ECONOMIC EFFICIENCY OF BARLEY PRODUCTION: THE CASE OF SMALLHOLDER FARMERS IN MEKET DISTRICT, AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

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We hereby certify that we have read and evaluated this Thesis titled "*Economic Efficiency of Barley Production: The Case of Smallholder Farmers in Meket District, Amhara National Regional State, Ethiopia"* prepared under our guidance by Getachew Wollie. We recommended that it be submitted as fulfilling the thesis requirement.

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DEDICATION

I dedicate this thesis manuscript to all members of my family, for nursing me with love and for their keen partnership in the journey of my academic life.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this thesis. Any scholarly matter that is included in the thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

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LIST OF ACRONYMS AND ABBREVIATIONS

AE	Allocative Efficiency
COLS	Corrected Ordinary Least Squares
CRS	Constant Returns to Scale
CSA	Central Statistics Agency
DEA	Data Envelope Analysis
EE	Economic Efficiency
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
MASL	Meter Above Sea Level
MDP	Meket Development Program
ML	Maximum Likelihood
MWBARD	Meket Woreda Bureau of Agriculture and Rural Development
MWHO	Meket Woreda Health Office
SPF	Stochastic Production Function
TE	Technical Efficiency
TLU	Tropical Livestock Unit
UNDP	United Nations Development Program
WB	World Bank

TABLE OF CONTENTS

STATEMENT OF THE AUTHOR **v**

BIOGRAPHICAL SKETCH **vi**

ACKNOWLEDGEMENTS **vii**

LIST OF ACRONYMS AND ABBREVIATION **viii**

LIST OF TABLES **xii**

LIST OF FIGURES **xiii**

LIST OF TABLES IN THE APPENDIX **xiv**

ABSTRACT **xv**

1. INTRODUCTION **1**

1.1. Background of the study 1

1.2. Statement of the Problem 2

1.3. Objectives of the Study 4

1.4. Scope and limitation of the Study 4

1.5. Significance of the Study 4

1.6. Organization of the Thesis 5

2. LITERATURE REVIEW **6**

2.1. Theoretical Review 6

2.1.1. Basic concepts and definitions 6

2.1.2. Approach of measuring production efficiency 6

2.1.2.1. Input oriented approach of measuring efficiency 7

2.1.2.2. Output oriented approach of measuring efficiency 9

2.1.3. Models for estimating efficiency 10

2.1.3.1. Non- parametric frontier models 10

2.1.3.2. Parametric frontier model 11

2.1.4. Estimation approaches of inefficiency variables 12

2.2. Functional Forms of Production Function 13

2.2.1 Cobb- Douglas production function 13

2.2.2. Trans logarithmic functional form 14

2.3. Trends of barley production in Meket district 15

TABLE OF CONTENTS (*Continued*)

2.4. Empirical Review of Related Studies 16
2.4.1. Studies outside Ethiopia 16
2.4.2. Studies within Ethiopia 17
2.5. Conceptual Framework 20
3. RESEARCH METHODOLOGY 21
3.1. Description of the Study Area 21
3.2. Types, Sources and Methods of Data Collection 22
3.3. Sampling Technique and sample size 23
3.4. Method of Data Analysis 23
3.5. Definitions of Basic Variables 29
3.5.1. Variables of production function 29
3.5.2. Variables for cost function 30
3.5.3. Variables for the determinants of inefficiency 30
4. RESULTS AND DISCUSSIONS 34
4.1. Descriptive Results 34
4.1.1. Demographic characteristics of the sample households 34
4.1.2. Land holding, cropping system and crops grown 35
4.1.3 Characteristics of barley farms 37
4.1.4. Farm operations 38
4.1.5. Farm and farmers related factors 38
4.1.6. Institutional factors 39
4.1.7. Barley output and input usage 39
4.1.8. Cost of production 41
4.1.9. Bottleneck problems in barley production 41
4.2. Results of Econometric Models 42
4.2.1. Hypothesis testing 42
4.2.2. Estimation of production function 44
4.2.3. Elasticity of production 46
4.2.4. Cost of production function 46
4.2.5. Technical, allocative and economic efficiencies scores of barley producers 47
4.2.6 Distribution of efficiencies score 48
4.2.7. Sources of inefficiency variation among barley producers 49

TABLE OF CONTENTS (*Continued*)

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS **55**

5.1. Summary and Conclusions 55

5.2. Recommendations 56

6. REFERENCES **59**

7. APPENDICES **66**

LIST OF TABLES

Table	Page
1. Number of households selected from sample *kebeles*	23
2. Age, education level, household size and farming experience	34
3. Sex and Marital status of the sample household farmers	35
4. Major crops grown with total output and number of growers	36
5. Crop rotation, soil fertility status and non-farm income	37
6. Farm and farm related factors	38
7. Three major institutional factors	39
8. The mean of barley output produced with major inputs	40
9. The total cost of barley output	41
10. Major constraints for barley production	42
11. Generalized likelihood ratio tests of hypothesis for the parameters of the SPF	42
12. Production and dual cost function model	45
13. Technical, allocative and economic efficiencies of barley	48
14. Efficiencies distribution	49
15. Source of technical, allocative and economic inefficiencies	50

