ECONOMIC EFFICIENCY OF SMALLHOLDE RPRODUCERS IN BARLEY PRODUCTION: THE CASE OF LEGAMBO DISTRICT, SOUTH WOLLO ZONE, AMHARA REGION, ETHIOPIA

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BY

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Economic Efficiency of Smallholder Producers in Barley Production: The Case of Legambo District, South Wollo Zone, Amhara Region, Ethiopia

A Thesis

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DEDICATION

This thesis is dedicate to all my family members specially to my father Moges Gesese, my mother Enani Shiferaw and my uncle Mengistu Gesese, for growing me up with love and being a constant source of stimulation as without their effort the thesis work would not have been completed.

STATEMENT OF AUTHOR

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BIOGRAPHICAL SKETCH

The author was born on August 24, 1992, in Amhara saint district, South Wollo Zone, Amhara region, Ethiopia. She attended her elementary education at Saint Adjibar primary school; secondary and preparatory education at Saint Adjibar general secondary and preparatory school. In June 2012, she completed her preparatory school and joined Jimma University in October 2013 and in 2015 she joined Arava International Center for Agriculture Training (AICAT) in Israel for one year and graduated with BSc. degree in Agricultural Economics at Jimma University in June 2016. After her graduation, she joined Jimma University College of Agriculture and Veterinary Medicine worked as an assistant lecturer. Then she joined Jimma University College of Agriculture and Veterinary Medicine to pursue her MSc. degree in Agricultural Economics in September 2016.

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ABBREVIATIONS AND ACRONYMS

ACSI	Amhara Credit and Saving Institution
AE	Allocative Efficiency
CSA	Central Statistical Agency
EE	Economic Efficiency
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
Ha	Hectare
Kg	Kilogram
LDANRDO	Legambo District Agricultural and Natural Resource Development Office
LR	Likelihood Ratio
MLE	Maximum Likelihood Estimation
NPS	Nitrogen Phosphorus Sulphur
Qt	Quintal
SFA	Stochastic Frontier Approach
SFP	Stochastic Frontier Production
TE	Technical Efficiency
TLU	Total Livestock Unit
UNDP	United Nations Development Program
USAID	United States Agency for International Development
WB	World Bank

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ABSTRACT

Even though the agricultural sector in Ethiopia is one of the most important sectors in the country,the productivity of the sector is lower compared to other developing countries. Efficient use of resources supported by application of modern technologies becomes more important to increase the productivity of the sector. This study was conducted in Legambo district, Amhara region, Ethiopia; with specific objectives; to estimate the levels of technical, allocative and economic efficiencies of smallholder producers in barley production and identify the main factors affecting of inefficiencies. The study was mainly based on the data obtained from 200 farmers selected through two stage sampling technique. Cobb-Douglas production function was fitted using stochastic production frontier model to estimate the levels of technical, allocative and economic efficiency; while, the Tobit model was used to identify factors affecting of inefficiencies. The estimated result of the frontier model indicated that there is space to increase barley output by increasing the use of farm inputs. Besides, the mean technical, allocative and economic efficiency of sample households were 75.1, 71.7, and 53.9 percent, respectively. This implies that output can be increased by 24.9%; the input cost can be reduced by 28.3 % and production cost decreased by 46.1% with existing level of technology and resources. A two-limit tobit model result indicated that technical efficiency positively and significantly affected by sex, education, livestock, non-farm income, and credit use; while, total expenditure had a negative and significant effect. The distance of farm from home and distance to nearest market had a negative and significant effect on allocative and economic efficiency; whereas, crop rotation and frequency of extension contact had a positive and significant effect on allocative efficiency. Economic efficiency was negatively and significantly affected by farm size; while, crop rotation, sex, non-farm income and frequency of extension contact had a positive and significant effect. So, it is important to formulating appropriate policies and strategies directed towards the above mentioned significant variables of inefficiencies of in the district.

Keywords: *Barley producers, Cobb-Douglas, Stochastic production frontier model, Tobit*

1. INTRODUCTION

1.1. Background of the Study

Ethiopia is the second-most populous (107.53 million) country in Africa followed by Nigeria with the population growth rate of the country is 2.46 percent (World Bank, 2018). Agriculture is one of the most important sectors in the county. The sector contributes 36.7 percent of GDP, 73% percent of employment and over 70 percent for export earnings will remain a critical sector of the economy, as well as, a major source of raw materials for agriculture-led industrialization process (UNDP, 2017).

Ethiopia is ranked twenty-first in the world in term of barley production, with a share of 1.2 percent of the world's total production (USAID, 2014), According to this report assessment of commodity and trade, barley cultivation is widely distributed across the country over one million hectares of land and by more than four million smallholder farmers. Currently, it is grown exclusively for the domestic market and is neither imported nor exported. It is a high-opportunity crop, with great scope for profitable expansion, particularly connected with the country's commercial brewing and value-added industries, and it is the second largest barley producer in Africa, next to Morocco and followed by Algeria, accounting of its about 25 percent of the total barley production in the continent (FAO, 2014).

Barley is the fifth most important crop in Ethiopia after teff, wheat, maize, and sorghum in meher season and it is the second major cereal crop after maize in terms of area coverage and total production in belg season. In 2015/16 production year, private peasants had about 14.26 million hectares of land covered by grain crops from which a total volume of about 285.91 million quintals of grains was obtained from the total area of cereals allocated in a hectare, barely covered only 14.65 percent, producing, 13.37 percent quintals with the yield of 10.42 quintal per hectare (CSA, 2016), but about 4.5 million smallholder farmers grew barley on more than one million hectares of land.It has increased from 1.1 million metric tons in 2003/4 to 1.9 million tons in 2013/14, which is equivalent to an annualized growth rate of 6 percent per year (Shahidur *et al.*, 2015).

According to the 2016/2017 estimates from Ethiopia's Central Statistics Agency, in the Meher season, about 0.959 million hectares of land was covered by barley, Corresponding barley production was about 20.249 million quintals, the yield of barley was 21.11 qt/ha in the country. Between 2015/16 and 2016/17, the area cover increased from 0.944 to 0.959 with the change of 1.57 percent; yield increased from 19.66 quintals per hectare to 21.11 quintal per hectare and the change was 7.38 percent; and total production grew from 18.567 million quintals in 2016 to 20.249 in 2017 (CSA, 2016; CSA, 2017).

In Amhara region barley was the fifth most important cereal crop next to teff, sorghum, wheat and maize in terms of the volume of production. It was produced by the highland and mid-altitude smallholder farmers mainly for consumption. The numbers of barley production holders were 1.335 million, meher (main) production season, the region cultivated 0.324 million ha of land and production 6.081 million qt barley and yield 18.79 qt/ha. In South Wollo Zone numbers of barley producer households were 0.257 million,cultivated land for barley, 0.0386 million ha, amount of production 0.655 million quintals and amount of barley yield 16.97 qt/ha and in Legambo district the cultivated land for barley, 0.0383 million ha, amount of barley production 0.779 million quintals and amount of barley yield 20.34 qt/ha (CSA, 2017).

In Legambo district, barley is the most main cereal crop and it takes a lion share in terms of the amount of production, food consumption, number of producers and area coverage relative to other cereals grown in the district. Therefore,this study focused on assessing the level of economic efficiency of smallholder producers in barley production and identifies factors affecting of efficiencies variation among barley producers in the study area.

1.2. Statement of the Problem

An increasing population pressure and environmental degradation followed by declining productivity and expansion of agricultural land farmers require either to use modern technologies and need to use resources efficiently in order to enhance outputs in the country. However, there is a lack of information on the level of efficiency in smallholder cereal crop production and related sources of inefficiency determinants (Essa, 2011).

Agricultural output can be increased by introducing modern technology and improving the efficiency of inputs with the existing level of technology. In addition, productivity can be increased through distribution of improved technology (fertilizer and high yield variety seed) and improving the productive capacity of the previously employed resources. This means that the need for the combination of modern technology with improved level of efficiency of smallholder crop producers (Endalkachew, 2012).

Improved the level of efficiency help for farmers to produce the maximum possible output from a given level of inputs or use a minimum of output input cost for a given level. Hence, improved level of efficiency was increased productivity (Sisay *et al.,* 2015). The existence of inefficiency not only limits the gain of the existing resources, but it backs the benefits could arise from the use of improved inputs; this is due to the fact that inefficiency is costly for the producing units as to the society.The empirical studies shown that there was a variation in the level of efficiency among smallholder barley producers in Ethiopia (Endalkachew, 2012; Mustefa, 2014; Getachew, 2017), according to these schollars the source of variation was due to different factors of inefficiency: such as, sex of household, age of household, education status, family size, participation in non-farm activities, livestock ownership, farm size, credit use, crop rotation, poor infrastructures, high expenditure and low quality of inputs, among others.

As the efficiency of barley production was concerned, there were few scholars that have studied the efficiency of barley production and limited documents in Ethiopia, particularly in the study area. Understanding the levels of the efficiency and factors of inefficiency contribute to identify production constraints at farm level. Also, this knowledge can help for policymakers to design appropriate policies for increase agricultural productivity through improving level of efficiency.

The aim of this study was to fill the gaps in knowledge about level of efficiency and factors of inefficiency by collecting cross-sectional data from smallholder barley producers in the study area. There was no study conducted previous to assess the level of efficiency and factors of inefficiency in the study area.

1.3. Research Questions

1. What is the level of technical, allocative and economic efficiencies of barley producers in the study area?

2. What are the factors that affect technical, allocative and economic inefficiencies of barley producers in the study area?

1.4. The Objectives of the Study

1.4.1. General objective

The general objective of this study was to assess the economic efficiency of smallholder producers in barley production in the Legambo District of South Wollo Zone, Amhara Region, Ethiopia.

1.4.2. Specific objectives

1. To estimate the level of technical, allocative and economic efficiencies of smallholder barley producers in the study area;
2. To identify factors that affect technical, allocative and economic inefficiencies of smallholders barley producer in the study area.

1.5. Scope and Limitation of the Study

In a situation when there was no well-developed system for gathering and handling production data, it was difficult to get reliable production data of barley crop individual farmers through the interview. As a result, the study was undertaken based on cross-sectional data for barley producer. So, the limitation of this study was cross-sectional data not show inter-temporal differences in efficiency levels of households; the farmers do not keep records; they could expression remembering problems of the past events rather than other information, they might probably give wrong information during the survey time. In addition, farmers could worry to give the correct information on their income due to fear of theft, income tax and public contribution. Further, the scope of the study was limited to the economic efficiency of the smallholder producers in barley production in the study area. Though, it is predicted that the results of the study on the economic efficiency of barley production in that specific area and conclusion drawn from the study are useful for other potential areas that produce a barley crop.

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1.6. The Significance of the Study

Efficiency study can show a significant role in providing useful information about the level of efficiencies in production and identify those factors affecting of inefficiencies. When the sources of efficiency were identified, a policy that goes towards improving farmers' performance can be effective; the ability to quantify efficiency helps decision-makers to monitor the performance of the units under the study. Therefore, this study was certainly useful in planning and adjusting different policies that were targeted to enhance the productivity and efficiency of farmers in the study area.

This study was indicated an admittance point for policy interventions to improve the efficiency of smallholder farmers as it comes up with the important idea of efficient utilization of available production inputs.The study was conducted on allocative, technical and economic efficiencies were having a significant role in the Ethiopian economy. It was used to differentiate the inefficient farm from the efficient farm, and to create awareness about better production practices from more efficient farms. Moreover, this economic efficiency study was playing a significant role in providing useful information regarding economic efficiency in production and identifying the different factors contributing to the inefficiency differentials among farmers.

1.7. Organization of the Thesis

Chapter two presents review concepts of efficiency, efficiency measurements, empirical studies on efficiency and conceptual frameworks are reviewed. Third chapter deals with the methodology used in the study. It starts with a description of the study area; the sampling design, type and sources of data, method of data collection and analysis, and describes hypothesized factors affecting efficiency variables. Chapter four is devoted to results and discussions.In the first of chapter four, presenting descriptive statistics results about the characteristics of the sample households. The second section starts by testing to stochastic production function, given the test results and consequently model specified in the study, parameter estimates of the stochastic frontier model and discussed the results of factors affecting of inefficiency variables in Tobit model. Chapter five presents the summary, conclusion and recommendations.

2. LITERATURE REVIEW

In this chapter, theoretical, empirical studies made on efficiency in different countries and conceptual frameworks of economic efficiency have been reviewed.

2.1. Concepts of Efficiency

Efficiency is considered to be one of the most important issues in the production process to helping as a guide for allocation of resources. Economic efficiency is the degree of ability of an occupant to produce a given level of output at a least cost. Economic efficiency may be divided into allocative and technical efficiencies. Allocative efficiency refers to the appropriate choice of input combinations at minimum cost. A farm is allocatively efficiency if production inputs are allocated according to their relative prices. Technical efficiency refers to the proper choice of production function among all those activities in use by occupants. A farm is technically efficient if it produces the maximum level of output from a certain amount of input, given its technology. A farm is considered technically more efficient compared to other farms if it produces a larger output from the same quantities of inputs (Farrel, 1957).

According to Ellis (1993),technical efficiency is the extent to which the maximum possible output is produced from a given set of inputs. A producer is understood to be allocatively efficient if production occurs in a set of an economic region of the production possibility set. A farmer has achieved both technical and allocative efficiencies, and then the farmer can be said economically efficient.

Productive efficiency consists of technical efficiency and allocative efficiency. Allocative efficiency refers to the ability to combine inputs and outputs in optimal proportions in the prevailing prices. Technical efficiency is measured as the ratio between the observed output and the maximum output, under the assumption of fixed input, or the ratio between the observed input and the minimum input under the assumption of fixed output (Porcelli, 2009).

2.2. Approaches of Measuring Production Efficiency

There are two approaches to measuring efficiency: input oriented and output oriented. The output-oriented approach deals with the question “by how much output might be expanded from a given level of inputs?” An input-oriented measure of efficiency “by how much can input of quantities be proportionally reduced without varying the output quantity produced?" 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 measures

The input-oriented approach addresses the question "by how much a production unit can be proportionally reduced" that is the quantities of input used to produce a given amount of output (Coelli *et al.,* 1998).

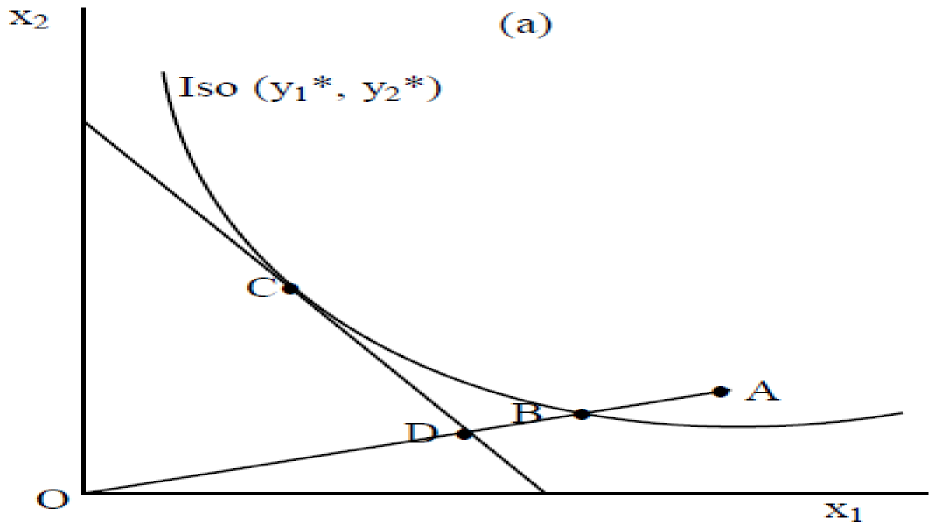

Figure 1: Input oriented efficiency measurement

Source: Coelli*et al.* (2005)

The measure of the technical efficiency of the firm at point A is OB/OA .The farm at point A would reduce both inputs by proportion OB/OA and still produce the same quantity of output (y_1*, y_2*). The economic efficiency of the farm at A is measured as OD/OA . Then the greatest economic efficiency is achieved at point C, at the tangency of an isocost and isoquant. Meanwhile, point D is at the same level of cost as C. Allocative efficiency is OD/OB or the divergence between minimum cost point and cost incurred at B. Generally, economic efficiency derived from $OD/OA = OB/OA * OD/OB$. This type of efficiency measurement is called input oriented efficiency measurement (Coelli *et al.,* 2005).

All three measures of efficiency are bounded between zero and one. This follows from the interpretation of distance DA as the reduction in costs if a technically and allocatively inefficient producer at A were to become efficient (both technically and allocatively) at C (Coelli, 1995).

2.2.2. Output oriented measures

While the input-oriented approach answers the question of how much the input use can be reduced without affecting the level of output, in the output-oriented approach one can alternatively answer the question of how much can the output be increased without increasing the number of inputs used (Coelli *et al.*, 1998).

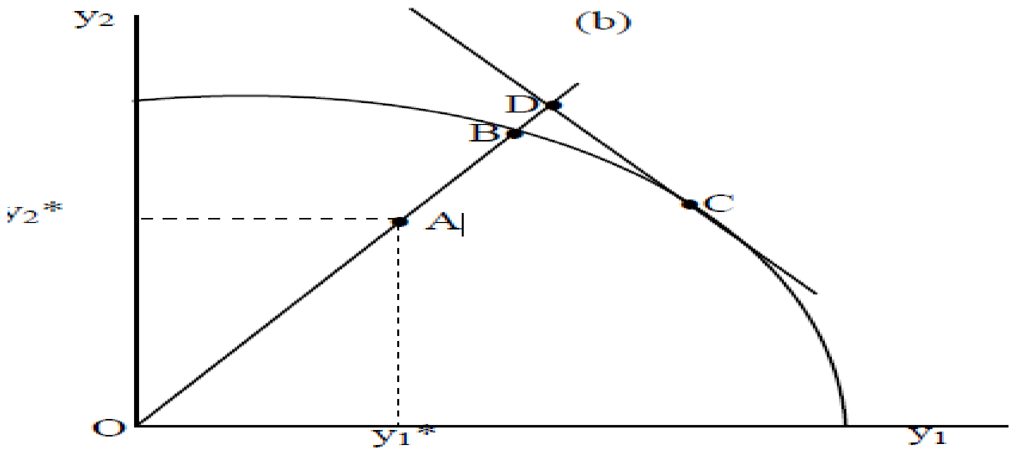

Figure 2: Output oriented efficiency measurement

Source: Coelli *et al*. (2005)

The measurement of firm-specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier at points B and C. To produce the right mix of outputs given the set of prices output allocative efficiency to point C. Economic efficiency contains resources for information on prices, costs or other valuable considerations.

$$TE = \frac{OA}{OB},\ EE = \frac{OA}{OD}\ \text{ and } AE = \frac{EE}{TE} = \frac{OB}{OD}$$

2.3. Models for Measuring Efficiency

Economists have established and used various models of efficiency measurements. Among those measurements' it is basically carried out using frontier methodologies, which shift the average response functions to the maximum output or to the efficient firm. These methodologies are broadly categorized under two frontier models; namely parametric and non-parametric.

