	0.626875	128	0.528126		
24	0.839643	59	0.38261	94	0.571165	129	0.386861		
25	0.387734	60	0.39883	95	0.604882	130	0.278335		
26	0.587137	61	0.623082	96	0.621649	131	0.67601		
27	0.605988	62	0.485272	97	0.616293	132	0.463196		
28	0.623862	63	0.391143	98	0.628658	133	0.224183		
29	0.627927	64	0.353577	99	0.67901	134	0.207179		
30	0.628287	65	0.6472	100	0.68961	135	0.380752		
31	0.615449	66	0.415125	101	0.64448	136	0.306609		
32	0.623572	67	0.527873	102	0.619729	137	0.703355		
33	0.562603	68	0.604331	103	0.434806	138	0.248991		
34	0.62266	69	0.516286	104	0.612014	139	0.248232		
35	0.606868	70	0.597321	105	0.484414	140	0.379037		

FI: Farmers identification

Questionnaire used for the survey

Questionnaire used for the survey entitled "Economic Efficiency of Maize Production: The Case of Smallholder Farmers in Gudeya Bila district, Oromia Regional state, Ethiopia"

The purpose of this questionnaire is to collect first hand data that will help to write my MSc thesis work. I am requesting your kind cooperation and patience in providing accurate and reliable responses for the questions. Your response is anonymous, completely confidential, and statistical information will be generated and reported in the study results. I would like to appreciate your courage and kind responses.

Prepared by: Tolesa Tesema (MSc. Student, Jimma University)

General Instruction for Enumerators:

1. Please first introduce yourself before starting the interview.
2. Inform the rationale of the study.
3. For all closed questions used circle and use the space for open questions.
4. This questionnaire is intended to cover 2017/18 cropping season.

Make sure that all questions are being asked and correctly filled before finishing each interview.

Name of the enumerator______________________________

Signature ______________________________ date__________________

(To be filled by the researcher)

Questionnaire number

/______/_____/_______/______

A: General Household Characteristics

1. Name of household head___ phone numbers __Kebele____ Age of household head_________

2. Sex: 1 male (M) _____ 0. Female (F) _____

3. Marital status: 1 Married ____ 2.Not married (Single)___3.Divorced ____ 4.Widowed___

4, Years of Education level of the household head __________ (Years completed):________

5. Family size and Structures

	Name of household member	Sex		Age	**Education**al level	**Health** conditions
		M	F			
1						
2						
3						
4						
5						
6						
7						
8						
9						

Health Code: 0 = sick; 1 = healthy

6. Maize farming experience ___________ (in year)

7. Main occupation of the household head: 1. Farmer 2.Civil servant 3. Other, specify

8. What is the criterion for assigning wealth status of people in your area? 1. Livestock 2. Money 3.Land 4. Corrugate iron house 5. Grain yield 6. Other, specify______

9. With the above criteria which group are you? 1. Rich 2. Medium 3. Poor

10. Is there any informal or formal social institution in your locality? Yes__1__ No__2__

11. If yes, mention the major social institution 1.Input supply cooperative/union 2.Local administration 3. Idir 4.Equb 5.Saving and credit association 6. Other, specify____

12. Do you participate in social institutions? Yes___1___ No__2___

13 if not participated why? ____

14. Asset ownership of the household and their value

Description	Number if you have	Current price	Remark
iron house			
Grass roofed house			
Others			

B. information on agricultural production and productivity

I. Main crops grown, area covered and input use

1. Please complete the table for five major crops for 2017/2018 cropping season.

Crop	Crop Code	Variety Variety (1=Improved 0=Local)	Total amount and cost of seeds			Source of seed	Area in Ha	Fertilizer				Other chemicals/inputs			
								NPS in kg		urea in kg					
			Amount in Kg	cost per unit	Types of improved seed			Amount	Cost per unit	amount	Cost per unit	Input Type	Amount	Unit code	cost per unit

Source (1=Store from previous harvest 2=Local market 3=from farmer cooperative 4=from private person 5. Other, specify____________

Types of improved seed (1=BH 661 2= limmu 3= Shone4=BH-660 5=BH-543 7= BH-5408= Gibe-1 9.Other/specify____________)

Unit code: 1=Kilogram, 2=Quintal, 3=Liter, 4=hectare, 5=number, 6=*tasa*, 7=qunna, 8=*kubbayya*,