LIST OF FIGURES

Figures **Page**

1. Input oriented measures of efficiencies 7
2. Output oriented measures of efficiencies 9
3. Trends of barley production in Meket district from 2005/06 to 2015/16 15
4. Conceptual frame work of the study 20
5. Map of the study area 22
6. Land holding of sample household farmers 36
7. Major crops in hectare 37

LIST OF TABLES IN THE APPENDIX

Appendix Table **Page**

1. The likelihood ratio of trans-log and Cobb-Douglas functional form 66
2. Exponential and truncated normal distribution of inefficiency variables 67
3. Hetroschedasticity test for allocative and economic inefficiency 68
4. Omitted variable tests for allocative and economic inefficiency 68
5. VIF test for allocative and economic inefficiencies variable 68
6. Conversion factor of man equivalent and adult equivalent 69
7. Conversion factors used to estimate Tropical Livestock Unit equivalents 69
8. Estimation of technical inefficiency variables by using ordinary least square method 70
9. Individual efficiency scores of the sampled household farmers 71
10. Questionnaires 74

Economic Efficiency of Barley Production: The Case of Smallholder Farmers in Meket District, Amhara National Regional State, Ethiopia

ABSTRACT

This study analyzed the economic efficiency of barley production by smallholder farmers in Meket district, Amhara National Regional State, Ethiopia using cross sectional data collected from a sample of 123 barley producers during the 2015/16 production season by applying two stage random sampling. To address the objective of the study, both descriptive statistics and econometric models were used to analyze the data. The trans-log functional form was chosen to estimate both production and cost function and OLS estimation method was applied to regress allocative and economic inefficiency factors while, technical inefficiency factors were analyzed by using single stage estimation approach. The estimated stochastic production frontier model indicated that input variables such as fertilizer, human labor and oxen power were the significant variables to increase the quantity of barley output while, barley seed had a negative effect. The estimated mean levels of technical, allocative and economic efficiencies of the sample farmers were about 70.9%, 68.6% and 48.8%, respectively which revealed that, presence of a room to increase their technical, allocative and economic efficiencies level on average by 29.1%, 31.4% and 51.2%, respectively with the existing resources. Among the hypothesized factors that affect technical, allocative and economic inefficiencies; extension contact and number of barley plots significantly and negatively affected all inefficiencies level. Besides, distance of residence from the nearest main market was found to have a positive and significant effect on all inefficiencies of sampled household farmers. On the other hand, participation of the households in non-farm income activities and their farming experience had positive while, livestock ownership had negative and significant effect on allocative and economic inefficiencies. Likewise, total expenditure and soil fertility also had positive and significant effect on technical and economic inefficiencies. Hence, emphasis should be given to decrease the inefficiency level of those more inefficient farm households via experience sharing among the farmers and usage of improved or certified barley seed. Besides to this, policies and strategies of the government should be directed towards increasing farmers' education, improve the system of input distributions and institutional facilities.

Keywords: Economic efficiency; Stochastic Frontier; Trans-log; Ordinary least square; Meket; Barley

1. INTRODUCTION

1.1. Background of the Study

Agriculture is the chief support of the Ethiopian economy not merely because of its contribution to the country's GDP, but also more than 84% of the population still derive their livelihood either directly or indirectly from agriculture (Bellmon, 2015). While agriculture remains a dominant sector, its share in GDP slightly declined from 43.7% in 2012/13 to 38.8% in 2014/15 production year (UNDP, 2015). The agricultural sector also contributes for employment of about 73% of total labor force in 2014, for 90% of foreign direct exports as well as, supplies 70% of the raw-material requirements of local industries (WB, 2015).

Ethiopia is ranked 21th in the world in terms of barley production with a share of 1.2% of the world's total production and the second largest barley producer in Africa, next to Morocco and followed by Algeria, accounting about 25% of the total barley production in the continent (Abu and Teddy, 2014; FAO, 2014). Ethiopia is not only the largest producer but also the biggest consumer of barley in Africa. Unlike in industrialized countries where barley is mainly used for animal feed and malting, barley is important for developing countries in terms of the lives and livelihood of smallholder farmers. At the national level, barley accounts for about 5.6% of the per capita calorie consumption as a main ingredient in staple foods and local drinks. It also a substitutable crop for other cereals in the country and serve as a roof thatch for many highlanders. Hence, in relation to its dynamic nature and wide range of uses, barley is known as the "king of grains" (Berhane *et al*., 2011; CSA, 2014).