The parametric models are basically estimated based on econometric methods and the non-parametric model, often referred to as Data Envelopment Analysis (DEA), involves the use of linear programming method to construct a non-parametric 'piecewise' surface (frontier) over the data (Coelli *et al*., 1998).

Farrell (1957) suggests the use of either a non-parametric piecewise linear convex Isoquaint constructed in such a way that no observed points should lie to the left or below it or a parametric function such as Cobb-Douglas production function.

2.3.1. Non-parametric frontier model

One of the methods of measuring efficiency in agricultural production is the non-parametric approach of the data envelopment analysis (DEA). It is an evaluation method particularly adapted to comprise a set of multiple indicators into overall performance. It enables frontier estimation with the use of non-parametric programming models leading to a ranking of all unit observations on the basis of efficiency scores. The focus is not on the estimation of an average technology production function used by all units analyzed, but to identify the best practicing units. The best-practice production frontier is constructed and all units of analysis are related to this frontier (Coelli, 1995).

Data envelopment analysis is based on the simple notion that an organization that employs less input than another to produce the same amount of output can be considered as more efficient. The efficiency frontier is constructed of linear segments that join up those observations with the highest ratio of output to input. The resulting frontier thus ‘envelops’ all the other observations. The main advantage of the DEA approach is that it can handle multiple inputs and multiple outputs and it avoids the parameter specification of technology as well as the distributional assumption for the inefficiency term and does not require the assumption of a functional form for the specification of the input-output relation. However, because the DEA is deterministic and attributes all the deviations from the frontier to inefficiencies, a frontier estimated by DEA is likely to be sensitive to measurement errors and other noise in the data (Coelli, 1995).

DEA has limitation: it is not possible to test the hypotheses regarding the existence of inefficiency; the piece-wise linear convex Isoquant assumes that no observed point lies to the left or below it; It assumes all deviation from frontier is inefficiency (do not capture noise) hence it is very sensitive for outliers; 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).

2.3.2. Parametric frontier models

The parametric approaches try to estimate the efficiency scores by estimating an efficient frontier. Thus, the difference between parametric and non-parametric approach is that non-parametric approaches try to calculate the efficiency scores directly without estimating any frontier, the parametric model estimates the efficient frontier by estimating the parameters of frontier, and measures the distance of observed input-output data to the estimated frontier.

The parametric approach depends on the assumptions about the mathematical form of production function. So, the conventional assumption of neoclassical production theory about the shape of production frontier is maintained in parametric approaches. Therefore parametric approaches, unlike the non-parametric ones, are subject to any criticisms directed to functional assumptions of the neoclassical production theory. In detail, the criticisms directed to non-parametric approaches for ignoring the economic theory stems from this point. The followers of parametric approach indicted the followers of non-parametric approach with ignoring the conventional production theory, while the followers of parametric approach accuse the others with "torching" the data by making a priori impositions about the functional form. The parametric approach is generally preferred by economists, while the champions of non-parametric approaches are generally from management and operations research (Hasan, 2006).

The parametric frontier model can further be classified into deterministic and stochastic frontier models. Both models use econometric techniques to estimate the parameters of pre-specified functional forms. The deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise.

2.3.2.1. Deterministic frontier model

According to Aigner and Chu (1968), a stochastic frontier production function for a sample of N firms can be specified as:

$$\mathbf{ln(Y_i) = F(X_i, \beta_i) - \mu_i, \qquad i = 1, 2, 3 \ldots N} \qquad (1)$$

Where Y_i is the output i^{th} of the firm; X_i is the vector of the input quantities used by the firm, β is a vector of unknown parameters to be estimated; *F* (.) denotes an appropriate function (Cobb- Douglas or translog); and μ_i is a non-negative variable representing the inefficiency in production.

Generally, non-stochastic/deterministic production frontier can be estimated using linear programming or econometric techniques such as Corrected Ordinary Least Squares (COLS). The limitation of Cobb-Douglas model is that treats random components (like measurement error, bad weather, etc.) as part of inefficiency.So, argues that one of the criticisms of the deterministic approach is that no account is taken of the possible influences of measurement errors and other noises upon the shape and positioning of the estimated frontier (Coelli, 1995).

2.3.2.2. Stochastic frontier model

To solve the problem associated with a random error in the deterministic approach an alternative estimation method called Stochastic Production Frontier Approach was independently developed by Aigner *et al*.(1977), Van den Broek (1977) and (Coelli, 1995). The application of the model for efficiency analysis was first indicated in the work of Aigner *et al*. (1977) to the US agricultural data and by Battese and Corra (1977) to the pastoral zone of Australia. Similarly, Bravo-Ureta Pinheiro (1993) offered a comprehensive review of the application of the model in measuring the efficiency of agricultural producers in developing countries. The stochastic production frontier was developed by adding an asymmetric error term (v_i) to the non-negative error term of the equation in as:

$$\mathbf{ln}(\boldsymbol{y_i}) = \boldsymbol{F}(\boldsymbol{X_i}, \boldsymbol{\beta}) + \boldsymbol{v_i} - \boldsymbol{\mu_i} \quad \boldsymbol{i} = \mathbf{1}, \mathbf{2}, \mathbf{3} \ldots \boldsymbol{n} \qquad (\mathbf{2})$$

The $\boldsymbol{v_i}$ assumed to be independent and identically distributed random errors following a normal distribution with zero mean and variance σ_v^2. The random error accounts for measurement error and other external factors such as climatic changes in the production process which is out of the control of the producer.The parameter of this model is preferably estimated by the help of an econometric procedure known as the Maximum Likelihood Estimation (MLE) approach, given suitable distributional assumptions for the error terms as it was suggested in a similar way by Afrait (1972) the corrected ordinary least squares (COLS) method could also serve as parameters estimation technique for stochastic model. The COLS is advised to use, for its simplicity in the analysis. However, ML method is asymptotically efficient than COLS.

2.4. Empirical Review on EconomicEfficiency

2.4.1. Economic efficiency of cereal production outside Ethiopia

According to Souleymane (2015), he conducted on the technical and economic efficiency of rice producers in Kou valley, western part of Burkina Faso. The stochastic frontier approach was used to estimate the production function, from a Cobb-Douglas stochastic frontier function and it dual which allow the estimation of the technical, allocative and economic efficiencies. The determinants of efficiency were simultaneously assessed along with the frontier functions. His results showed that farm size, fertilizer used, years of experience and literacy are the explicative factors of rice production in the Kou valley. The costs of the different production factors significantly contribute to explaining the total production cost, and that is in concordance with the economic theory. The technical, allocative and economic efficiencies of producers were, on average, 80.15, 92.7, and 74.43% respectively.

Based on Sihlongonyane *et al.* (2014), performed on the determinant of economic efficiency maize production in Swaziland by applying Cobb-Douglas production function. His results showed that the mean technical, allocative and economic efficiencies were 64.7, 99.52, and 64.3%, respectively. His result found from Tobit regression revealed that household size, formal education, and education were the significant variables that affect the farmer's efficiency level.

Mburu *et al*. (2014) the study conducted on the effect of farm size on economic efficiency among wheat producers and estimated the levels of technical, allocative, and economic efficiencies large and small-scale wheat producers in Nakuru District. The results of the Cobb- Douglas stochastic model showed that the mean technical, allocative, and economic efficiency of small-scale wheat farmers were 85, 96, and 84%, respectively. His result fromTobit model shown that the number of years of school a farmer has had informal education and the size of the farm had a positive effect while the distance to extension advice had a strong and negative influence on the efficiency levels.

According to Mohammed (2012) studied on the technical efficiency of sorghum production and its determinants, using the stochastic frontier production function which includes a model of inefficiency effects in the Hong, Adamawa,Nigeria. Result showed that land, seed, and fertilizer were factors that influence changes in sorghum output.

So,education, extension contact, and household size were found to have significant effects on the technical inefficiency among the sorghum producers. The mean technical efficiency was72.6%. The implication of the study is that efficiency in sorghum production among the farmers could be increased by 28% through better use of land, seed, and fertilizer in the short term given the prevailing state of technology.

2.4.2. Economic efficiency of cereal production within Ethiopia

Level of efficiency and factors affecting barley production

Mustefa (2014) employed a Cobb-Douglas production function was fitted using SPFA to estimate technical, allocative and economic efficiency levels in Chole district, EastArsi zone, Ethiopia, the results indicated the mean TE, AE,and EE of barley producers were 78.20, 46.05 and 35.26%, respectively. Tobit model revealed that age, education, total cultivated land, extension contact, family size, soil fertility, non-farm income, sex, crop rotation and livestock ownership were positive and significantly affected technical efficiency while land fragmentation and total expenditure had a negative and significant effect. Inaddition, age, education, total cultivated land, training, crop rotation and livestock ownership positively and significantly affected allocative efficiency while extension contact, land fragmentation, a distance of the farm from the homestead, and total expenditure were found to have a negative and significant effect. And also age, education, training, family size, non-farm income, crop rotation and livestock ownership were found to have a positive and significant effect on economic efficiency.

Endalkachew (2012) estimated the technical efficiency of malt barley production in the case of smallholder farmers in Debark District, North Gondar, Ethiopia. Applied Cobb-Douglas functional form with MLE method used in a single estimation procedure to estimate the technical efficiency, the result shows mean TE of 0.805 (80.5%) and MLE result has indicated the significant negative coefficients of efficiency were age, education, malt barley experience, soil fertility, and livestock holding, implied that efficiency improves with increased use of these inputs. However, family size, age square, and plot distance appeared with positive coefficients, meaning the increase in these factors lead to declining technical efficiency of barley production.

Accordingly Getachew (2017) he conducted on the economic efficiency of barley production by smallholder farmers in the Meket district, Ethiopia.Applied the trans-log functional form was chosen to estimate both production and cost function and OLS applied to regress technical, allocative and economic inefficiency factors were analyzed.The result shown that mean levels of TE, AE and EE of the sample farmers were 70.9, 68.6 and 48.8%, respectively. OLS results revealed that; extension contact and number of barley plots significant and negative effect on all inefficiencies. Distance from the nearest market was a positive and significant effect on all inefficiencies. Non-farm income activities and farming experience had a positive while; livestock ownership had a negative and significant effect on allocative and economic inefficiencies. Likewise, total expenditure and soil fertility had a positive and significant effect on technical and economic inefficiencies.

Level of efficiency and factors affecting cereal production

According to Musa *et al*. (2015)he estimated the level of technical, allocative and economic efficiencies of maize production in the central rift valley of Ethiopia. The result presented that the mean TE, AE and EE were 84.87, 37.47, and 31.62% respectively. The result indicated that there is room to increase the efficiency of maize producers.Among factors of the level of efficiency scores, education was found to determine allocative and economic efficiencies of farmers positively while the frequency of extension contact had a positive relationship with technical efficiency and it was negatively related to both allocative and economic efficiencies. Credit was also found to influence TE and EE positively and distance to market and soil fertility affected technical efficiency negatively.

Essa (2011) performed on the economic efficiency of smallholder major crop production in the central highlands of Ethiopia. By applied DEA approach, the result showed that the mean technical, allocative and economic efficiencieswere 79, 43and31% respectively. A two- limit Tobit regression model results shown that family size, farming experience, credit access, distance to the nearest main market, and total own land cultivated affect technical inefficiency positively and significantly; age of household head was found to have a negative and significant influence on technical inefficiency, family size, farming experience, and membership to associations was positively and significantly affected economic inefficiency; for household heads having a role in their community contributed negatively and significantly to economic inefficiency.

Accordingly Kifle (2014) investigated on the economic efficiency of smallholder farmers in maize production, applied stochastic frontier production function approach. He reported that the mean TE, AE, and EE were 82.93, 66.03, and 54%, respectively. Implies that increase output by 17.07%, decrease cost of inputs by 33.97% and decrease cost of production by 46%, respectively. Tobit model was applied to recognize factors affecting efficiency farmers. The results showed that age, non-farm activities, sex, amount of land owned and perception on agricultural policy had a significant effect on Technical Efficiency. Education, frequency of extension contact, perception on agricultural policy and livestock holding had a significant effect in AE while age, non-farm activities, sex, land owned, credit utilized and perception on agricultural policy had a significant effect on Economic Efficiency.

Moges (2017) conducted on determining the level of technical efficiency and identifies factors affecting the technical efficiency of smallholder farmers of teff production of Jamma district, Ethiopia. The estimated mean levels of technical efficiency of the sample farmers were about 78%. His result showed that there exists a possibility to increase the level of teff output by 22% through efficiently utilizing the existing resources. The stochastic production frontier model showed the result of the inefficiency parameters that were; age, education, improved seed, training, and credit were found to have a negative and significant effect on technical inefficiency whereas farm size was found to have a positive and significant effect on the technical inefficiency of teff production.

Hailemaraim (2015) measured technical efficiency of teff production in Bereh District, Ethiopia. He used a Cobb-Douglas stochastic frontier production analysis approach with simultaneously to estimate technical efficiency and identify the determinants of efficiency variations among teff producer farmers. The maximum likelihood parameter estimates showed that teff output was positive and significantly influenced by area, fertilizer, labor, and number of oxen. fertility status, off-farm occupation, education, credit service, and extension contact was found negatively and significantly, however, the age of the household head, family size, number of farm plot, and total farm size were found to affect technical inefficiency positively and significantly.

Musa (2013) studied on the economic efficiency of smallholder farmers in maize production the case of the Arsi Negelle district, Ethiopia. He applied Cobb-Douglas production function stochastic production frontier approach to estimate technical, allocative and economic efficiency levels;he reported that the mean technical, allocative and economic efficiencies were 84.87, 37.47 and 31.62% respectively. Among factors determine the level of efficiencies, education was found to significantly determine allocative and economic efficiencies of farmers positively while the frequency of extension contact had a 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 and soil fertility significantly affects technical efficiency negatively.

Sisay *et al*. (2015) the study conducted on technical, allocative and economic efficiency among smallholder maize farmers in South western Ethiopia. The study estimates that applied Cobb-Douglas and Two-limit Tobit regression model. He reported 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. The result shown that important factors that affected technical, allocative and economic efficiency are a number of family size, level of education, extension service, cooperative membership, farm size, livestock holding.

Ermiyas (2013) measured the levels of technical, allocative and economic efficiencies of sesame producers and identify factors affecting these efficiencies in the Selamago district of the South Omo Zone, Southern Ethiopia. A SPF model was applied to estimate technical, allocative and economic efficiency levels, whereas Tobit model was used to identify factors affecting efficiency levels. The results showed that the mean TE, AE and EE of sample households were 67.10, 67.25, and 45.14%, respectively. Labor and seed were positively affected the production of barley. The results of Tobit model shown that soil fertility, non-farm income, and credit access positively and significantly affected technical efficiency. Soil fertility had a positive and significant effect on allocative efficiency. Experience, a distance of farm from the residence, non-farm income and extension contact affected AE negatively and significantly. Soil fertility, non-farm income, and credit access had a positive and significant impact on economic efficiency. However, extension contact affected economic efficiency negatively and significantly.

Desale (2017) conducted on production efficiency and sources of inefficiency differentials of sesame in Kafta Humera District,Tigray region, Ethiopia. He applied a Cobb-Douglas functional from. The result shown that average technical, allocative and economic efficiencies were 71, 90 and 64% for large-scale producers,the results of factors of inefficiency shown that education level, the frequency of the farm visit, experience in sesame production, type of road and credited amount obtained were significant sources of technical, allocative and economic inefficiencies. The distance of the farm from the residence, ownership of living home and livestock and cooperative membership were also significant sources of technical and economic inefficiencies.

Awol (2014) studied on estimated of economic efficiency of rain-fed wheat producing farmers in NorthEasternAlbukodistrict Ethiopia. The Maximum Likelihood Estimates of Cobb-Douglas stochastic frontier production function was used to calculate the technical efficiency of farmers. The result revealed that mean of technical, allocative and economic efficiencies were 72.49, 42.70, and 31.65% respectively.The result of Tobit model found that the sex, land fragmentation, fertility status of land, slope, credit use, and training obtained and oxen numbers significantly and positively effect on technical efficiency, while negative related to farm size. The allocative and economic efficiency was positively and significantly affected by the sex of the household heads, frequency of extension, oxen number, family size, slope and training. However, age of the household heads and number of livestock have negatively related to allocative and economic efficiency level.

Generally, the above different empirical studies used different models to analyze the level of efficiency of farmers and different factors of efficiency. So, undertaking studies on smallholder household efficiencies in different localities support the policymakers and development workers to design and implement an appropriate policy intervention. It was also shown that a number of factors can affect the efficiency level of farmers, but these factors are not equally important and not similar in all places at all time. A crucial factor in one place at a certain time may not essentially be a significant factor in other places or even in the same places after some time different. In case of Legambo district, such type of research work has been not conducted and there were need to know the level of economic efficiency of smallhousehold farmers, particularly with respect to barley production.Therefore, this study was expected to fill this information and knowledge of efficiency.

2.5. Conceptual Framework

Based on empirical studies, a framework is presented for the first objective in figure three and second objective in figure four. Figure 3 shows that the interaction between various factors that were considered to have varying degree and direction of effect on the level of technical, allocative and economic efficiency of barley production.