Other input/chemical type code: 1=Organic Fertilizer 3=Pesticides; 4=insecticide; 5= herbicides; 7=other (Specify)

Crop code: 1 =Maize, 2=Wheat, 3= Teff, 4=Barley, 5=sorghum, 6=Niger seed, 7=bean, 8=other

2 .Major Crop output and use and income 2017/18: please use above code

name	code	**Variety** 1=improved 0=local	Estimated quantity(output) of all 2017/18 harvests in quintals	Quantity consumed at home in quintals in a year	Quantity sold out in quintals		Quantity used for seed in quintals	Quantity used for animal feed in quintal	Quantity given out as gifts or as payments in-kind	Quantity currently in store in quintal
					Qty	Unit Price				

3. Farm implements used by household head

Description	Number	Unit price	Total price
Ox-plough			
Hoe			
Sickle			
Axe			

II.Information on livestock

1. Did you have livestock? 1. Yes 2. No

2. If yes to question number 3 please fill the following Table.

Livestock	code	Breed (variety)		amount (2017/2018)	Sales (2017)		Purchases (2017)		Consumed by household	Given-away *(No)*	Receipt *(No)*	Death ** *(No)*
		Local (0)	Improved (1)		No	Value	No	Value				
Cattle												
Cow	01											
Heifer (young cow	02											
Calve	03											
Steer (young male)	04											
Ox	05											
Bull	06											
Small Ruminants												
Goat(young	07											
Goat adult)	08											
Sheep(young/	09											
Sheep adult)	10											
Donkey(young	11											
Donkey(adult)	12											
Mule	13											
Horse	14											
Chicken	15											
Beehive (No)	16											
Causes of death: 1 – animal diseases; 2 – fell in gorge; 3 – lack/insufficient grazing land; 4 – lack of water; 5 – leech; 6 – theft												

3. Income from livestock product

Livestock product	Amount (average) produced per month		Number of months produced in 2017	Amount Sold per month		Unit price	Number of months sold	Amount (average) consumed/used per month	
	Qty	Unit		Qty	Unit			Qty	Unit
Milk									
Meat/beef									
Skin/hide									
Egg									
Honey									
Butter									

Unit code: 1=Kilogram, 2=Quintal, 3=Liter, 4=hectare, 5=number, 6=*tasa*, 7=qunna, 8=*sini*,9=*kubbayya*, 10=feresulla, 11=grams,

C: Input and output Information during 2017/18 Cropping Season.

I.land use pattern and output information

1. Please fill space bellows for your land use pattern what you have?

Total area of land _________ (timad (olmaa)Cultivated land____(timad (olmaa))

Grazing land_______(timad (olmaa)) Homestead land_____timad(olmaa)

2, What was the motive for start ploughing maize? 1, Income generation 2, home consumption 3, employment 4, pastime 5, other

3. How much quintal of maize did you obtained last year? _______(quintal)

4. How is this year output as compared to previous year's output? 1. Worst 2. Some 3. Better

5. Estimate land used for maize cropping

No of plot	The type of land used for maize production 2017/2018(R*)	Area in timad (olmaa)	Slopes of land(**S***)	Fertility status(**T***)	Soil types(**U***)	Distance from house in minute

R*(1, owned 2, Share land 3, rented land from others 4, Land obtained by other means)

S* (1, flat, 2, medium, 3.steep) **T***(1. Fertile 2.medium 3.infertile),

9. Do you involved in share cropping and land rent? Yes __1__ No __2__

10. If yes, what is the size and of land?

3.1. Rented in land ___timad (olmaa) 3.2. Rented out land_____timad (olmaa)

3.3. Share land_____timad (olmaa) 3.4. Share out land_____timad (olmaa)

11. If the land is rented in, how much did you pay per timad? _______birr

12. If the land is rented out, what is the price per (timad)? _______ (birr)

III. Oxen power used

1. What is the primary source of draft power you use? 1. Oxen 2. Other, specify_____________

2. Do you have oxen? ____1___Yes ___2___No

3. If yes, how many oxen do you have? ______________

4. What types of oxen were used for maize cropping? 1. Owen__ 2. Shared __3. Leased __4. Other specify__________

5. How many pairs of oxen were used for maize cropping activities? (Fill table below)

Types of activities	Total pair of oxen used
1st Ploughing	
2nd Ploughing	
3rd Ploughing	
4th Ploughing	
5th Ploughing	
Planting	
Fertilizer application	