In the main season *(meher*) of Ethiopia, barley is the fifth most important cereal crop after *teff,* wheat, maize, and sorghum but, in the off-season (*Belg*), it is the second major cereal crop after maize in terms of area coverage and total production. In 2015/16 production year, private peasants hold about 14.26 million hectares of land covered by grain crops from which a total volume of about 285.91 million quintals of grains were obtained. From the total grain cultivated area, 79.07% of hectares were covered by cereals which produce 86.08% of the total production. The same source showed that, from the total area of cereals allocated in hectare barley covered only 14.65% producing 13.37% quintals with the yield of 10.42 quintal per hectare (CSA, 2016).

It was also indicated that in 2015/16 production year, in Amhara National Regional State barley covered 33.06% of land allocated for total grains to produce a total of 806.18 thousand quintals with yield of 9.13 quintal per hectare. Even if, barley covers the largest percentage in terms of area and production it had less yield as compared to maize (14.49), *teff* (10.69) and wheat (9.41) quintal per hectare (CSA, 2016). Coming to North Wollo, in 2014/15 production season there were 196,071 smallholders who allocated 41,394.36 hectare of land for barley and produced a total of 596,351.13 quintal of barley scoring the productivity of 14.41 quintal per hectare (CSA, 2015).

In Meket district, Barley is a major stable food and it takes the lion share in terms of the extent of production, food consumption, number of producers and area coverage relative to other major cereals grown in the district but, its production was owned by small holder farmers which produces only to survive their hand to mouth livelihood. Therefore, it is crucial to increase their volume of production and efficiency at least to secure their food needs. Hence, this study focused on analyzing the economic efficiency of small holder barley producers and identify factors that cause inefficiencies variation in Meket district.

1.2. Statement of the Problem

In Ethiopia, Around 98% of cereals were produced by small landholder farmers and 2% are produced by commercial farms primarily for seed purposes. Grain production constitutes the primary share of agricultural production and contributes significantly to the gross domestic product. However, the country is net importer of food crops, there are still large pockets of food insecurity and the peoples are living with poverty in various regions (Abu and Teddy, 2014). Therefore, due attention is vital in the country's efforts to increase grain production and efficiency of smallholder farmers which helps to sustain the broad based growth of the economy, to attain food security, to increase foreign earning, keep its contribution to the employment of labor force and to provide inputs for the agro-industrial sector. Crop productivity and efficiency may be improved through the application of modern inputs and improve the service rendered by institutions besides hardworking and experience sharing among farmers.

The total yield of barley has been increased by 4.99% between 2013/14 and 2014/15 and also by 5.2% to the year 2015/16 (CSA, 2016). Furthermore, among the major cereals, barley is found to have experienced the highest annual fluctuation in area and yield. Hence,

this fluctuation in barley yield and area shows that barley has received far less attention compared to the other major cereals, especially *teff*, maize, and wheat (Shahidur *et al.*, 2015).

Rapid population growth multiplies the problems concerning food and other fundamental human needs. Increasing food production is itself a complex process involving more intensive and extensive use of land and water, increased availability of basic agricultural inputs, appropriate agricultural policies and rural institutions and strengthened agricultural researches. However, if effort is made, the potential for increasing food production in every country in the world would be substantial. But, there is still yield gap between the output obtained from research stations and farmer's field. There are several factors believed to contribute to the low yield including moistures stress, shortage of seeds for improved varieties, degradation of soil fertility, insect pests, diseases, weeds and birds (Aung, 2012). This higher gap between yields of crops under farmer's management and what it can be obtained from on research farm clearly indicated that farmers has an opportunity to narrow this gap by increasing their crop production and earn higher yield as much as possible equal to the yield obtained at a research farm.

In fact, several scholars had conducted a study to analyze efficiency of smallholder farmers for different crop production in Ethiopia. However, all those studies disclosed that there is a room to improve the efficiency of farmers with the current resource existed at hand rather than creating new technology. In Ethiopia, related to barley crop there was limited number of researches conducted on barley crop and they were merely focused on malt barley and technical efficiency (Hassena *et al.*, 1999; Wadi'ah, 2012; Endalkachew *et al.*, 2012). Even if, technical efficiency is one component of economic efficiency but it is not enough to provide plenty of information for decision makers and policy intervention. Therefore, this study had tried to explore the overall and allocative efficiencies variations and factors causing inefficiencies of smallholder food barley producers. Because, studying the overall efficiency of food barley production is needed to know at what level the farmers are used the input combination in optimal way with their respective price to produce food barley. By taken in to account those problems, this study tried to answer the following research questions.