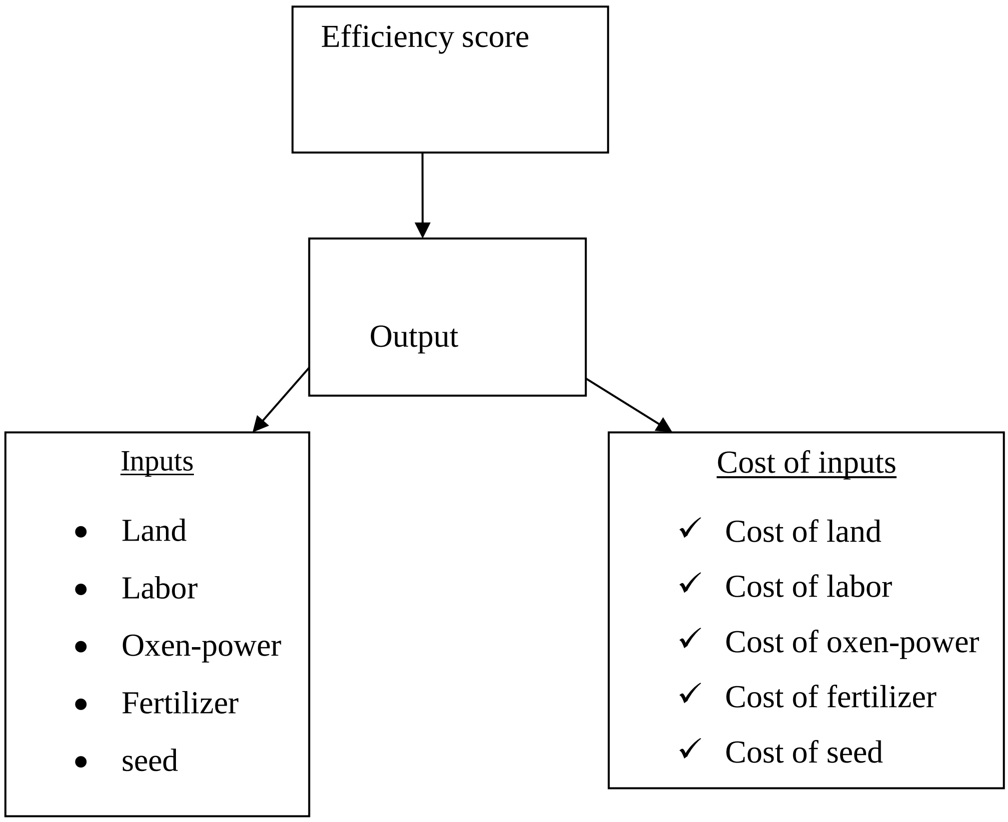

Figure 3. Conceptual framework of efficiency scores

Source : Own sketch (2018)

The factors that are conceptualized to factors affect inefficiency are summarized as demographic, socioeconomic, institutional and farm-related factors. Such are institutional factors include credit use, extension contact, distance to nearest market; the factors related to demographic characteristics are sex, age of household head and family size; the factors related to socio-economic characteristics of household are livestock ownership, non-farm activities, non-input expenditure, farm size and level of education; the factors related to farm-related characteristics include:crop rotation, farm location and distance.

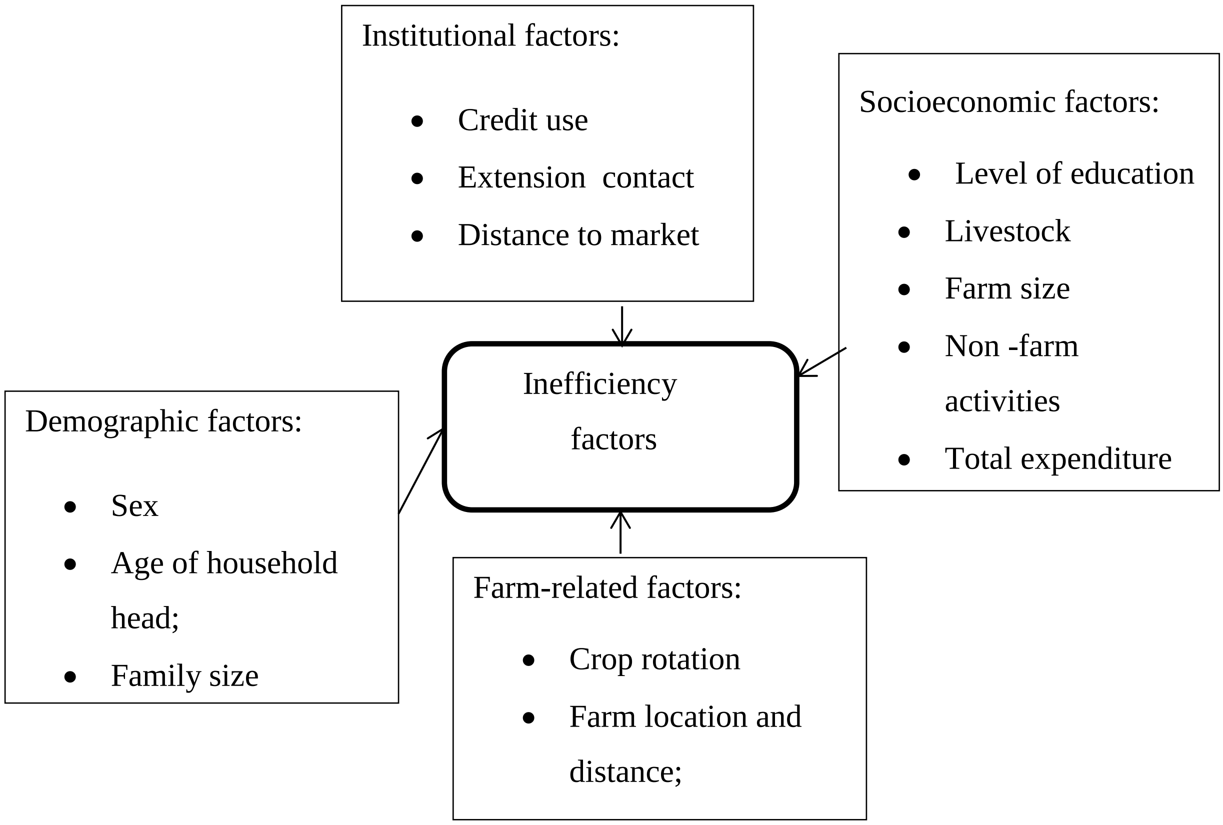

Figure 4: Conceptual framework of inefficiency factors

Source: Modified from Kaijage, A. M. (2016).

3. RESEARCH METHODOLOGY

In this chapter, description of the study area, sampling technique, types and source of data, techniques of data collection, and methods of data analysis and definition of variables presented.

3.1. Description of the Study Area

Legambo district is 550 km away from Addis Ababa, the capital city of Ethiopia. It is located in the Northern part of Ethiopia, Amhara Region, and South Wollo Zone. It is located at Latitude 11°00'00.0"N and Longitude 39°00'00.0"E. It is bordered on the South by Kelala and Wegde, on the West by Mekane-Selma and Sayint, on the North by Tenta and Mekdela, and on the East by WereIlu, Dessie Zuria, and Legahida. Towns in Legambo include Akesta and Embacheber. The district has 35 rural kebeles and 3 small urban Kebeles (Legambo District Agricultural and Natural Resource Development Office, 2018).

The district has a total population of 194,959 of which 98,208 are men and 96,750 women. A total of 41,176 households were counted in this district. The district has total area coverage of 108,868 hectares. The majority of the inhabitants in the district were Muslim, with 93.34%, while 6.5% of the population follow Orthodox Tewahedo Christianity. The largest ethnic group reported Amhara (99.9%).Amharic was spoken as a first language by 99.92% (LDANRDO, 2018).

Based on the Ethiopian agro-ecological classification, the study area categorized as four major agro-ecological zones i.e. wurich, dega, woina dega and kola.40 % wrich (high land), 33 % dega (high land), 17 % woina dega (mid altitude) and 10 % kola (low land). The annual rainfall was ranged in 700 ml-1200 ml, the average temperature is 18^{o}c. The altitude of this district reaches 3000 meters above sea level with nearly 65% of the area is located in the highland and the livelihood of the community is largely dependent on subsistent agriculture of crop production and livestock, which is highly dependable on rainwater (LDANRDO, 2018).

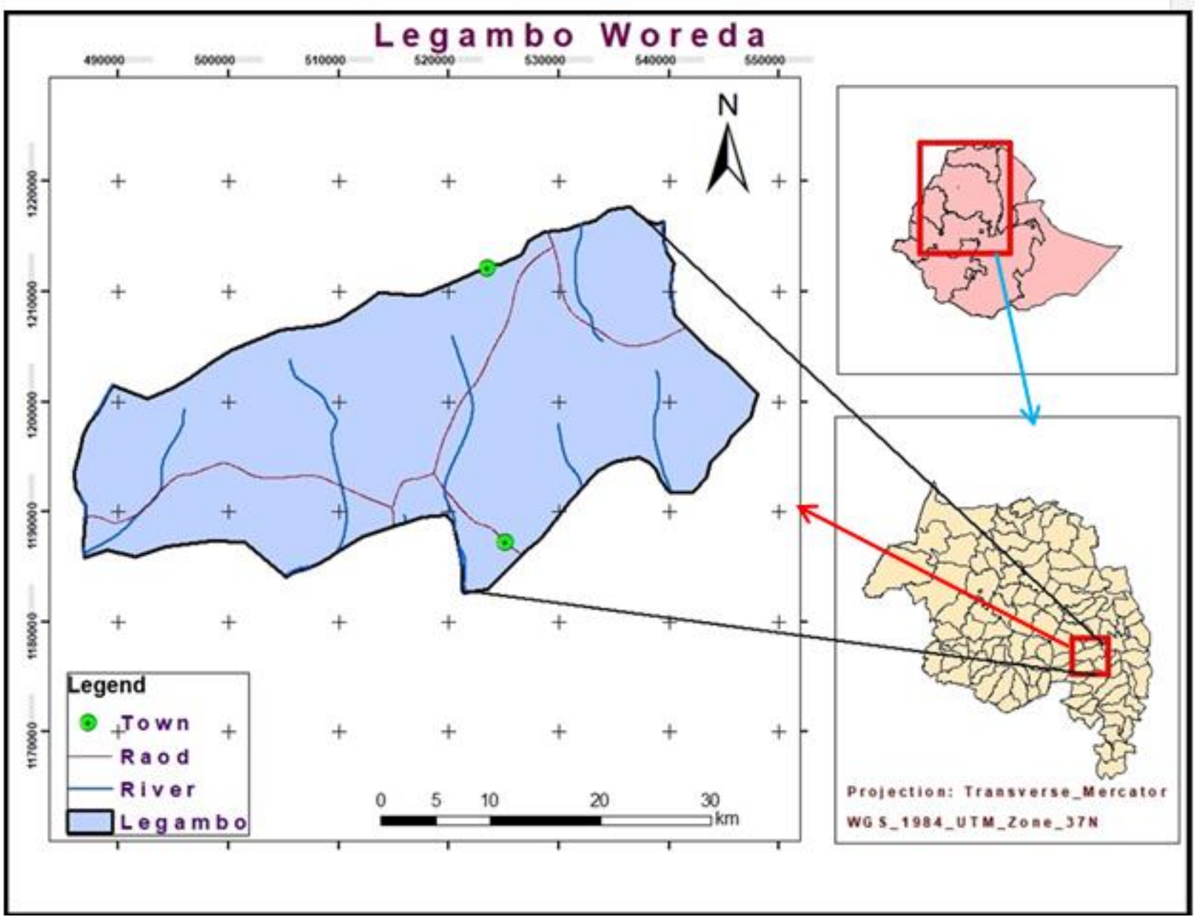

Figure 5: Map of the study area

Source: Etho- GIS-2017 output

3.2. Sampling Technique and Sample Size

In this study, used multistage random sampling techniques were employed to draw the appropriate sample households. Legambo district was selected purposively for the study because of its potential area for barley production in South Wollo Zone. The district has 35 rural kebeles of which 11 kebeles were engaged in barley production.To determine the sample *kebeles* and households, the two-stage random sampling procedure was used. In the first stage, four kebeles out of 11 barley producing kebeles were selected randomly. In the second stage,200 farmer households were selected randomly from those who were producing barley taking into account by probability proportional to size of barley producers in each of the four selected *kebeles*. The sample size was determined based on the following formula given by (Yamane, 1967).

$$n = \frac{N}{1 + N(e^2)} \quad (3)$$

Where, n = sample size, N = number of households and e= the desired level of accuracy.Given the total population of barley producer households in the study district 11 kebeles 9,350 assuming 7% level of precision, total of 200 sample households.

Table 1: Sample kebeles and sample size selected from each kebele

Name of Kebele	Barley growing households		
	Participant households	Percent	Sample size selected
Segno gebaye	827	25	50
Chiro	760	23	46
Dembesh	831	25	50
Terad	892	27	54
Total	3310	100	200

Source: Own survey (2018)

3.3. Types, Sources and Methods of Data Collection

This study was used both qualitative and quantitative types of data from primary and secondary sources of data. Primary data were collected using a semi-structured questionnaire, personal interview and focus group discussion. The process of primary data collection was done by enumerators; the enumerators were trained on data collection procedures. A structured questionnaire was important to make an improvement on the questions based on the feed backs obtained from the pre-testing exercise. Trained enumerators were used to gather data on different demographic, socioeconomic, farm-related and institutional variables from sample households. Focus group discussions interviews were made by farmers, concern agricultural professionals and administration officers by the researcher. Secondary data were collected from sources such as related journals, quarterly and annual report documents, and district agricultural documents, governmental and non-governmental institutions including both published and unpublished documents.

3.4. Methods of Data Analysis

The study was applied both descriptive and econometric methods. Descriptive statistics were measured mean, frequency, percentages and standard deviation. A stochastic frontier approach was used to measure the levels of technical, allocative and economic efficiency;

In addition, Tobit model was applied to analyze the factors affecting the technical, allocative and economic inefficiency of smallholder barley producers.

3.4.1. Descriptive statistics

Descriptive statistical techniques were helped to analyses demographic, socioeconomic, farm-related and institutional characteristics of smallholder barley producers. In addition, input uses, outputs of production, were presented.

3.4.2. Econometric models

The econometric model was used to estimate the objectives of the study based on the appropriate data. Such as, stochastic frontier approach and Tobit models were used to estimate the levels of technical, allocative and economic efficiency and identify factors affecting of inefficiencies of smallholder barley producers, respectively.

3.4.2.1. Stochastic frontier approach

The stochastic frontier production function was employed to assess the level of technical, allocative and economic efficiencies of barley producers.The stochastic frontier production function was autonomously developed by Aigner *et al.* (1977) and Meeuwsen and Van den Broeck (1977). The approach offers some sensible advantages over the other methods that usually use the efficiency analysis. The most important of this model is to allow segregating the effect of statistical noises from systematic sources of inefficiency; the technique was consistent with most of the agricultural production efficiency studies (Mohammed, 2012). In general, the stochastic frontier model was specified as follows:

$$Y_i = F(X_i, \beta) + (V_i - U_i) = F(X_i, \beta) + \varepsilon_i , \quad i = 1, 2, 3 \ldots \ldots n \qquad (4)$$

Where:Y_i is the production of the i^{th} farmer, Xi is a vector of inputs used by the i^{th} farmer, β,is a vector of unknown parameters,V_i is a random variable which is assumed to be N $(0, \delta_v^2)$ and independent of the U_i, which is non-negative random variable assumed to account for inefficiency in production.

The stochastic frontier functional approach requires a priori specification of the production function to estimate the level of efficiency. Among the possible algebraic forms, Cobb-Douglas and translog functions have been the most popularly models used in the most empirical studies of agricultural production analysis. Production function was either Cobb-

Douglas or translog that requires specified by likelihood ratio test Aigner *et al.* (1977) and Meeuwsen and Van den Broeck (1977).

According to Coelli (1995) the Cobb-Douglas functional form has more attractive features which are its simplicity and logarithmic form. A logarithmic transformation provides a model which is linear in the logs of inputs and hence it lends itself to econometric estimation. Moreover, the 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.

Selection of appropriate functional form, that better fit the data was selected after testing the null hypotheses using the generalized likelihood ratio test (Section 4.2.1), $LR = -2[lr(Cobb - douglas) - lr(Trans - \log)]$ which indicates $-2[(-55.84) - (-44.91)]$ equals to 21.86 (Table 13). The statistic is distributed with degrees of freedom equal to the number of variables added to the alternative hypothesis in this case the degrees of freedom were 15.The calculated value (21.86) is lower than the upper 5% critical value of the χ^2 with its respective 15 degrees of freedom (24.99). Therefore, the null hypothesis was accepted that states all coefficients of the product term in Cobb-Douglas specifications are equal to zero and the alternative hypothesis was rejected, means that the square and interaction terms in the translog specification were not different from zero. This implies that the Cobb-Douglas production function was adequately in the data set and more appropriate model for this study.The linear form of Cobb-Douglas production model defined as:

$$lnY_i = \beta_0 + ln\sum_{j=1}^{5}\beta_j\, x_{ji} + \varepsilon_i \qquad (5)$$

$$lnY = \beta_0 + \beta_1\,\text{Ln}(labour) + \beta_2\,\text{Ln}(ox) + \beta_3\,\text{Ln}(fertilizer) + \beta_4\,\text{Ln}(land) + \beta_5\,\text{Ln}(seed) + \varepsilon_i$$

Where: $\varepsilon_i = V_i - U_i$

Ln=denotes the natural *logarithm*

j = represents the number of inputs will be used

i = represents the ith farmer in the sample

Y_i = represents the observe barley production of the i^{th} farmer

X_{ij}= denotes j^{th} farmer input variables will be used in barley production of the i^{th} farmer

ß = stands for the vector of unknown parameters to be estimated

ε_{i}= is a composed disturbance term made up of two elements (v_i and u_i)

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 inefficiency.

Aigner *et al*. (1977) proposed the log-likelihood function for the model in equation (5) assuming a half-normal distribution for the technical inefficiency effects (μ_i). The expressed the likelihood function using λ parameter, where λ is the ratio of the standard errors of the non-symmetric to symmetric error ($\lambda = \delta_{\mu}/\delta_{v}$). However, there is an association between γ and λ. The reason is that λ 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. According to Bravo and Pinheiro (1997) gamma (γ) can be formulated as:

$$\gamma = \frac{\lambda^2}{1 + \lambda^2} \qquad (6)$$

The parameter γ measures the inconsistency between frontier and observed levels of output and it interpreted as the total variation of output from the frontier attributable to technical inefficiency. It has a value between zero and one. The value of zero indicates that the non-negative random variable, μ_i is absent from the model while the value of one shows the absence of statistical "noise" from the model and hence low level of farm's production compared to the "best" practice of the other farm, that is totally a result of farm specific inefficiency. Likewise, the significance of δ^2 indicates whether the conventional average production function adequately represents the data or not.

Production function of Cobb-Douglas was preferred over translog based on generalized likelihood ratio test, as it was considered to be the appropriate functional form that better fit the data. The value of the generalized log-likelihood ratio (LR) statistic to test the hypothesis that all interaction terms, including the square root specification (in the translog functional form),are equal to zero ($H_0 = \beta_{ij} = 0$) was calculated as:

$$LR = -2[L(CD) - L(Tl)] \quad (7)$$

Where: LR = Generalized log-likelihood ratio, L (Cd) = Log-likelihood value of Cobb-Douglas and L (Tl) = Log-likelihood value of translog.