6. If any oxen rented amount paid per day (for eight working hours)____________

7. If there is exchange ox to labor, what is the ratio? 1. Equal 2. One to two 4. Others specify___

8. If there is any land to labor exchange, what is the proportion of land to labor?

9. If there are any oxen to land exchange, what is the proportion of oxen to land? _______

VI. Information on labor used

1. The types of labor used for the production of maize during the current farming season? 1 Family labor2. . Hired labor 3. Exchange

2. Is there any labor constraint Yes _____1_____ No _____2_____

3. If yes, how do you overcome labor shortage? 1. Hired 2. Exchange labor 3.Both 4. Other

4. If you overcome by hired labour, indicate the payment made to labour in 2017/18 (for 8 working hour)? _____ Birr

5. Estimate the number of labor force you used for maize cropping for each activity with their respective age categories (fill table 5.1, 5.2 and 5.3 below)

5.1 Family labor used for maize production

Types of activities	Total household labor used in maize production							
	Total male labour used				Total female labour			
	10-13	14 -16	17-50	>50	10-13	14 -16	17-50	>50
Land preparation								
1st Ploughing								
2nd Ploughing								
3rd Ploughing								
4th Ploughing								
5th Ploughing								
Planting								
Fertilizer application								
Weeding and cultivation								
Harvesting								
Threshing								
Transporting								

- ✓ 10-13, 14 -16, 17-50, >50 (shows age category)

5.2. Exchange labor used for maize production (if you used)

Types of activities	Total exchange labor used in maize production							
	Total male labour used				Total female labour			
	10-13	14 -16	17-50	>50	10-13	14 -16	17-50	>50
Land preparation								
1st Ploughing								
2nd Ploughing								
3rd Ploughing								
4th Ploughing								
5th Ploughing								
Planting								
Fertilizer application								
Weeding and cultivation								
Harvesting								
Threshing								
Transporting								

- ✓ 10-13, 14 -16, 17-50, >50 (shows age category)

5.3. Hired labor used for maize production (if you used)

Types of activities	Total hired labor used in maize production							
	Total male labour used				Total female labour			
	10-13	14 -16	17-50	>50	10-13	14 -16	17-50	>50
Land preparation								
1st Ploughing								
2nd Ploughing								
3rd Ploughing								
4th Ploughing								
5th Ploughing								
Planting								
Fertilizer application								
Weeding and cultivation								
Harvesting								
Threshing								
Transporting								

- ✓ 10-13, 14 -16, 17-50, >50 (shows age category)

D. Information on Institutional Characteristics

I. Market, Extension and Information accesses.

1. Do you have easy access to market for maize production? Yes __1__ No __2__
2. How distant is the closest market to you? ________________________ Hours (km)
3. Do you have all weather roads to the market? Yes __1___ No __2__
4. Do you have transportation facilities to the market? Yes __1__ No __2__
5. Do you have market agent selling of your maize production? Yes __1__No __2__
6. If yes to whom do you sell 1.Wholesalers 2. Retailers 3. Consumers 4. Cooperatives 5 Farmers
   6. Collectors 7.Middleman 8. Other/specify______
7. What is the selling price one quintal maize at harvesting time __and slack period____in birr?
8. Do you believe that the current market price for maize is fair (good)? Yes __1__2. __No__
9. If no, what are the major reasons? 1. Low price (below average) 2.Fluctuation 3.Others,
10. How is the price for your maize product decided in the market? 1. Farmer 2.Traders 3.Both
11. Do you use agricultural extension services (DA)? Yes __1___ No__ 2____