The self-dual natures of the Cobb-Douglas production and cost functions provide the computational advantage in obtaining the estimates of technical, allocative and economic efficiency. The self-dual functional form allows the cost frontier to be derived and used to estimate the economic efficiency when the farmers expression similar price. In smallholder farming, the technology is unlikely to be considerably affected by variable returns to scale (Coelli, 1995).
The dual cost frontier function can be represented in general form as follows:

$$C_{i=}f(p_i, Y_i^*, a) \quad (8)$$

$$lnC_i = \alpha_0 + \sum_{j-1}^{5} \alpha_{ij} p_{ij} + \alpha_i \gamma_i^* + v_i + u_i$$

Where C_i: is the minimum cost of i[th] farm associated with the output Y_i^*.

Y_i^*: is output with the i[th] farm

a : is the vector of parameters to be estimated

p_i: is the vector of input prices for the i[th] farm

j= 1… k, inputs used and i= i[th] household

vi = accounts for the stochastic effects beyond the farmer's control, measurement errors well as other statistical noises and ui =captures the inefficiency.

The economical efficient input vector for the i[th] farmer derived by applying Shepard's Lemma and substituting the firm's input price and adjusted output level in the resulting system of input demand equations.

According to Sharma *et al*. (1999), the above cost measures are used to estimate the technical, allocative and economic efficiencies.
The farm-specific technical efficiency define in terms of observed output (Y_i) to the corresponding frontier output (Y_i^*) using the existing technology

$$TE_i = \frac{Y_i}{Y_i^*} \quad (9)$$

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

$$EE_i = \frac{C^*}{C} \quad (10)$$

Following Farrell (1957) allocative efficiency index of the i^{th} farmer can be derived from two equations (9 and 10); allocative efficiency can be derived as the ratio of economic efficiency to technical efficiency.

$$AE_i = \frac{EE_i}{TE_i} \quad (11)$$

After measuring the mean level of technical, allocative and economic efficiency, Tobit model was estimated to identify factors affecting inefficiencies.

3.4.2.2. Tobit model

In order to determine the relationship between demographic, socioeconomic, farm-related and institutional factors affecting of technical, allocative and economic efficiencies; Tobit model was applied. Using two-limit censored Tobit model on explanatory variables that explained variation of efficiency across smallholder barley producers. Two-limit censored Tobit model applied through two tails censored at minimum and maximum score with left and right censored respectively.

Following Upadhyaya*et al*. (1993) the two-limit Tobit regression model was estimated as:

$$U_{i\ TE,\ AE,\ EE}^* = \beta_0 + \sum_{j=1}^{13} \beta_j Z_{ij} + \mu_i \quad (12)$$

$U_i = 1, if\ U_i^* \geq 1$

$U_i = U_i^*, if\ 0 < U_i^* < 1$

$U_i = 0, if\ U_i^* \leq 0$

Where: i refers to the i^{th} farm in the sample households; j is the number of factors affecting technical, allocative and economic efficiency; U_i is efficiency scores representing the technical, allocative and economic efficiency of the i^{th} farm. U_i^* is the dormant (latent) variable, β_j are unknown parameters to estimate and μ_i is a random error term that is independent and normally distributed with mean zero and common variance of $\sigma^2(\mu_i \sim IN(0,\sigma^2))$. Z_{ij} are socio-economic, institutional, farm-related and demographic variables which expect to factors affecting of technical, allocative and economic inefficiency of smallholder barley producers.

According to Maddala (1999), the likelihood function of this model is as specified:

$$L\big(\beta,\sigma\big|U_j,X_jL_{1j},L_{2j}\big) = \prod_{U_j-L_{1j}} \varphi\left(\frac{L_{1j}-\beta^{\cdot}X_j}{\delta}\right) \prod_{U_j-U_j^*} \varphi\left(\frac{U_j-\beta^{\cdot}X_j}{\delta}\right) \prod_{U_j-L_{2j}} \varphi\left(\frac{L_{2j}-\beta^{\cdot}X_j}{\delta}\right) \quad (13)$$

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

The regression coefficients of the two-limit Tobit regression model cannot be interpreted as coefficients.That interpreted as the magnitude of the marginal effects of change in the explanatory variables on the probability, expected and total value of the dependent variable. 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. Therefore, the total marginal effect takes into account that a change in explanatory variable would have a simultaneous effect on the probability of being efficient in barley production and value of efficiency scores in barley production.

McDonald and Moffitt (1980) proposed useful decomposition techniques of total marginal effects. Based on the likelihood function of the model stated in equation (13), the total marginal effect divided into the three marginal effects as follows:

1. The unconditional expected (total)value of the dependent variable:

$$\frac{\partial E(U)}{\partial x_j} = [\varphi(Z_N)-\varphi(Z_L)]\frac{\partial E(U^*)}{\partial x_j} + \frac{\partial[\varphi(Z_N)-\varphi(Z_L)]}{\partial x_j} + \frac{\partial[1-\varphi(Z_N)]}{\partial x_j} (14)$$

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

$$\frac{\partial E(U^*)}{\partial x_j} = \beta_k \left[1 + \frac{\{Z_L \varphi(Z_L) - Z_N \varphi(Z_N)\}}{\{\varphi(Z_N) - \varphi(Z_L)\}}\right] - \left[\frac{\{\phi\,(Z_L) - \phi\,(Z_N)\}^2}{\{\varphi(Z_N) - \varphi(Z_L)\}^2}\right] \quad (15)$$

3. The probability of being between the limits:

$$\frac{\partial[\varphi(Z_N - \varphi(Z_L)]}{\partial x_j} = \frac{\beta_k}{\delta}.[\varphi(Z_N) - \varphi(Z_L)] \quad (16)$$

Where: $\varphi(.)$ is the commutative normal distribution, $\phi\,(.)$ is the normal density function, $Z_L = -\beta^{'} X/\delta \;\; and \; Z_N = (1 - \beta X)/\delta$are standardized variables that came from the likelihood function given the limits of U^* and δ is the standard deviation of the model.

3.5. Definition of Variables and Hypotheses

3.5.1. Production function variables

Output: This is the dependent variable of the production function. It is the actual quantity of barley produced measured in quintals obtained by a household in 2017/2018 production year.

Inputs: These are the total inputs that were used in the production of barley: such as land, labor, oxen, seed, and fertilizer were used for the barley production in 2017/2018 production year.

Land: This represents the total physical unit of land under barley production and measured in hectare. The land may belong to the farmer; it may be obtained through renting or share-cropping arrangements.

Labor: This represents the total labor that was used for barley production in the production season. It was measured in man-days (eight hours are equivalent to one man-day) and converted to a homogenous variable using the standard conversion factor.

Oxen: It is a continuous variable and defined as the total number of oxen power used by the sample farmer in barley production activities and measured in oxen-days (one oxen-day is equivalent to eight working hours).In the study area, oxen power is one of the major inputs of production. In the study area, the activities of plowing, threshing, and hoeing are done using by oxen.

Seed: It is a continuous variable and defined as the total amount of barley seed used for barley production and measured in kg.

Fertilizers (Urea/NPS): It is a continuous variable and defined as the total amount of Urea/NPS that was used for barley production measured in kg used by each household for barley production during the production year.

3.5.2. Input costs

Cost of land (C1): It is a continuous variable and defined as cost of land used for barley production and measured in birr.

Cost of labor (C2): It is a continuous variable and defined as cost of labor used for barley production period and measured in birr per man-day.

Cost of oxen power (C3): It is a continuous variable and defined as cost of oxen power used for barley production and measured in birr per oxen-day.

Cost of Urea and NPS (C4): It is a continuous variable and defined as cost of Urea and NPS used for barley production and measured in birr.

The total cost of seed used (C5): It is a continuous variable and defined as the total cost of seed used for barley production and measured in birr.

Table 2: Variables in stochastic frontier Cobb-Douglas production

Variables	Description	Unit of Measurement
Output		
Y_1	Barley output	Quintal
Input Variables		
X1	Total barley area	Hectare
X2	Total labor utilized	Man-days
X3	Oxen	Oxen-day
X4	Amount of Urea and NPSused	Kilograms
X5	Amount of barley seed used	Kilograms
Cost of Input Variables		
C1	Land rent (cost of land)	Birr
C2	Total wage for labor	Birr
C3	Total cost oxen	Birr
C4	Cost of Urea and NPS used	Birr
C5	Cost of barley seed used	Birr

3.5.3. Factors affecting inefficiency of barley production

Age of household: It is a continuous variable and measure as the age of the household head in years. The age of the farmer can be a proxy of the experience of the household head in farming. Age can reflect the capacity of the farm worker has to engage in farming activities.After certain age limit as farmers get older, they start to be more conservative and their managerial ability is expected to decrease efficiency (Endalkachew, 2012; Mustefa, 2014). Age of household increases the ability of the productivity of that person decreases. So, in this study age was expected to have a negative effect on efficiency.

Sex of the household head: A dummy variable takes the value 1 if the household head is male and 0, otherwise. Since women represent zero who is responsible for many household domestic activities than agricultural activities, with this background including the existing gender differences, male-headed households have better mobility, participate in different meetings and have more exposure to information about better farm inputs and practice. So that female household heads are less efficient than male household heads (Sisay *et al.,* 2015). Therefore, in this study, sex was hypothesized male headed household have better efficient than female headed households.

Family size: It represents the number of persons living in the household and measured in man-equivalent. Family is an important source of labor supply. Since labor is the main input in crop production, as the farmer has large family size, he/she would manage crop plots on time (Essa, 2011, Sisay*et al.,* 2015). Therefore, in this study,family size was hypothesized to have a positive effect on the efficiency of the barley farmers.

Education: This represents the educational level of the household head measured in years of formal education. The educated farmers are more responsive to improved farming techniques and they have a higher level of efficiency than farmers with less education status. Household heads are advancing in school level have a better opportunity for system of agricultural productivity (Mustefa, 2014; Desale, 2017). So, in this study, education was hypothesized to have a positive effect on efficiency of smallholder barley farmers.

Farm size: This represents the total crop land in hectares managed by a farmer and measured in hectare. It is important to assess whether a large farm sizes are more efficient or not than small ones. As the farm size of a farmer increases the managing ability of her/him was decreased in the given level of technology. Large farm size is relatively less efficient than small size farms (Mustefa, 2014; Sisay*et al.*, 2015).Hence; in this study, farm size was expected to have anegative effect on efficiency of smallholder barley farmers.

Livestock ownership (exclude oxen): It is a continuous variable and defined as the total number of livestock exclude oxen of household own in terms of Tropical Livestock Unit (TLU). Livestock could support crop production in several ways; they can be a source of cash and manure that used to maintain soil fertility. In this case they would have positive relationship with efficiency. That mean the households having large number of livestock are more efficient than others (Endalkachew, 2012;Mustefa, 2014; Kifle, 2017). Therefore, in this study livestock ownership was hypothesized to have positive effect on efficiency.

Participation of non-farm income: It is a dummy variable, which takes the value 1 if the farmer participation in non-farm income activities and 0, otherwise. Non-farm income activities can the supplement of the agricultural activities in terms of providing cash income; by purchase the necessary production inputs on time which cannot provide from on-farm income (Ermiyas, 2013; Getachew, 2017). So, in this study, participation of non-farm income activities was hypothesized to have a positive effect on the efficiency of smallholder barley producers.

Credit use: This represent the amount of money which is the household head borrows from different lending institutions and measured in birr. So, credit useis an important source of financing and it enables that the smallholder farmers to purchase agricultural inputs on time that increase their production (Ermiyas, 2013; Desale, 2017). So, in this study, credit use was hypothesized to have a positive effect on efficiency of farmers.

Extension contact: This represents the number of interactions per production year of the household head with DAs and measured in numbers per production season in year. Extension contact assists the distribution of new technologies to farmers as a way of increasing agricultural productivity; enhanced to the adoption or use of new technologies and practices. Extension service found to affect economic efficiency positively in the work of (Mohammed, 2012; Mustefa, 2014). Therefore, in this study, extension contact was expected to have a positive effect on efficiency of smallholder barley producers.

Crop rotation: It is the sequences of the crops are grown on specific plot during a given period of time. It is a dummy variable which takes the value of 1 if the farmer adopted crop rotation and 0, otherwise. If the farmers who practice crop rotation were more efficient than his counterparts as it helps to increase output by recycling and restoring nutrients require for barley production (Musa, 2013; Mustefa, 2014). Therefore, in this study, crop rotation was hypothesized to have a positive effect on efficiency of barley farmers.

The distance of the farm from home: This is defined as the distance between farms to farmer home was measured minutes. It was the average distances between the homes of the household to the farm. The furthest home distance from the farmer field, the low the supervision so low efficiency of farmers, because of distance between farm and home increases. A farmer living nearly on the farm was more efficient than the one living at the farthest distance (Getachew, 2017). So, in this study, distance of the farm from farmers home was hypothesized to have a negative effect on efficiency of barley farmers.

Distance to the nearest market: This is defined as the distance of farmers from the nearest market to their home was measured in km. When farmers were located far from the market, there was limited access to input and market information. In addition, higher distance to market leads to higher transaction cost that reduces the benefits to the farmer (Musa, 2013; Mustefa, 2014; Desale, 2017). So, in this study, distance to nearest market was hypothesized to have a negative effect on the efficiency of barley farmers.

Non-input expenditure: It is a continuous variable measured in birr and refers to all annual expense of the households on consumption, education, medication and social obligation excluding agricultural input expense (Musa, 2013; Mustefa, 2014). Therefore, in this study, expenditure was hypothesized to have a negative effect on the efficiency of the barley producers.

Table 3: Description of variables in two-limit Tobit regression model hypothesis

Variable	Definition	Category	hypothesis sign
Age	Age of household head in year	Continuous	-
Sex	Sex of the household head (= 1 if male; 0 otherwise)	Dummy	+
Family size	Total family size of household in man–equivalent	Continuous	+
Education	Household head educational level in formal years of schooling	Continuous	+
Farm size	Total cultivated land of the household in hectare	Continuous	+
Livestock	Total number of livestock (TLU)	Continuous	+
Non-farm activities	Household head activities on income generated in (= 1 if yes, 0 otherwise)?	Dummy	+
Credit use	Credit use of household head in birr	Continuous	+
Extension contact	The frequency of extension contact with the household in number	Continuous	+
Crop rotation	Rotation of crops growing household head in a season: 1 if adopted and 0 not adopted	Dummy	+
The distance of the farm	The distance of the farm from home in an minute	Continuous	-
Distance to market	Distance to nearest market of household in km	Continuous	-
Expenditure	The total expenditure of household in Birr	Continuous	-

Source: Owncomputation (2018)

4. RESULTS AND DISCUSSION

This chapter has been divided into two main sections. The first section deals with the results of a descriptive analysis of demographic, socio-economic, farm-related characteristics and institutional factors; while, the second section that studied the econometric results related to the mean level of technical, allocative and economic efficiency and identify the factors affecting inefficiencies.

4.1. Descriptive Results

The descriptive statistics presented in this section was comprised of the various subsections. The discussion is includes demographics, socioeconomic characteristics, farm-related and institutional factors and description of variables used in stochastic frontier production.

4.1.1. Demographic characteristics of the sample households

The average age of the sample household head based on the survey information was 47.48 years, a maximum of 76 and a minimum of 24 years old with a standard deviation of 9.35. Family members including household head are the major sources of labor for crop production in the study area. As a result, family size ranges from 1.6 to 6.4 with an average of 3.23 and standard deviation of 1.10 (Table 4).

The sex of respondents, about 71% from the sample households were male-headed and the remaining 29% were female-headed. This indicates that the male-household head was more participant in agricultural work than the female-household head. This indicates male headed households were more efficient than female-headed households. Females are head of households when they were divorced or widowed; take responsibility and starting farming activities (Table 4).

Based on survey results among the given sample households showed that 61.50%, 15.00%, 10.67% and 6.50% of the sample households were married, divorced,widowed and single respectively. This implies that most of the sample respondents were married followed by divorce, widowed and single (Table 4).

Table 4: Demographic characteristics of the sample households head

Characteristics	Mean	Minimum	Maximum	Std.dev
Age	47.48	24	74	9.35
Family size	3.23	1.6	6.4	1.10
	Response	Frequency (N=200)	Percentage	
Sex of the household	Male	142	71.00	
	Female	58	29.00	
Marital status	Single	13	6.50	
	Married	123	61.50	
	Divorced	30	15.00	
	Widowed	34	17.00	

Source: Own survey (2018)

4.1.2. Socioeconomic characteristics

The educational status of sample households enhances the gaining and utilization of information on improved technologies to farms. Education was increased with experience to guide farmers to better manage their farm activities. The education level of the sample household in the study area was ranging from 0 to grade 10. The average years of formal schooling of the sample farmers were found to be 3.82 years with standard deviations of 3.19. The maximum educational achievement for the sample farmers was grade 10. The average livestock population of the sample household farmers measured in tropical livestock units was 8.67 with a minimum of 3.20 to a maximum of 15.20. The households have more livestock number were more efficient than others (Table 5).

Farmers in the study area are engaged in various non-farm activities in addition to farming activities. Most of the non-farm activities (petty trade, selling local drink, wage employment, selling firewood and handcraft) achieved by the sample households. Based on the survey information of respondents said that 73.50% of the farmers were participated in different types of non-farm income activities while about 26.50% were not participated in any source of non-farm income. Around 73.50% of the sample farmers reported that they participated at least in one of the above-mentioned non-farm activities (Table 5).

Table 5: Socioeconomic characteristics of sample households head

Variable	Mean	Minimum	Maximum	Std.dev
Education	3.82	0	10	3.19
Livestock ownership	8.67	3.20	15.20	2.34
	Response	Frequency(N=200)	Percent	
Non-farm activities	Yes	147	73.50	
	No	53	26.50	

Source: Own survey (2018)

4.1.3. Farm characteristics

Farmers produce barley by using both family labor and oxen power for performing different farming operations such as ploughing, sowing, manuring, weeding, plant protecting, harvesting and threshing. On average, farmers plough their plot of land depend on rain 2.5 times ranging from a mid of February until mid of July with a minimum of 2 times to a maximum of 5 times per production season with 0.7 standard deviations (Table 6).

The mean number of plots allocated for barley crop production was 4.2 plots located at the minimum of 2 plots and the maximum of 8 plots was in a different location of the household home. The average distance between the barley farm and the farmer's home was 26.9 minutes ranging from a minimum of 5 minutes up to a maximum of 60 minutes. The households were more money expend for their livelihood the efficiency of the household was less. The mean annual total expenditure of the sample households was 4727.0 birrs within the range of 550 birrs to 7650 birr (Table 6).

From the survey information of the respondents said that, 59.0% of sample households were adopted the crop rotation. This indicated, that they may practice on crop rotation as a means to increase the soil fertility of their land and better efficient than their counterparts; while, the remaining 41.0% of the sample households were not practicing crop rotation and less efficient than others (Table 6).

Table 6: Farm and farmers related factors

Variable	Mean	Minimum	Maximum	Std.Dev
Number of ploughing	2.5	2.0	5.0	0.7
No. barley plot	4.2	2.0	8.0	1.4
Distance farm to home(minutes)	26.9	5.0	60.0	12.6
Total expenditure	4727.0	550.0	7650.0	1367.7
	Response	Frequency(N=200)	Percent	
Crop rotation	Yes	118	59.0	
	No	82	41.0	

Source: Own survey (2018)

4.1.4. Institutional factors

The mean frequency of extension contact was 21.87 times with a minimum of 0 to a maximum of 48 times per barley production season of the year. That means some farmers are being visited more frequently (21.87 times) and more efficient than their counterparts; while, no chance to get visited by extension workers (0 times). The average amount of credit obtained from different sources of lender was 2168 birr ranges from 0 to 10000 birr. There exist both formal and informal lending institutions to provide credit. The formal sources of credit in the study area were Amhara Credit and Saving Institution (ACSI) followed by informal credit sources such as neighbors, friends, and relatives. This indicates that the households used credit from different sources were better efficient than their counterparts. Market is one of the basic institutions for the purchase of different farm inputs and to sell their outputs. The residence of households was far from the nearest market, they spend more transaction cost and less efficiency than their opposite side. The average distance of the nearest market to the farmers' home was 7.38 km ranging from 3 km to15 km (Table 7).

Table 7: Institutional factors

Variable	Mean	Minimum	Maximum	Std.dev
Frequency of extension (no.)	21.87	0.00	48.00	16.07
Credit use (Birr)	2168.00	0.00	10000.00	2083.48
Distance to nearest market (km)	7.38	3.00	15.00	3.02

Source: Own survey (2018)

Based on survey information the major annual crops produced by the sample households were grown in the study area include barley, lentil, pea and wheat. The production and area coverage of these major crops in the production year by sample household are presented in Table 8. On average, the sample households allocate 1.20 hectares of their land for barley production. Next to barley, lentil, pea and wheat were crops that take the lion's share of the households' total cultivated land covering 0.55, 0.47 and 0.32 ha of land, respectively. The total average production of barley, lentil, pea and wheat were 19.5, 3.35, 2.43 and 2.14 quintals per average area allocated, respectively. From the total crop produced in 2017/18 production year by sample farmers, barley was higher than other annual crop produced by sample respondents (Table 8).

Table 8: Major crops produced by sample households

Crop type	Number of producers	Area (ha)				Production (Qt)			
		Mean	Min	Max	Std.dev	Mean	Min	Max	Std.dev
Barley	200	1.20	0.50	2.50	0.40	19.5	5	46	8.10
Lentil	52	0.56	0.25	1.00	0.15	3.35	1	14	2.19
Pea	26	0.47	0.25	0.58	0.20	2.43	1	10	0.79
Wheat	16	0.32	0.25	0.45	0.21	2.14	1	8	0.82

Source: Own survey (2018)

4.1.5. Description of production and cost function variables

The production function for this study was estimated using five input variables (labor, oxen power, fertilizer, land, and seed). To draw some image about the distribution of inputs, mean and range of input variables is discussed as follows:

Barley output was the dependent variable in the production function and estimated mainly with five significant inputs which are labor, oxen power, fertilizer, land and seed. The mean of barley output for the sample household in the study area during the 2017/18 production season was relatively 19.5 quintals with a minimum of 5 quintals to a maximum of 46 quintals (Table 9). Labor especially family labor had the main roles in the production of barley activities like ploughing, sowing, weeding, and plant protection, harvesting and threshing. On average, a total labor of 40.5 man-days were needed for performing all related activities of farming in man-days with a minimum of 7.4 man-days to a maximum of 75.1 man-days (Table 9).

The average oxen-day, the total oxen of 31.9 oxen-days were used by sample households for barley production and it was ranged between a minimum of 10 oxen-days and a maximum of 66 oxen-days (Table 9). The average inorganic fertilizer (Urea/NPS) application for the production of barley among the sample respondent used 35.4 kg with a minimum of zero and a maximum of 100 kg. On average, the households allocate 1.2 ha of their farm land with a minimum of 0.5 ha and a maximum of 2.5 ha for barley production (Table 9).

According to focus group discussion and survey information there is no use improved barley seed among the respondents. This is mostly due to, a limited supply of improved barley seed and has not any information about improved seed. So, all sample households apply only local barley seed with a mean of 64.5 kg and the ranging from a minimum of 25 kg to a maximum of 120 kg, which was lower than the predicting way of recommended barley seed rate 120 kg (Table 9).

Table 9: Summary of descriptive statistics of variables used in the production function

Variable	Mean	Minimum	Maximum	Std.dev
Barley output (qt)	19.5	5.0	46.0	8.1
Labor (man-day)	40.5	7.4	75.1	16.8
Oxen power (oxen-day)	31.9	10.0	66.0	12.1
Fertilizer (kg)	35.4	0	100.0	20.3
Land (ha)	1.2	0.5	2.5	0.4
Seed (kg)	64.5	25.0	120.0	15.6

Source: Own survey (2018)

Like to the production function, the mean, range and standard deviation of each input variables used in the cost function along with their contribution to the total cost of cultivation are summarized and presented in (Table 10).

On average, farmers gained 7569.65 amounts of birr by the production of 19.5 quintals of barley output with a minimum of 1250 birr and a maximum of 25300 birr. From their total income, the barley producing farmers had expected to consume a higher amount of money for a wage, oxen power and land rent (that is 2044.65, 2041.60 and 1212.44 birr), respectively. Others were consumed less proportion, which is 441.33 and 614.36 birr for application of seed and fertilizer, respectively (Table 10).

Table 10: Summary of descriptive statistics of variables used to the cost function

Variable	Mean	Minimum	Maximum	Std. Dev.
Gross income (Br)	7569.65	1250	25300	3681.37
Cost of labor (Br)	2044.65	288	5190	1035.88
Cost of oxen power (Br)	2041.60	500	4650	828.28
Cost of fertilizer (Br)	614.36	0	2500	391.92
Cost of land (Br)	1212.44	335	3000	448.89
Cost of seed (Br)	441.33	150	1200	158.96

Source: Own survey (2018)

A total of 13 variables was hypothesized to affect the technical, allocative and economic efficiency of barley producers, 10 variables are continuous and others 3 of them were dummy variables (Table. 11).

Table 11: Summary of variables included in the efficiency model

		Continuous variable			
Variable		Mean	Min	Max	Std.dev
Age (years)		47.48	24	74	9.35
Education (years)		3.82	0	10	3.19
Family size (man-equivalent)		3.23	1.6	6.4	1.10
Farm size (ha)		2.54	0.5	4	0.76
Distance from farm to home (minute)		26.93	5	60	12.59
Livestock ownership (TLU)		8.67	3.2	15.2	2.30
Credit use (birr)		2168	0	10000	2083.48
Frequency of extension contact (N)		21.87	0	48	16.07
Distance to nearest market (km)		7.38	3	15	3.02
Total expenditure (birr)		4727.03	550	7650	1367.68
Dummy variable			Frequency (N=200)		percent
Sex	Male=1		142		71
	Female=0		58		29
Crop rotation	Yes=1		118		59
	No=0		82		41
Non-farm income	Yes=1		147		73.5
	No=0		53		26.5

Source: Own survey (2018)

4.1.6. Barley production constraints faced by sample household

Based on the survey information and focus group discussion the reason that the majority of the sample households (31.5%) reported a higher amount of their barley output lost due to frost in the production season and 33.0% problems of barley production loss byfrost and climate change, 25.0% climate change (untimely rainfall during harvesting time and drought during sowing time), shortage of draft animal and labor, shortage of seed and shortage of land (12.50%, 8.0% and 1.5%) respectively were reported as factors which unfavorably output from their crop in the study area during the 2017/18 production season. Even if, there are many different problems of barley production the most serious problems were frost and climate change in the study area (Table 12).The summation of parcentage is not 100% because of multiple response from the respondents.

Table 12: Problems in barley production

Major constraint	Frequency (N=200)	Percent
Frost	63	31.5
Climate change	50	25.0
Shortage of draft animal and labor	25	12.5
Shortage of seed	16	8.0
Shortage of land	3	1.5
Frost and climate change	66	33.0

Source: Own survey (2018)

4.2. Results of Econometric Models

This section presents the econometric results of the study. The results of production and cost functions, efficiency scores and factors affecting of inefficiency are discussed.

4.2.1. Test of hypothesis

Before going on the estimation of the model parameters, a different hypothesis test was conducted. So, the functional form that can better fit to the data in hand was selected by testing the null hypothesis which states that all coefficients of the product term in Cobb-Douglas specifications are equal to zero $H_0 = \beta_{ij} = 0$ against alternative hypothesis which states that the coefficients of all interaction terms and square specifications in the translog functional forms are different from zero.Generally, the general likelihood ratio (LR) is calculated on null (H_0) and (H_a) alternative hypotheses.

Table 13: Generalized likelihood ratio tests of hypothesis for the parameters of the SPF

Null hypothesis	Critical value χ2 (0.05)	Calculated value (LR)	Decision
$H_0 = \beta_{ij} = 0$	24.99	21.86	Accept H_0
$H_0 : \gamma = 0$	3.84	5.62	Reject H_0
$H_0 : \mu_i = \delta_0 = \delta_1 = ... = \delta_{13} = 0$	22.36	134.08	Reject H_0

Own computation (2018)

The first hypothesis was that selected the appropriate functional form of a model which fits the data set by using the likelihood ratio test. The most common functional forms reviewed in most previous researchers were Cobb-Douglas and Trans-log. The likelihood test statistic is calculated in the following way;

$LR = -2[lr(Cobb - douglas) - lr(Trans - \log)]$ Which indicates $-2[(-55.84) - (-44.91)]$ equals to 21.86 (Table 13). The statistic is distributed with degrees of freedom equal to the number of variables added to the alternative hypothesis in this case the degrees of foredoomwas 15.The calculated value (21.86) islower than the upper 5% critical value of the χ^2 with its respective 15 degrees of freedom (24.99).Therefore, the null hypothesis was accepted that states all coefficients of the product term in Cobb-Douglas specifications are equal to zero and an alternative hypothesis was rejected that means the square and interaction terms in the translog specification were not different from zero. This implies that the Cobb-Douglas production function was adequately represented in the dataset.

The second test was the null hypothesis of all coefficients that explain inefficiency is equal to zero and the alternative hypothesis of all coefficients that explain inefficiency is different from zero. As a result, the null hypothesis is rejected in favor of the alternative hypothesis that explanatory variables associated with the inefficiency effects model are simultaneously different from zero and the null hypothesis of all coefficients that explain inefficiency is not equal to zero. From the above hypothesis, the value of $\gamma= 0$ is rejected, and the value of λ is 1.767 (Table 13).

The third hypothesis was determining whether the explanatory variables associated with inefficiency effects are simultaneously zero $H_0 = \delta_1 = \delta_2 = ... = \delta_{13} = 0$ or not. The null hypothesis states that a model without explanatory variables of inefficiency effects while, the alternative hypothesis states the full frontier model with explanatory variables is supposed to determine inefficiency. $LR = -2[(-55.844) - (11.118)]$=133.924 (Table 13)which is greater than the critical value of (22.36) at 13 degrees of freedom, suggesting that, the null hypothesis that explanatory variables are simultaneously equal to zero was rejected at the 5 % level of significance. Therefore, explanatory variables of inefficiency can together determine variation in the production of barley output in the study area.

4.2.2. Estimation production and cost functions

The Maximum Likelihood Estimation (MLE) of the parameters of the SFPF specified in equation (5) was obtained by using the STATA 13 computer program. These results together with the standard Cobb-Douglas frontier estimates of the average production function are presented (Table 14).

The stochastic production frontier was applied using the maximum likelihood estimation (MLE) procedure. The dependent variable of the estimated production function was barley output (qt) produced in 2017/18 production season and the input variables used in the analysis were area barley farm (ha), oxen (oxen-days), labor (man-days), the quantity of seed (kg) and inorganic fertilizers (kg). To include those farmers who did not apply inorganic fertilizers in the estimation of the frontier a very small value that approaches zero was allocated for non-users of fertilizers, so as to estimate their results.

The result of the model showed that the total of input variables measured in the production function all had positive and a significant effect on barley output among the sample farmers. Consequently, increases these inputs were increased production of barley output. The coefficients of the production function are interpreted as elasticity. Hence, high elasticity of output to seed (0.481) suggests that barley production was highly sensitive to seed. That means, 1% increase in the amount of seed, production of barley output increase by 48.1%, remain other factors constant. This indicates barley production was sensitive to seed, followed by land, oxen, labor and inorganic fertilizers respectively (Table.14).

The value of sigma square for the frontier of barley output was 0.203 which was significantly different from zero and significant at 1% level of significance (Table 14).

The significant value of the sigma square indicates the goodness of fit and correctness of the specified assumption of the composite error terms distribution.

The estimate for the variance parameter, gamma (γ) which measures the effect of inefficiency in the variation of observed output, is greater than zero and close to one, which indicates that the inefficiency effects are likely to be highly significant in the analysis of the value of the output of the farmers. The ratio of the standard error of $\mu(\delta_\mu)$ to the standard error of $v(\delta_v)$, given lambda $(\lambda = \delta_\mu / \delta_v)$ was 1.767 (Table 14). Based on λ, gamma (γ)which measures the effect of inefficiency in the variation of observed output can be derived: $\gamma = \lambda^2 / (1 + \lambda^2)$.The estimated value of gamma was 0.757 which indicated that 75.7% of the total variation in barley farm output was due to technical inefficiency. 24.3% of variation in output from the frontier is due to random noise or random error.

Table 14: Estimates of the Cobb-Douglas frontier production function

Variables	Parameter	Coefficients	Std. Err.
Intercept	β_o	0.148	0.520
Ln (labor)	β_1	0.114**	0.043
Ln (ox power)	β_2	0.153**	0.059
Ln (inorganic fertilizer)	β_3	0.029*	0.017
Ln (land)	β_4	0.362***	0.085
Ln (seed)	β_5	0.481***	0.110
$\delta^2 = \delta_\mu^2 + \delta_v^2$		0.203***	0.038
$\lambda = \delta_\mu / \delta_v$		1.767***	0.088
$\gamma = \lambda^2 / (1 + \lambda^2)$	0.757		
Log-likelihood	-55.844		

***, ** and * indicates the level of significance at 1%, 5% and 10% respectively.

Own computation (2018)

The returns to scale analysis can serve as a measure of total factor productivity. The coefficients were calculated to be 1.139; this indicates increasing returns to scale and increasing to increasing rate, because the value of return to scale greater than one. This means that there is potential for barley producers to continue increase of their production because they are in stage I production. If the farmers were increase 1% in all inputs proportionally increases the total production of barley output by 1.139 % (Table.15). This result is consistent with the study of (Mustefa, 2014) he estimated the returns to scale to be 1.04% (stage I) in his study of the economic efficiency of barely production chole district. But this finding was inconsistent with the study of Getachew (2017) in Meket district found a return to scale to be 0.801 which is a stage II production.

Table 15: Elasticity and return to scale in production function of the parameters

Variable	Elasticity's
Labor	0.114
Oxen power	0.153
Fertilizer (Urea/NPS)	0.029
Land	0.362
Seed	0.481
Return to scale	1.139

Source: Own computation (2018)

The dual frontier cost function derived analytically from the stochastic production frontier with in Cobb-Douglas shown:

$$\ln C_i = 3.973 + 0.908 \ln Y_i^* + 0.042 \ln p_{labor} + 0.038 \ln p_{oxenpower} + 0.009 \ln p_{fertilizer} + 0.103 \ln p_{land} + 0.081 \ln p_{seed}$$

Where $\mathbf{C_i}$ is the minimum cost of barley production of the i^th^ farmer Y^* refers to the total amount of barley production in qt quantities for any statistical noise and scale effects; **p** stands for input prices.

4.2.3. Efficiency scores

The average technical efficiency was found to be 75.1% with a minimum of 41.9% and a maximum of 92.9% (Table.16). It indicated that farmers on average could decrease inputs by 24.9% if they were technically efficient. In other words, it implied that if resources were efficiently utilized, the average technical efficiency of the farmer could increase current output by 24.9% using the existing resources and level of technology.

The result indicates that the farmer with an average level of technical efficiency would enjoy an increase about19.16% derived from $[(1-0.751/0.929)]*100$ to attain the level of the most efficient farmer. The most technical inefficient farmers would have an efficiency enhance of 54.898% derived from $[(1-0.419/0.929)]*100$ to attain the level of the most technical efficient farmers. Similarly, barley producers can save 28.3% of their current cost of inputs by cost minimizing way. On the divergent, the economic efficiency of 53.9% succeeds that an economically efficient farmer can produce 46.1% barley output additional (Table.16).

The average allocative efficiency of the sample households was 71.7% with a minimum of 37.7% and a maximum of 95.2%; this indicates that there is a need to improve the present level of allocative efficiency by save 28.3% of their current cost of inputs by cost minimizing way (Table.16). Furthermore, the estimates showed that the farmers have sufficient chance to increase their allocative efficiency. For instance, a farmer with an average level of allocative efficiency would enjoy a cost saving of 24.68% derived from $[(1-0.71704/0.952)]*100$ to attain the level of the most efficient farmer. The most allocative inefficient farmer would have an efficiency gain of 60.46% derived from $[(1-0.3765374/0.9523433)]*100$ to attain the level of the most economic efficient farmers.

The average economic efficiency of the sample households was shown that 53.9% with a minimum of 20.0% and a maximum of 85.0% (Table.16). This means that the producer with an average economic efficiency level could reduce the current average cost of production by 46.1% to achieve the potential minimum cost level without reducing output. It can be indirect that if farmers in the study area were to achieve 100% economic efficiency, they would skill considerable production cost saving of 46.1%.This implicit that the reduction in the cost of production through eliminating resource uses inefficiency could add 46.1% of the minimum annual income. In addition, the result indicates that the farmer with an average level of economic efficiency would enjoy a cost saving of about 36.589% derived from $[(1-0.5390183/0.85)]*100$ to attain the level of the most efficient farmer. The most economically inefficient farmers would have an efficiency gain of 76.40% derived from $[(1-0.0.200582/0.85)]*100$ to attain the level of the most efficient farmer.