12. If yes to question above how many days is the number of extension visit during the 2017/2018 maize production year________ (day)
13. How frequent is the extension agent visit you? twice in a week __1__ once in a week __2__Once in two weeks __3__ Once in a month __4__Once in a quarter __5__ Once in 6 months __6__Once in a year __ 7__
14. How do you rate the services provided by extension agent Poor _1_Average _2__Good _3__Very good __4__
15. Is the extension services provided sufficient Yes __1___ No__ 2___
16. Do you have access to farmer to farmer Extension services Yes__1__ No__2__
17. Do you have clear market information about your products? Yes __1__ No __2__
18. If the answer is YES, what types of information do you get1.Price of maize products 2. Quantities of products supplied 3. Level of demand for our products 4.other specify
19. Do you have radio? Yes ___1____ No___ 2___
20. Do you have TV? Yes ___1____ No___ 2___
21. What type of information do you get through radio and TV? 1. Weather Condition 2. Maize product prices 3. Input prices 4. Disaster Others_ 5______________________
22. If you do not have any of the above information sources; can you use from your neighbor? Yes ___1___. No ____2____
23. Distance of your home from framer straining center_______ hour (km)
24. Distance of your home from cooperative office _________ hour (km)
25. Distance of your home from School _______________ hour (km)
26. Distance of your home from DA office _______________ hour (km)

II. Credit utilization

1. Have you got credit in 2017/2018? Yes ___1___ No ____2____
2. Amount of credit received: In cash___________ in kind_____________
3. For how many years did you received credit? _______________ Years
4. If you have not received credit, what are the reasons? 1. Fear of risk 2 Reason not known 4. Credit service not available 5. Others, specify ____________
5. The amount of borrowing in 2017/2018

No	Purpose	Amount	Source	Where do you save you money(R*)	Type of disbursement	Remarks
1	NPS fertilizer					
	urea fertilizer					
2	Seed					
3	Fattening					
4	Livestock Production					
5	Beehives (modern)					
6	Chemicals					
7	Other specify					

Source: 1. Wasasa 2.Oromia Credit and saving share company (OCSSCO) 3. Agricultural and Rural development office 4. Friend and relatives 5. Commercial bank of Ethiopia, R*(1.Commercial bank of Ethiopia, 2.by yourself 3.cooperative union 4.Others specify

8. Have you got credit in 2017 for maize production? Yes __1__ No __2__

9. If yes, credit is given in what form? (Multiple answers possible) 1. Seed_____ 2. Cash______ 3.Fertilizer ____4. Herbicide__ 5, pesticide___ 6, all

E. Annual income from perennial crop and off-farm activities

1. Perennial crops and annual income if any

Types of perennial crop	Area(ha)	Unit sold in year		
		Unit	Amount	Annual income in birr
Banana				
Sugarcane				
Coffee				
Hope				
Mango				
Avocado				
Other specify				

2. Do you have any source of income other than farming? Yes __ 1 __ No __2__

3. If yes, what is the source?

1, Off-farm activity 2, Pension payments 3, Remittance 3, Constant transfer payment Salary/wage 4, Rent from asset or real estate 5, none 6, other (specify income information

4. On average how much revenue do you get per year/month from the income source you mentioned? _____ and how much is your average expenditure per Year/month________Birr

5. Have you participated in off/non-farm activity? Yes __1__ No ___ 1___

6. If yes what types of off/non-farm?

1. Handcrafting: 1. woodwork 2. Tailors (cloth making) 5. Pottery 6. Other, specify
2. Petty trading: 1. hide and skin 2. Agricultural inputs 3. Life animals 4. Animal Product (egg, honey, etc.) 5. Crop 6.other specify
3. Service renting: 1. Animal renting 2. Land renting 3. House renting 4. Food/drink (tea) selling
4. Resource extraction: 1. Fire wood 2.Construction tree selling,

7. Who participated in off/non-farm activity? 1. Household head 2. Wife if household head is male 3. Children 4. Other, specify______________

8. On average, how many days per week do you spend in non/off-farm activities you mentioned? 1. One day in a week 2. Two days in a week 3. Three days and above in a week

9 Is the off/non -farm activity usually done on holidays? Yes __1__ No__2__

10. How many holidays per month do you consistently celebrate (being out of main farming activities especially (plowing, weeding and harvesting) __________In the months may to December/January

F.Problems in the production of maize please encircle it

What are main problem in the production of maize?

1. soil factor 2, Low productivity of local varieties,3 High weed infestations4, Poor land preparation5, due to shortage of oxen 6, Shortage of rain during Water logging 7, Flooding 8, High maize disease and pest (specify the type of disease and/or pest)_____

Question for Focus group discussion

1. Major problems encountered in maize farming in your area and how it is occurred and what do you think is possible remedies for problem occurred?
2. In your opinion what suggestion can you give that will improve maize production and productivity in the district?

Thanks for your co-operation