Table 16: Descriptive statistics of efficiency scores

Efficiency	Mean	Minimum	Maximum	Standard deviation
TE	0.751	0.419	0.929	0.117
AE	0.717	0.377	0.952	0.160
EE	0.539	0.201	0.852	0.148

Source: Own computation (2018)

4.2.4. Distribution of efficiency scores

The distribution of the technical efficiency scores indicated that the higher distribution groups were ranging from 71% to 90%, which covers 70% of sample households out of the total sample respondents (Figure 5). But there were also some households whose technical efficiency levels were restricted to the range 41 to 70% which covers 27.5% of sample households. Households in this group have space to enhance their barley production at least by 70% on average. Out of the total sample households, only 2.5% had a technical efficiency use of 91% to 100%. This implies that 98.5% of households can increase their production by at least 10%.

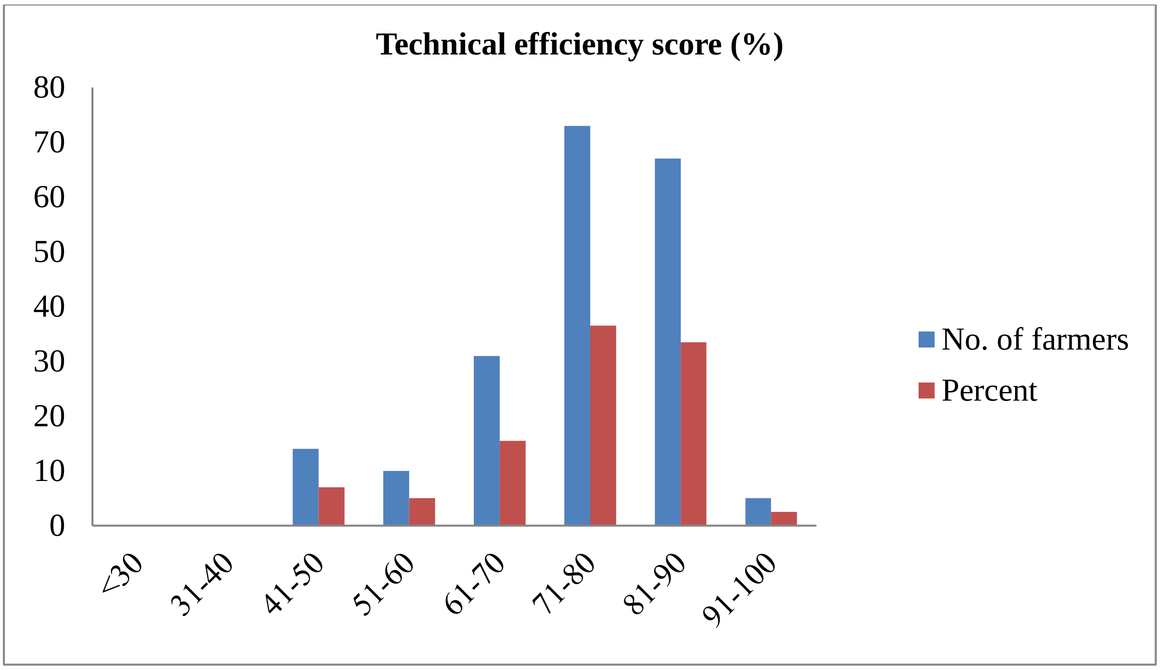

Figure 6: Distribution of technical efficiency scores

Source: Own computation (2018)

The allocative efficiency distribution scores showed that out of total sample household the largest efficiency group of barley producers (77%) cover between 51% and 90%score of AE level. Households in this group can save at least 10% of their current cost of inputs by be having in cost-minimizing way, 11.5% households from the total sample households had an allocative efficiency score that ranged between 31 to 50%. Similar to this 11.5% household from the total sample household had an allocative efficiency those scores between 91% and 100%. This shows that all barley producing farmers (100%) can save at least 10% of their current input cost by reallocation of resources in a cost-minimizing way (fig. 6).

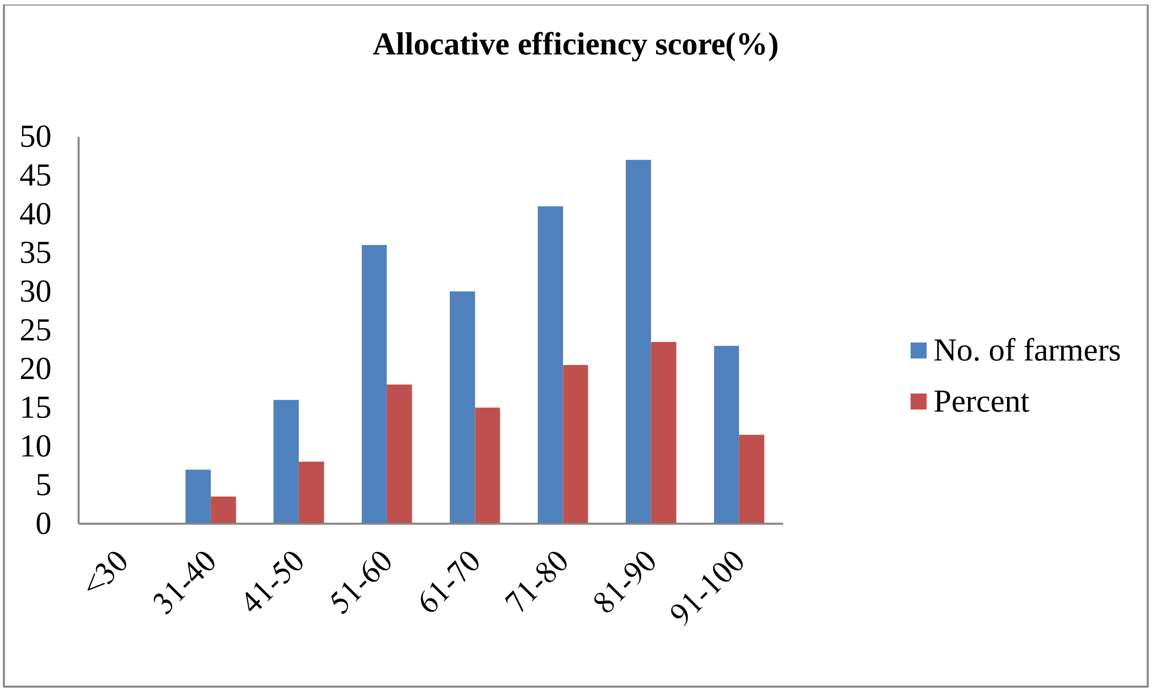

Figure 7: Distribution of allocative efficiency scores

Source: Own computation (2018)

The distribution of economic efficiency scores indicated that the majority of the farmers (64.5%) were covered between 40% and 69% economic efficiency level. 19% of sample households were performed between 20% and 39%. 13.5% of the respondents were scored 70% to 79% and only 3% of respondents scored between 80% and 89%. The low level of average economic efficiency was the total effect of both technical and allocative efficiencies. This indicates that the existence of important economic efficiency in the production of barley during the study (Fig.7).

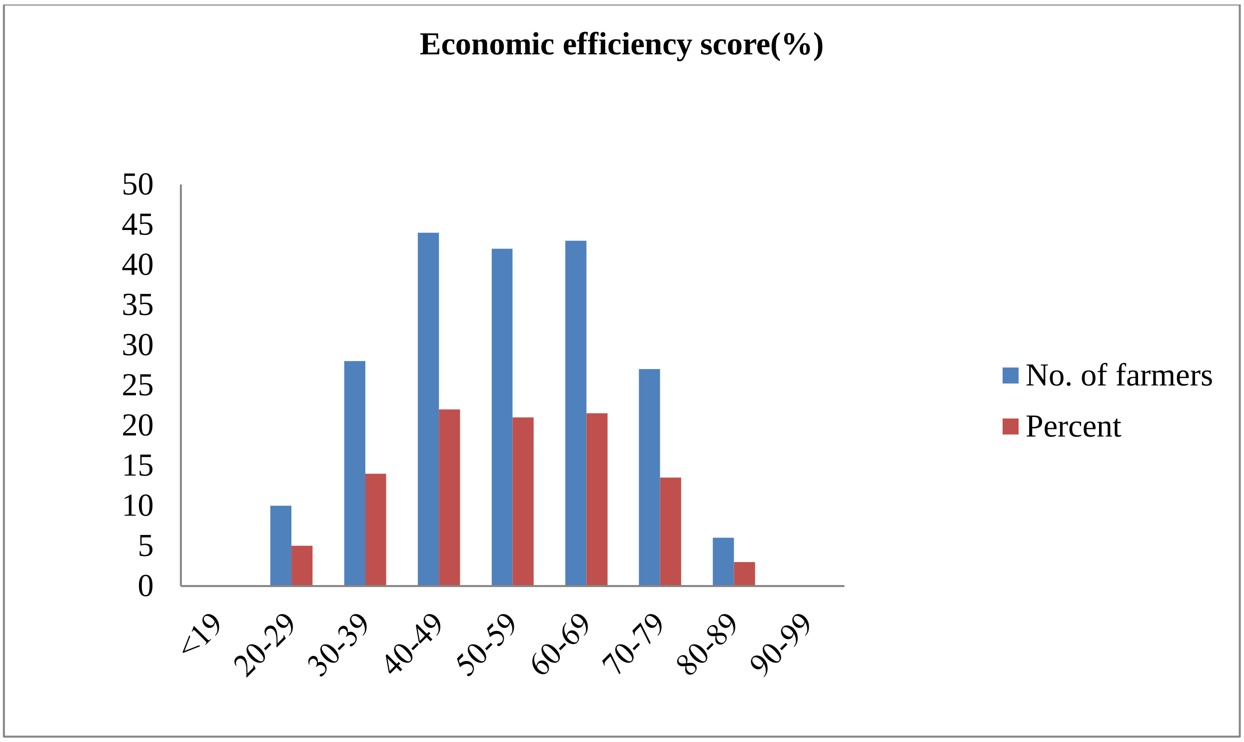

Figure 8: Distribution of economic efficiency scores

Source: Own computation (2018)

4.2.5. Factors affecting of inefficiency of barley producers

After determining the presence of efficiency difference among barley producers and measuring the levels of their technical, allocative and economic efficiency; then identify the factors affecting of these efficiencies was the next important specific objective of the study. The factors of these efficiencies estimate from the model regressed on demographic, socioeconomic, farm-related and institutional variables that were clarifying the variations of the efficiency across sample households using Tobit model. These demographic, socioeconomic, farm-related and institutional variables areage, sex, family size,education,non-farm income,farm size, crop rotation, livestock ownership, distance farm to home, credit use, frequency of extension contact, distance to the nearest market and total expenditure, which expected to be affect the efficiencies.The result of Tobit regression model indicatedfrom these variables sex, education, livestock ownership, credit use,total expenditure, farm size, distance farm to home, crop rotation, non-farm income, frequency of extension contact and distance to market were significant effect on efficiencies.

Table 17: Tobit model results on the technical, allocative and economic efficiency of barley production variables

Variables	TE		AE		EE	
	Coefficient	Stad.err	Coefficient	Stad.err	Coefficient	Stad.err
Constant	0.6042***	0.0405	0.8020***	0.0848	0.5066***	0.0679
Age	-0.0000	0.0006	0.0003	0.0012	0.0001	0.0010
Sex	0.1854***	0.0123	0.0019	0.0259	0.1327***	0.0208
Education	0.0031*	0.0016	0.0010	0.0035	0.0020	0.0028
Family size	-0.0002	0.0044	0.0026	0.0092	0.0012	0.0074
Farm size	-0.0092	0.0075	-0.0211	0.0158	-0.0250**	0.0127
Distance farm to home	-0.0002	0.0004	-0.0019**	0.0009	-0.0016**	0.0007
Crop rotation	-0.0127	0.0120	0.0766***	0.0254	0.0491**	0.0203
Livestock ownership	0.0143**	0.0063	-0.0152	0.0132	0.0027	0.0106
Non-farm income	0.0202	0.0133	0.0288	0.0281	0.0396*	0.0225
Credit use	0.0162*	0.0091	-0.0015	0.0077	0.0021	0.0068
Frequency of extension	0.0003	0.0004	0.0013*	0.0008	0.0011*	0.0006
Distance to market	0.0012	0.0018	-0.0100***	0.0038	-0.0072**	0.0031
Total expenditure	-0.0025**	0.0010	0.0001	0.0012	0.0001	0.0002
Sigma	0.0697	0.0035	0.1472	0.0074	0.1179	0.0059
Log-likelihood	243.443		95.916		139.791	
Number of observation	200		200		200	
LR chi^2 (13)	209.04		35.95		93.95	
Prob > chi^2	0.0000		0.0006		0.0000	
Pseudo R^2	-0.7524		-0.2307		-0.5061	

***, ** and * indicates the level of significance at 1%, 5%, and 10% respectively.

Source: Based on model output (2018)

Table 18: Marginal effects of technical, allocative and economic efficiencies after Tobit model

Variables	The marginal effect of TE			The marginal effect of AE			The marginal effect of EE		
	$\frac{\partial E(U)}{\partial X_j}$	$\frac{\partial E(U^*)}{\partial X_j}$	$\frac{\partial[\varphi(Z_N - \varphi(Z_L)]}{\partial x_j}$	$\frac{\partial E(U)}{\partial X_j}$	$\frac{\partial E(U^*)}{\partial X_j}$	$\frac{\partial[\varphi(Z_N - \varphi(Z_L)]}{\partial x_j}$	$\frac{\partial E(U)}{\partial X_j}$	$\frac{\partial E(U^*)}{\partial X_j}$	$\frac{\partial[\varphi(Z_N - \varphi(Z_L)]}{\partial x_j}$
Age	-.0000	-.0000	-0.000	0.0003	0.0002	0.0002	0.0001	0.0001	0.0000
Sex	0.1843	0.1790	0.0357	0.0018	0.0014	0.0011	0.1315	0.1243	0 .0090
Education	0.0030	0.0029	0.0007	0.0001	0.0008	0.0006	0.0020	0.0020	0.0000
Family size	-0.0002	-0.0002	-0.0001	0.0024	0.0019	0.0015	0.0012	0.0012	0.0000
Farm size	-0.0092	-0.0089	-0.0020	-0.0197	-0.0155	-0.0121	-0.0249	-0.0238	-0.0011
Distance farm to home	-0.0002	-0.0002	-0.0000	-0.0018	-0.0014	-0.0011	-0.0016	-0.0015	-0 .0001
Crop rotation	-0.0126	-0.0122	-0.0030	0.0717	0.0563	0.0382	0.0488	0.0466	0.0014
Livestock ownership	0.0142	0.0137	0.0032	-0.0142	-0.0111	-0.0087	0.0027	0.0025	0.0001
Non-farm income	0.0201	0.0195	0.0038	0.0270	0.0213	0.0143	0.0393	0.0376	0.0004
Credit use	0.0162	0.0010	0.0005	-0.0015	-0.0080	-0.0008	-0.0021	-0.0011	-0.0001
Frequency of extension	0.0003	0.0003	0.0001	0.0012	0.0009	0.0007	0.0011	0.0010	0.0000
Distance to market	0.0012	0.0012	0.0003	-0.0093	-0.0073	-0.0057	-0.0072	-0.0068	-0 .0003
Total expenditure	-0.0025	-0.0010	-0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001

Marginal effects computed only for significant variables and value in cell explain $\frac{\partial E(U)}{\partial X_j}$ (Total change), $\frac{\partial E(U^*)}{\partial X_j}$ (Expected change) and $\frac{\partial[\varphi(Z_N - \varphi(Z_L)]}{\partial x_j}$ (Change in probability).

Source: Model result

The results of Tobit regression model indicated that five variables out of thirteen variables were the significant effect on the technical efficiency of sample farmers. These are sex, education, livestock ownership, credit use and total expenditure. In addition, four variables (distance farm to home, crop rotation, frequency of extension contact and distance to market) had a significant effect on the allocative efficiency of the sample households. Other seven variables (sex, farm size, and distance farm to home, crop rotation, and non-farm income, frequency of extension contact and distance to nearest market) had a significant effect on the economic efficiency of the sample households. These variables are discussed separately as follows depending on their marginal effect.

Sex of the household head had a positive and statistically significant at the 1% level of significance effect on technical and economic efficiencies. This indicates the male household headed was better efficient than female. This indicates that the household head male would increase the probability of a farmer to fall under TE and EE by 3.57and 0.90 percent and the expected value of TE and EE by 17.90 and 12.43 percent with an overall increase in the probability and the expected level of efficiencies by 18.43 and 13.15 percent, respectively. This finding is in line with the study of Awol (2014), Mustefa (2014) and Sisay *et al*. (2015).

Education level of the household head had positive coefficient and statistically significant at the 10% level of significance related to technical efficiency. This shows the education status of the household head increases the technical efficiency of the barley producers increases. The educated household heads expected to increase managerial ability and guide to good decisions in farming systems; because of their better skills, access to information and good farm planning. Literate farmers are better to manage their farm resources, agricultural activities and willing to adopt improved production technologies than illiterate one. This indicates that education level of farmers in years of schooling become one year higher than others, technical efficiency of the barley producers' would increase the probability of a farmer to fall under TE 0.07 percent and expected value of TE by 0.29 percent with an overall increase in the probability and the expected level of technical efficiency 0.30 percent.This finding is similar to the study of Mustefa (2014), Sisay *et al*. (2015) and Moges (2017).

Farm size is important to assess whether the large farms are more efficient or not**.** It was found negative and statistically significant at the 5% level of significance related to economic efficiency. This implies that the farmers were operated small area of land is more efficient than large area farm size. If the farm size of farmers small relative to others, the economic efficiency of farmers better to the counterparts.a unit change increase in farm size would decrease by 0.11 percent change in the probability of a farmer of economic and the expected value of EE by 2.38 percent with an overall decrease in the probability and expected the level of efficiency by 2.49 percent. This result is in line with the study of Sisay *et al*. (2015) but inconsistent with the study made of Mustefa (2014).

The distance of the farm from the home of the household was found negative and statistically significant at 5% level of significance related to both allocative and economic efficiency. This implies that as the distance of the farm from home increases the allocative and economic efficiency decreases. The negative coefficient indicates that farmers home far from the farm of the households are less allocative and economic efficiency compared to their counterparts. This was in the cause of farmers far from their farm were earning more cost compared to her/his counterparts. The distance of the farm from home increases would decrease the probability of a farmer to fall under AE and EE by 0.11 and 0.01 percent and the expected value of AE and EE by 0.14 and 0.15 percent with an overall decrease in the probability and expected the level of efficiencies by 0.18 and 0.16 percent, respectively. This finding is supported by the study of Ermiyas (2013), Mustefa (2014) and Moges (2017).

Crop rotation is a dummy variable which represents whether the farmer adopted crop rotation or not. It found positive and statistically significant for allocative and economic efficiency at 1% and 5% significance level respectively. It was hypothesized that farmers who practiced crop rotation had more efficient than their opposite-parts, as it helps to increase output by recycling and restoring nutrients required for barley production. As a result, adopted crop rotation specially cereals with legume crops can restore and keep soil fertility, so increase the allocative and economic efficiency of barley producers. Each farmer adopted crop rotation would increase the probability of a farmer to fall under AE and EE category by 3.82 and 0.14 percent and the expected value of AE and EE by 5.63 and 4.66 percent with an overall increase in the probability and the expected level of efficiencies by 7.17 and 4.88 percent, respectively. This result is similar to the study made by Mustefa (2014).

Livestock ownership owned by household was hypothesized to have a positive effect on efficiency. The result found farmers having more livestock were positive and statistically significant at the 5% level of significance related to technical efficiency. This means that, farmers increased their number of livestock holding by one TLU could increase their technical efficiency the probability of TE by 0.32 percent and expected value of TE by 1.37 percent with an overall increase in the probability and the expected level of technical efficiency by 1.42 percent. This finding is in line with the study of Mustefa (2014).

Participation in non-farm income activity is a dummy variable which represents whether the farmer participates in non-farm activity or not. It had positive and statistically significant at 10% level of significance connected to economic efficiency. This suggests that the income obtained from such non-farm activities could be used for the purchase of agricultural inputs and enhances financing household expenditures which would also put pressure on on-farm income. This could be due to the most non-farm activities (petty trade, selling local drink, wage employment, selling firewood and handcraft) performed by the sample households. This implied hat farmers used the income earned from different non-farm activities to cover their budget constraint to purchase the required farm inputs. Farmers were participated in non-farm income, economic efficiency of the barley producers would increase the probability of a farmer to fall under EE by 0.04 percent and the expected value of EE by 3.76 percent with an overall increase in the probability and the expected level of economic efficiency by 3.93 percent. This finding is agreed with the study of Ermiyas (2013) and Moges (2017).

The amount of credit use affected the efficiency of farmers positively and statistically significant at the 10% level of significance related to technical efficiency. This indicates that farmers who use more credit have a higher level of technical efficiency. Credit use was easy change the cash constraint outwards and enables farmers to make timely purchases of inputs that they cannot afford from their own sources. This means that farmers who had to use more credit could increase their technical efficiency the probability of TE by 0.05 percent and expected value of TE by 0.1 percent with an overall increase in the probability and the expected level of technical efficiency by 1.62 percent. This finding is similar to the study of Ermiyas (2013), Musa (2013), Hailemaraim (2015) and Desale (2017).

The frequency of extension contact had a positive and statistically significant effect at the 10% level of significance related with an allocative and economic efficiency of barley production. Which are, the farmers who had a number of extension visit days during the production season, allocativelly and economically more efficient than those who had less number of extension visit day during the production season of in the year. Each farmer increase in the frequency of extension contact would increase the probability of a farmer to fall under AE and EE category by 0.07 and 0.00 percent and the expected value of AE and EE by concerning 0.09 and 0.10 percent with an overall increase in the probability and the expected level of efficiencies by 0.12 and 0.11 percent, respectively. This result is agreed with the study made by Ermiyas (2013), Musa (2013), Mustefa (2014) and Sisay *et al.* (2015).

Distance to nearest market was found to negatively and statistically significant at 5% level of significance related to both allocative and economic efficiency. This implies that as the distance of the farmer home far from the nearest market, the allocative and economic efficiency decreases and this is the cause of the transportation cost were increasing. This result indicates that increasing the distance to the nearest market by one km would decrease the probability of a farmer to fall under AE and EE category by 0.57 and 0.03 percent and the expected value of AE and EE by 0.73 and 0.68 percent with an overall decrease in the probability and expected the level of AE and EE by 0.93 and 0.72 percent, respectively. This finding is similar to the study of Bealu *et al.* (2013), Musa (2013) and Mustefa (2014).

The non-input total expenditure of households had negative and statistically significant at 5% level of significance relationships with technical efficiency of farmers. This indicates that the farmers total expenditure was more consume to different aspects without agriculture expense, the technical efficiency of farmers decrease relative to the counterparts. Based on the survey information majority of sample respondents their income is much to spend for the consumption of their household feed and social obligations. This finding result is similar to the study of Mustefa (2014) and Moges (2017).

5. SUMMARY, CONCLUSION, AND RECOMMENDATIONS

5.1. Summary

The objective of this study was to estimate the levels of technical, allocative, and economic efficiency and identify factors affecting these efficiencies of the smallholder producers in barley production in Legambo district, South Wollo, Amhara region, Ethiopia. Both qualitative and quantitative types of data were used from primary and secondary source of data. The two-stage random sampling technique was employed to draw the appropriate sample households which were interviewed using a structured questionnaire to obtain data related to input usage and different factors. Two-stage random samplings were used. Four kebeles out of 11 barley producing kebeles were selected randomly. In the second stage, 200 farmer households were selected randomly from four selected kebeles based on probability proportion to size.

The appropriate collected data were analyzed by descriptive and econometric methods. The descriptive parts measure mean, frequency, percentages, and standard deviation were used; and in the econometric model analyses, Cobb-Douglass production function with stochastic frontier approach was applied to estimate the levels of technical, allocative and economic efficiency and Tobit model was applied to identify factor affecting of these efficiencies of smallholder barley producers in the study district. The results of the stochastic production frontier model indicated that all inputs (labor, oxen power, fertilizer, land, and seed) had positive and significant effect on barley production. This result is shown that there was significant amount of variation of efficiency among barley producers. Accordingly, the mean of technical, allocative and economic efficiencies were 75.1, 71.7 and 53.9% respectively. The value of lambda was $(\lambda = 1.767)$. So, the value of the gamma parameter (γ=0.757) which indicated that 75.7% of the total variation in barley output due to farmers were used resource inefficiently. The result of the Tobit model indicated that technical efficiency was positively and significantly affected by sex, education, livestock, non- farm income, credit use; however, total expenditure had a negative and significant effect. Distance of farm from home and distance to nearest market were negatively and significantly affected on allocative efficiency; whereas, crop rotation and frequency of extension contact had a positive. Economic efficiency was negatively and significantly affected by farm size, a distance of farm from home and distance to the nearest market; while, crop rotation, sex, non-farm income and frequency of extension contact had a positive and significant effect.

5.2. Conclusion

The study was conducted that smallholder barley producers are resource use efficiently in the production of barley production with the mean of technical, allocative and economic efficiency levels were 75.1, 71.7and 53.9%, respectively. This implies that the farmers can increase their barley production on average by 24.9%, they were technically efficient, reduce the current cost of inputs, on average by 28.3% they were allocatively efficient and the result also indicated that reduce 46.1% on average of their costs of production the farmers were economically efficient.

The result of the production function indicated that labor, oxen power, fertilizer, land, and seed had positive coefficients of 0.114, 0.153, 0.029, 0.362and 0.481 respectively. This means that the use of these inputs increasing by one unit, the barley output increase by 11.4, 15.3, 2.9, 36.2 and 48.1% respectively. Accordingly the result of Tobit model, the technical efficiency was positively and significantly affected by sex, education, livestock, non-farm income, and credit use; however, total expenditure affected negatively and significantly. This indicates that male-headed households, higher educated farmers, have more livestock, participating in non-farm income, credit use and lower expenditures were higher technically efficient. The distance of farm from home and distance to nearest market were negatively and significantly affected the allocative efficiency; whereas, crop rotation and frequency of extension contact had a positive effect. This implies increase in the distance of farm from home and distance to the market, allocative efficiency decrease; whereas, crop rotation and more contact with the extension service were increased the allocative efficiency. And economic efficiency negatively and significantly affected by farm size, a distance of farm from home and distance to the nearest market; while, crop rotation, sex, non-farm income and frequency of extension contact had a positive and significant effect. This means that large farm size, increase distance farm from home and distance to the market, the economic efficiency decreased; however, farmers have adopted crop rotation, male-headed households, participating in non-farm activities and more contact with the extension service increases the economic efficiency of farmers than their counterparts.

5.3. Recommendations

Based on the results of the study, the following recommendations are drawn:

The positive and significant coefficient of labor, oxen power, fertilizer, land, and seed indicate the significance of these inputs to increasing barley production. The local governments should put more emphasis on strengthen the efficient use of labor, oxen power, fertilizer, land, and seed for the farmers in the study area.

Sex of households' head had a positive and significant effect on technical and economic efficiency. This implies that male-headed households had better efficient than female-headed households. Therefore, local governments and gender office should focus on how to strengthen female farmers to improve their level of efficiency through experience sharing, giving training on input use and market information, and promoting credit use to improve their agricultural productivity.

Education level had a positive and significant effect on the technical efficiency of barley producers. So, the regional and local government should focus on how to deliver sufficient and effective basic educational opportunities for farmers. The district education office should provide youth training centre, practical training, create awareness and knowledge about the application of inputs, technology and different farming system.

Farm size had a negative and significant effect on economic efficiency. Therefore, the district government should give attention for large farm size farmers to enhance the efficiency in their production through providing training how to manage the large farm and material support of large farm farmers.

Crop rotation had a positive and significant effect on allocative and economic efficiency. Therefore, the concerned bodies; like extension workers, rural and agricultural development offices should have to work more on practice crop rotation by giving a positive reception to the existing condition of the farmers and create awareness to non adopted farmers about the importance of crop rotation.

Livestock ownership had a positive and significant effect on technical efficiency. That means farmers have more number of livestock were better technical efficiency of barley production. Hence, design appropriate policy and strategies for improving livestock production and productivity systems, which helps to enhance the technical efficiency of barley output. Therefore, the regional and local government should focus on the mixed farming system were livestock and crop production.

Non-farm income had a positive and significant effect on technical and economic efficiency in the study area. So, local government should focus on how to introduce non-farm activities that enhance the income of households, create awareness diversification system of non-farm income activities that helps to an additional income to facilitate the necessary resource used for barley production.

Credit use had a positive and significant effect on the technical efficiency of barley producers. This means farmers who were using credit more efficient than not use. Therefore, the regional and local governments should intervene to strength the operation of rural saving and credit institutions at the village level and creates awareness for the farmers. Amhara credit and saving institution (ACSI) should focus on how to provide credit services, create awareness about credit use and create better access for the farmers.

The frequency of extension contact had a positive and significant effect on the allocative and economic efficiency of barley producers. Therefore, district governments and other concerned bodies (like agricultural officice) should give more emphasis on strengthening of agricultural extension service through providing training, upgrading the educational level and assigning the right position/responsibilities of extension workers with their profession.

The distance to the nearest market had a negative and significant effect on allocative and economic efficiencies. The local governments should improve the efficiency of the farmers through developing road and market infrastructure to reduce home to market distance and launching new markets around their home to purchase farm inputs and to sell their outputs with a minimum transaction cost.

The total non-input expenditure of households which is excluding for production inputs had a negative and significant effect on the technical efficiency of barley producers in the study area. The policymaker should have strong work on create awareness on the use of efficient allocation resources, mostly on the money resource.

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7. APPENDICES

Appendix 1: Appendix Tables

Appendix table 1: Conversion factor for computation of man- equivalent

	Man-equivalent	
Age group	Male	Female
<10	0	0
11-13	0.2	0.2
14-16	0.5	0.4
17-50	1.0	0.8
>50	0.7	0.5

Source: Strock *et al*., 1991(as cited by Moges, 2017)

Appendix table 2: Conversion factors used to estimate TLU

Animals	TLU
Cow/ox	1.000
Bull	0.800
Calf	0.200
Sheep young	0.060
Sheep adult	0.130
Donkey young	0.350
Donkey adult	0.700
Chicken	0.013
Heifer	0.750
Horse/mule	1.100
Camel	1.250

Source: Strock *et al*., 1991(as cited by Moges, 2017)

Appendix table 3: Scores of technical efficiency of the sample farmers

FI	TE	FI	TE	FI	TE	FI	TE	FI	TE
1	0.724116	42	0.73709	83	0.73189	124	0.734577	165	0.847953
2	0.670575	43	0.767358	84	0.795344	125	0.867477	166	0.770936
3	0.763937	44	0.803882	85	0.739519	126	0.863858	167	0.891441
4	0.78991	45	0.830855	86	0.684556	127	0.783537	168	0.64264
5	0.846677	46	0.872228	87	0.790227	128	0.768257	169	0.496788
6	0.652291	47	0.629755	88	0.64373	139	0.782833	170	0.51505
7	0.788785	48	0.763314	89	0.869231	130	0.837395	171	0.669289
8	0.762429	49	0.830193	90	0.842666	131	0.813766	172	0.889984
9	0.607672	50	0.644097	91	0.793714	132	0.496511	173	0.474026
10	0.746827	51	0.797349	92	0.62178	133	0.679946	174	0.876479
11	0.730103	52	0.804345	93	0.782858	134	0.837158	175	0.878434
12	0.77129	53	0.799859	94	0.57436	135	0.702098	176	0.582724
13	0.717816	54	0.653292	95	0.710991	136	0.828377	177	0.695474
14	0.773823	55	0.770456	96	0.868142	137	0.638114	178	0.49035
15	0.781907	56	0.850082	97	0.725158	138	0.924844	179	0.702797
16	0.647683	57	0.761286	98	0.68887	139	0.459524	180	0.731231
17	0.781593	58	0.817724	99	0.87324	140	0.792119	181	0.693947
18	0.826023	59	0.640581	100	0.718139	141	0.861793	182	0.494018
19	0.810397	60	0.762177	101	0.90122	142	0.749614	183	0.780762
20	0.711669	61	0.794853	102	0.639911	143	0.667409	184	0.919393
21	0.761036	62	0.460762	103	0.761232	144	0.881677	185	0.893962
22	0.876257	63	0.83377	104	0.866461	145	0.672363	186	0.873483
23	0.815336	64	0.846903	105	0.797771	146	0.819952	187	0.815506
24	0.708691	65	0.718756	106	0.633344	147	0.847337	188	0.870463
25	0.53857	66	0.902203	107	0.818056	148	0.889676	189	0.900622
26	0.817743	67	0.881896	108	0.766012	149	0.418757	190	0.796057
27	0.687533	68	0.64644	109	0.865434	150	0.895684	191	0.911818
28	0.867208	69	0.880337	110	0.777129	151	0.74689	192	0.929466
29	0.811874	70	0.705824	111	0.576904	152	0.883224	193	0.830268
30	0.862594	71	0.488461	112	0.731697	153	0.5182	194	0.919003
31	0.519761	72	0.783146	113	0.728462	154	0.776083	195	0.890909
32	0.430587	73	0.843972	114	0.723368	155	0.773879	196	0.882027
33	0.782284	74	0.722079	115	0.711533	156	0.445135	197	0.740749
34	0.754345	75	0.81236	116	0.840701	157	0.871095	198	0.706095
35	0.734277	76	0.895363	117	0.744794	158	0.753198	199	0.444364
36	0.804711	77	0.74505	118	0.83479	159	0.808336	200	0.816026
37	0.614875	78	0.714744	119	0.879024	160	0.853054		
38	0.552625	79	0.801384	120	0.82947	161	0.729243		
39	0.819651	80	0.737368	121	0.883125	162	0.771405		
40	0.703923	81	0.545768	122	0.698963	163	0.87293		
41	0.710514	82	0.825783	123	0.491161	164	0.503022		

Source: Own computation (2018)

Appendix table 4: Scores of allocative efficiency of the sample farmers

FI	AE	FI	AE	FI	AE	FI	AE	FI	AE
1	0.887334	42	0.901273	83	0.78141	124	0.888843	165	0.825794
2	0.599544	43	0.839856	84	0.771806	125	0.73652	166	0.473027
3	0.868383	44	0.943179	85	0.883268	126	0.931604	167	0.557045
4	0.84512	45	0.891458	86	0.419045	127	0.84076	168	0.551984
5	0.481223	46	0.600922	87	0.516181	128	0.920223	169	0.612486
6	0.515297	47	0.895315	88	0.42162	139	0.840319	170	0.640823
7	0.457868	48	0.938474	89	0.395856	130	0.923515	171	0.550606
8	0.537487	49	0.792813	90	0.770497	131	0.779041	172	0.578136
9	0.37815	50	0.754677	91	0.395639	132	0.815191	173	0.456908
10	0.567027	51	0.865543	92	0.539421	133	0.917913	174	0.798608
11	0.588599	52	0.89225	93	0.869074	134	0.848262	175	0.932128
12	0.885497	53	0.771293	94	0.80778	135	0.936245	176	0.891914
13	0.619293	54	0.700287	95	0.700108	136	0.510449	177	0.802114
14	0.847534	55	0.808828	96	0.703113	137	0.533791	178	0.94365
15	0.706524	56	0.622885	97	0.686251	138	0.823386	179	0.801848
16	0.623528	57	0.630945	98	0.572781	139	0.47282	180	0.944707
17	0.659895	58	0.612382	99	0.480569	140	0.571782	181	0.611469
18	0.649936	59	0.740855	100	0.443719	141	0.468706	182	0.485842
19	0.60766	60	0.610668	101	0.391764	142	0.430753	183	0.564164
20	0.723662	61	0.376537	102	0.525114	143	0.532955	184	0.926558
21	0.691634	62	0.435327	103	0.54776	144	0.710754	185	0.723923
22	0.73191	63	0.608608	104	0.59855	145	0.577852	186	0.873626
23	0.662982	64	0.573752	105	0.40767	146	0.61766	187	0.888437
24	0.827674	65	0.525665	106	0.454303	147	0.613701	188	0.625136
25	0.581135	66	0.398088	107	0.485726	148	0.64264	189	0.888737
26	0.593109	67	0.443216	108	0.535831	149	0.67388	190	0.730032
27	0.846998	68	0.605339	109	0.933194	150	0.563688	191	0.745453
28	0.667657	69	0.896401	110	0.731025	151	0.564569	192	0.72821
29	0.951258	70	0.75772	111	0.800083	152	0.858589	193	0.699507
30	0.773767	71	0.691561	112	0.770085	153	0.938822	194	0.893632
31	0.920869	72	0.714271	113	0.952343	154	0.835096	195	0.820972
32	0.79758	73	0.551503	114	0.790417	155	0.745707	196	0.671994
33	0.596591	74	0.858176	115	0.854477	156	0.947665	197	0.945763
34	0.771458	75	0.863595	116	0.883193	157	0.881187	198	0.849748
35	0.876324	76	0.819994	117	0.729214	158	0.658615	199	0.738091
36	0.756019	77	0.792947	118	0.865584	159	0.659947	200	0.935505
37	0.839489	78	0.783115	119	0.801045	160	0.786239		
38	0.92242	79	0.843959	120	0.590977	161	0.598311		
39	0.754422	80	0.951498	121	0.904788	162	0.931895		
40	0.675204	81	0.894928	122	0.770347	163	0.717909		
41	0.874038	82	0.859812	123	0.828418	164	0.91871		

Source: Own computation (2018)

Appendix table 5: Scores of the economic efficiency of the sample farmers

FI	EE	FI	EE	FI	EE	FI	EE	FI	EE
1	0.642533	42	0.664319	83	0.571907	124	0.652924	165	0.700235
2	0.40204	43	0.64447	84	0.613851	125	0.638914	166	0.364674
3	0.66339	44	0.758205	85	0.653193	126	0.804773	167	0.496572
4	0.667569	45	0.740672	86	0.28686	127	0.658766	168	0.354727
5	0.40744	46	0.524141	87	0.4079	128	0.706967	169	0.304276
6	0.336123	47	0.563828	88	0.27141	139	0.657829	170	0.330056
7	0.36116	48	0.71635	89	0.34409	130	0.773348	171	0.368515
8	0.409796	49	0.658188	90	0.649272	131	0.633956	172	0.514532
9	0.229791	50	0.486085	91	0.314024	132	0.404751	173	0.216586
10	0.423471	51	0.69014	92	0.335401	133	0.624132	174	0.699963
11	0.429738	52	0.717677	93	0.680361	134	0.71013	175	0.818813
12	0.682975	53	0.616925	94	0.463957	135	0.657335	176	0.519739
13	0.444538	54	0.457492	95	0.497771	136	0.422845	177	0.557849
14	0.655841	55	0.623166	96	0.610402	137	0.340619	178	0.462719
15	0.552436	56	0.529503	97	0.497641	138	0.761504	179	0.563536
16	0.403848	57	0.480329	98	0.394572	139	0.217272	180	0.690799
17	0.51577	58	0.50076	99	0.419652	140	0.45292	181	0.424327
18	0.536862	59	0.474578	100	0.318652	141	0.403927	182	0.240015
19	0.492446	60	0.465437	101	0.353065	142	0.322898	183	0.440478
20	0.515008	61	0.299292	102	0.336026	143	0.355699	184	0.851871
21	0.526359	62	0.200582	103	0.416972	144	0.626655	185	0.64716
22	0.641341	63	0.507439	104	0.51862	145	0.388526	186	0.763097
23	0.540553	64	0.485913	105	0.325227	146	0.506451	187	0.724526
24	0.586565	65	0.377825	106	0.28773	147	0.520012	188	0.544157
25	0.312982	66	0.359156	107	0.397351	148	0.571741	189	0.800416
26	0.485011	67	0.39087	108	0.410453	149	0.282192	190	0.581147
27	0.582339	68	0.391315	109	0.807617	150	0.504886	191	0.679718
28	0.578998	69	0.789135	110	0.568101	151	0.421671	192	0.676846
29	0.772302	70	0.534816	111	0.461571	152	0.758326	193	0.580778
30	0.667446	71	0.337801	112	0.563469	153	0.486498	194	0.82125
31	0.478632	72	0.559378	113	0.693746	154	0.648103	195	0.731411
32	0.343428	73	0.465453	114	0.571762	155	0.577087	196	0.592717
33	0.466703	74	0.619671	115	0.607989	156	0.421839	197	0.700573
34	0.581945	75	0.70155	116	0.742502	157	0.767597	198	0.600002
35	0.643465	76	0.734193	117	0.543114	158	0.496067	199	0.327981
36	0.608376	77	0.590785	118	0.722581	159	0.533459	200	0.763396
37	0.516181	78	0.559727	119	0.704138	160	0.670704		
38	0.509752	79	0.676335	120	0.490197	161	0.436314		
39	0.618363	80	0.701604	121	0.799041	162	0.718868		
40	0.475291	81	0.488423	122	0.538444	163	0.626685		
41	0.621016	82	0.710018	123	0.406887	164	0.462131		

Source: Own computation (2018)

Appendix 2: Data collection Tools

QUESTIONNAIRE

Questionnaire on: Economic efficiency of smallholder producers in barley production: The case of Legambo district, South Wollo Zone, Amhara Region, Ethiopia**.**

The main aim of this study is providing academic research advice regarding the level of economic efficiency (technical, allocative, and economic efficiencies) of barley production to Legambo district, South Wollo Zone in the Amhara Region of Ethiopia. Moreover, the demographic, socioeconomic, institutional and other factors that affect economic efficiency in barley production are also determined. After this study gives the recommendation for the study area community, Legambo district concerned body about barley production efficiency and factors.

Instruction:

- Introduce yourself and tell the purpose of the study before starting the interview.
- For all closed questions encircle the appropriate response and use the space provided for open-ended questions.

Name of Enumerator ____________________________ Date _______________

Questionnaire Number ____ Kebele ____.

Part 1: General Information on Farm Household

1. General information

1.1. Name of the kebele____

1.2. Name of the respondent _______________________Date of interview_____________

1.3. Respondent identification number (code) ____________________________

1.4. Age of the household head_________ years.

1.5. Sex of the household head. 1. Male 2. Female

1.6. Education status of the household head attained_______________grade.

1.7. Marital status: 1. Single 2. Married 3. Divorced 4. Widowed

1.8. Years of farming experience ___year.

1.9. For how long have you been producing barley? _______Years.

1.10. Family size? Male ________ Female_________ Total____________

1.11. Family age distributions.

No.	Name of family member	Age	Sex 1=If female 2=Male	Relationship 1=Father 2=Mother 3=Children 4=Relatives 5=Other	Educational level 1.Illiterate (0) 2.Read and write (1-3) 3.Primary-schooling(4-8)4.High-school(9-12) 5.Above >12
1					
2					
3					
4					
5					
6					

Part 2: Crop Production and inputs

1. Crops produced and type of inputs used in 2017/18 production season?

Type of Crop	Land allocated (Ha)	Production (Qt)	Type of seed used		Did you use fertilizer?		
			Local seed (kg)	Improved seed (kg)	Yes		No
					NPS (kg)	Urea (kg)	
Barley							
Wheat							
Teff							
Bean							
Pea							
Lentil							
Others							

2. What is your reason to produce barley? 1. High yield 2. Required lower labor
   3. High grain price 4. Pest and disease tolerance 5.No other alternative
   6. Other, ____
3. Do you have your own means of transportation? 1. Yes . 2No
4. If yes, what? 1. Motor bike 2. Bike 3. Horse 4. Mule 5. Others_____________

5. What is your source of barley seed? 1. Own 2. From market 3. Agriculture office 4. Other____

6. Do you use organic fertilizer on a barley field in the 2017/2018 year? 1. Yes 2. No

7. If yes, what kind of organic fertilizer do you use? 1. Green manure 2. Animal waste 3. Compost 4. Others, ___________________________________

8. How many Kg of organic fertilizer do you apply for your barley production 2017/18 year? _____.

9. If you are not using organic fertilizer, why? 1. Its bulkiness to transport 2. Lack of awareness 3. I don't have animals to prepare it
   4. Others ____.

10. Do you use inorganic fertilizer in a barley field in the 2017/2018 year? 1. Yes2. No

11. If yes, what kind of inorganic fertilizer do you use? 1. NPS 2. Urea 3.Both

12. If yes, how many Kg of NPS? ______and how many Kg of Urea use? _____.

13. How much money did you pay per Kg? _________

14. If you do not use inorganic fertilizer, why? 1. Not timely available 2. Not available on all 3. Inconvenient to transport 4. Not good to apply for barley field 5. Too expensive 6. Others ____________________________

15. Do you practice plowing? 1. Yes 2. No

16. If yes, after how many years of harvesting do you plow your land? _________years

17. How long you plow your land? _____Years.

18. Is weeding barley crop a common practice? 1. Yes2. No

19. If yes, when did you start weeding barley? _______week of ______month.

20. How many times do you weed your barley? _______times.

21. What method do you use for weeding?
    1. Hand weeding 2. Use chemicals 3. Others________________________

22. Do you use improve barley varieties this year? 1. Yes2. No

23. If yes, how many Kg use improve barley varieties this year? ______

24. If no, why? 1. Too expensive 2. Not better than local varieties 3. It is a dwarf
 4. It is not easily accessible 5. Others __________________________

25. Did you practice crop rotation for barley production? 1. Yes 2. No

26. If yes, what kind of practice? 1. Barley to other cereals 2. Barley to legume crops
    3. Others____

27. If no, why? ____

28. How many plots or locations do you have? ___________

29. Total size of land covered by annual crops in 2017/18 year_____timad.
30. How many plots did you use to produce barley in the year 2017/18? _______Plots.
31. On what land do you produce barley? 1. Owned 2. Rented in 3. Shared in
4. Shared Out 5. Other,____________________________.
32. If the land is rented, the total size of land rented in, in 2017/18 year_____timad.
33. If own land rented out, the total size of own land rented out at 2017/18 year_____timad.
34. If the land is rented in, how much did you pay per timad? ____birr
35. If the land is rented out, what is the price per timad? _________birr.
36. If land share out, the total size of land share cropped out in 2017/18 year_____timad.
37. If a land shares in, the total size of land share cropped in 2017/18 year ____timad.
38. If the land is share out, how much did you pay per timad? ____birr
39. If the land is share in, what is the price per timad? _______birr
40. Characteristics of barley farm

No.	Name of farm	Farm distance from home (minute)	Crop grew last year	Farm status 1. Owned 2. Rented in 3.Sharedin 4.Shared out
1				
2				
3				
4				
5				
Average				

41. Hove you own oxen? 1. Yes 2. No
42. If yes, how many oxen you have? _____.
43. If no, what is your source of oxen for the 2017/18 production season?
1. Own 2. Rented 3. Shared 4. Others ____________________
44. Have you hired labor for your barley farm in the 2017/18 production season?
    1. Yes 2. No
45. Amount of human labor and oxen power allocate for barley production?

	No. of day	Human Labor		Wage per worker	Quantity	Total Expenditure	Oxen no.		Rate per oxen
		Family	Hired labor				Own	Rent	
Ploughing1									
Ploughing2									
Ploughing3									
Ploughing4									
Sowing									
Fertilizer application									
Weeding1									
Weeding2									
Harvesting									
Threshing									
Transportation									

46. How many hours per day did you use? 1. Oxen ___ hr. 2. Family labor__ hr. 3. Hired labor __ hr.
47. Is there disease and pest occurrence in your barley farm in the year of 2017/18 production season? 1. Yes 2. No
48. If yes, do you apply any chemical for control? 1. Yes 2. No
49. Do you use pesticides and herbicides in a barley field in 2017/18 production season? 1. Yes 2. No
50. If yes, how much do you use in Litter? ________and how much money did you pay in Birr? ________ .
51. If yes, what is the total cost of herbicide and pesticide use for production of barley in 2017/18?

Name of herbicide and pesticide	Unit	Amount in Lt	Unit price/Lt	Total price

52. If no, why? 1. Too expensive 2. Lack of knowledge 3. Not timely available 4. Not available at all 5. Not effective 6. Risky for animals

7. Other ____

Part3: Information on prices of barley production inputs

<table>
<tr><th rowspan="2">No.</th><th rowspan="2" colspan="2">Input</th><th colspan="2">Quantity</th><th rowspan="2">Unit price</th></tr>
<tr><th>Own</th><th>Purchase</th></tr>
<tr><td rowspan="2">1</td><td rowspan="2">Seed</td><td>Local</td><td></td><td></td><td></td></tr>
<tr><td>Improve</td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Fertilizer</td><td>Urea</td><td></td><td></td><td></td></tr>
<tr><td>NPS</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">Land</td><td>Rent in</td><td></td><td></td><td></td></tr>
<tr><td>Owned</td><td></td><td></td><td></td></tr>
<tr><td>Shared in</td><td></td><td></td><td></td></tr>
<tr><td>Shared out</td><td></td><td></td><td></td></tr>
<tr><td rowspan="3">4</td><td rowspan="3">Oxen</td><td>Own</td><td></td><td></td><td></td></tr>
<tr><td>Rent</td><td></td><td></td><td></td></tr>
<tr><td>Shared</td><td></td><td></td><td></td></tr>
<tr><td>5</td><td colspan="2">Wage for labor</td><td></td><td></td><td></td></tr>
</table>

Part 4: Wealth, Farm Resources and Non-farm activities

1. Type of animal owned by the sample farmer.

No.	Type of livestock owned		Numbers of livestock	Livestock sold (birr)
1	Oxen			
2	Bull			
3	Cow			
4	Calves			
5	Donkey	Adult		
		Young		
6	Horse			
7	Mule			
8	Sheep	Adult		
		Young		
10	Poultry			
11	Beehives			
12	Others			
Total				

2. Annual income from annual agricultural production.

No.	Type of annual crop	Area (timad)	Quantity produced (Qt)	Quantity sold (in Qt.), if any	Unit price	Total Value
1	Barley					
2	Wheat					
3	Teff					
5	Bean					
6	Pea					
7	Lentil					
8	Others					

3. Do you have any source of income from other than farm activities? 1. Yes 2. No
4. If yes, what are the main sources of income generating activities of the household?

No.	Activities (sources)	Numbers of family members engaged	Annual income in Birr	In kind
	Non-Farm			
1	Petty trade			
2	Selling local drink			
3	Wage employment			
4	Selling fire wood			
5	Handcraft			
6	Remittances			
7	Rent from asset			

5. How much total income did you get from non-farm activities in production year 2017/18? _____Birr.

Part 5: Institutional factors

Credit service

1. Do you have any source of credit? 1. Yes 2. No
2. If yes, how much did you borrow in Birr? ___________.
3. If yes, what sources of credit do you have? 1. Formal sources 2. Informal 3. Both
4. What are the formal sources of credit institutions? 1. Commercial banks 2. Amhara Credit and Saving Institution (ACSI) 3. Others____________________________
5. Which one of the following are the informal sources of credit you use?
   1. Traders 2. Relatives 3. Friends 4. Others ________________
6. If in "1'' yes, for what purpose do you borrow for the 2017/18 production season?

No.	Purpose		Amount	Source	Timely repaid	Remained unpaid
	Fertilize	NPS				
		Urea				
1	Seed					
2	School					
3	Health care					
4	Basic needs					
5	Chemical					
6	Livestock					

7. Which time frame is expected for the credit repaid? _________months
8. How much is the interest rate per month? ________%
9. What collateral is requested for the credit? 1. Animals 2. Land 3. Durable goods 4.Friends or relatives 5. No guarantee 6. Others________________

Extension Service

1. Do you get agricultural extension contact? 1. Yes 2. No
2. If 'yes' how many times do you contact DAS at production season in this year? _______________
3. How many times do you visit the extension workers?
   1. Weekly 2. Monthly 3. Quarterly 4. Others _________________________
4. Average frequency of contact with DA and extension professions in 2017/18 ______ times in week. ______times in a month. _________times in a year.
5. Is there a farmer-training center in your area? 1. Yes 2. No
6. If yes, do you get any practical training with regard to barley production? 1. Yes 2. No
7. If yes, how many trainings have you taken? ______________________
8. If yes, what types of training________________ duration___________.
9. How much barley you would have produced in 2017/18 had there not been an extension service? 1. The same as I produce 2. A little lower than I produce 3. Much lower than I produce 4. Totally impossible to produce without the extension service 5. I could not determine this way
10. What are the major agricultural extension service problems in the area?
    ____
11. What information did you obtain that influenced your barley production?
    ____

Marketing

1. How many quintals of barley did you produce in 2017/18 production year?
2. Do you have enough market demand for your barley product? 1. Yes 2. No
3. If no, what are the major reasons?
   ____.
4. Purpose of production of barley. 1. All for sale 2. All for consumption 3. Partly for consumption and partly for sale 4. others __________________________
5. What was the average selling price of barley? ______ birr/qt.
6. Do you have any information about barley production market access? 1. Yes 2. No

7. Do you believe that the current market price for barley is fair? 1. Yes 2. No
8. If no, what are the major reasons?

____

9. Who is the price for your barley product decided in the market?

1. By the farmer himself 2. By the merchants 3. By the market

4. Other ____

10. How far is the nearest market which you sell your barley product for your home? ______km.
11. How do you transport your barley product to the market?

1. Using human labor 2. By car3. By animal 4. Other ____________________

12. What is the selling price of one quintal of barley at harvest time in 2017/2018? _____
13. What is the selling price of one quintal of barley during the slack period 2017/2018? _______birr/qt.
14. Do you have unsold barley waiting for the better market season? 1. Yes 2. No
15. If yes, how many? _____ Quintals.
16. In which month/s do you expect to sell__________& at what price? ________birr/qt.
17. Do you have problems with regards to barley marketing? 1. Yes 2. No
18. If yes, what are the major problems? 1. Low price 2. High seasonal price fluctuation

3. Inadequate demand 4. High marketing cost 5. Lack of market information

19. In your opinion, what will be the solution for these problems?

____.

20. General annual expenditure of the household in the year 2017/18.

No.	Types of expenditure	The annual expense in birr
1	Consumptions	
2	Clothing	
3	Education	
4	Social obligation	
5	Medication	
6	Others	
	Total expenditure	

21. Distance from the home of the household to Infrastructure

No.	Type of infrastructure	Distance in hour
1	Nearest market	
2	School	
3	Health center	
4	DA office	
5	Farmer training center	

22. What are the major constraints of barley production? 1. Frost 2.Climate change 3. Shortage of Seed 4. Shortage of draft animal 5. Shortage of labor 6. Crop pest 7. Others, ___________________________________
23. Do you have anything to say about the barley production in this area? ____ ____.

Checklist for focus group discussions

1. What kind of inorganic fertilizer use in the area?
2. How much money did you pay per Kg of Urea/NPS?
3. What kind barley seed use?
4. What is your source of barley seed?
5. What kind of practice for crop rotation?
6. What source of land do you produce barley?
7. What is the price of land per timad?
8. What are the major characteristics of barley farm?
9. How long plow the land in the area?
10. What is the major source of oxen in the area?
11. What are the major annual crop productions in the area?
12. What is the total size of land covered by annual crops in 2017/18 year?
13. What are the main sources of income generating activities of the in the area?
14. What sources of credit use in the area?
15. What are the formal sources of credit institutions?
16. What are the informal sources of credit use?
17. What are the major agricultural extension service problems in the area?
18. What are the main purposes of production of barley?
19. What are the major constraints of barley production?