1. What are the mean level of technical, allocative and economic efficiencies of small scale barley producers?

2. What are the major source of inefficiencies for barley producers in the study area?

1.3. Objectives of the Study

The general objective of this study was to analyze the economic efficiency of barley production the case of smallholder farmers in Meket district, Amhara National Regional State, Ethiopia. The specific objectives of the study were:

1. To estimate the mean level of technical, allocative and economic efficiencies of small holder barley producers and
2. To identify the determinants for variation of inefficiencies of barley producers in Meket district.

1.4. Scope and limitation of the Study

There are two varieties of barley crops in Ethiopia which are malt barley and food barley. Since, farmers in the study area produces only for the second variety which is food barley rather than malt barley. Therefore, this study was conducted on technical, allocative and economic efficiencies of barley limited to Meket district that is one of the major barley producer in North Wollo zone of Amhara regional state. The findings of the study must be viewed in lights of some potential limitations. The study was conducted by taking samples from a district which was selected randomly that could not allow making generalization about the whole district. The study also used a cross-sectional data collected from a total of 123 sample farmers in line to this it reflects farmer's circumstances in a given year, specific weather conditions of the year may affect agriculture. Moreover, the result of cross-sectional data does not show inter temporal differences in economic efficiency levels of households.

1.5. Significance of the Study

The result from this study provides important information for all concerned bodies. There were not enough documents and materials related to barley efficiency production as such like other crops particularly in the district and in Ethiopia at a large. Therefore, this study will contribute for further researchers as a starting point and used as a reference. In that, an adequate understanding of the factors that affect inefficiencies of farmers are important for informed decision and transfer of the recommended practice to reduce inefficiency. It is

also important for researchers and policy makers in various aspects. The information also will assist researchers for developing appropriate technologies that better fit the needs of smallholder farmers to improve their wise use of resource; and policy makers also benefiting from the information to formulate appropriate policies, strategies, programs and interventions that help to increase productions and productivity of barley.

1.6. Organization of the Thesis

The thesis encompasses five major chapters. The first chapter presents background, statement, objectives and significance of the study. The remaining part of the thesis is presented as follows. Chapter two briefly discussed basic concepts related to efficiency, production, measurement tools, models and different researches conducted by different scholars at different period of time within and without Ethiopia. Then, the third chapter also clearly put the methodological parts and all the materials used to undertake this manuscript. The output of the study also presented in the fourth chapter by dividing the section in to descriptive and econometric main sub sections. The last chapter wind-up this study by drawing summary, conclusion and recommendations based on the finding of the study.

2. LITERATURE REVIEW

2.1. Theoretical Review

2.1.1. Basic concepts and definitions

The term productivity and efficiency have been used frequently in the media over the last years by many commentators. They are often used interchangeably but, they are not precisely the same thing. Productivity of the farmer is the ratio of outputs that it produces to the input used. Total factor productivity is a productivity measure involving all factors of production (Coelli *et al*, 1998). However, efficiency is the ratio of the value of output produced to the cost of inputs used. It is also defined as, achieving something with minimum or no wastage of resources. Yield is the ratio of total production of crops in per hectare basis.

Technical efficiency is the ability of the producer or decision maker to produce maximum amount of output from the given set of input at the specified time period and within the specified technology. Whereas, allocative (price) efficiency expresses the ability of a firm to use his/her inputs in optimal proportions in light of their respective prices. These two measures are combined to give a measure of economic (overall) efficiency. That is economic efficiency is the product of technical and allocative efficiencies (Bravo-Ureta and Pinheiro 1997).

2.1.2. Approach of measuring production efficiency

The measurement of production efficiency has been intimately linked to the use of frontier functions. The modern literature in efficiency fields begin with the same seminar paper, namely Farrell (1957). Farrell greatly influenced by Koopman (1951) formal definition and Debrew (1951) measure of technical efficiency introduced a method to decompose the overall efficiency of a production unit into its technical and allocative components. Farrell characterized different ways in which a productive unit can be inefficient either by obtaining less than the maximum output available from a determined group of inputs (technically inefficient) or by not purchasing the best package of inputs given their prices and marginal productivities (allocatively inefficient). The two main definitions of technical efficiencies are given by:

(a) According to Koopmans (1951) a producer is technically efficient if an increase in an output requires a reduction in at least one other output or an increase in at least one input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one output.

(b) Differently, Debrew (1951) and Farrell (1957) defined the following measure of technical efficiency known as the Debreu-Farrell measure, one minus the maximum equi-proportionate reduction in all inputs that still allows the production of given outputs, a value of one indicates technical efficiency and a score less than unity indicates the severity of technical inefficiency. Farrell's efficiency measure follows two schemes. These are input oriented approaches and output oriented approaches.

2.1.2.1. Input oriented approach of measuring efficiency

The input oriented approach deals with the question that by how much quantities of input can be proportionally reduced without changing the quantity of output produced? On the other way it is the ability to minimize inputs keeping outputs levels fixed. In his first work on efficiency, Farrell (1957) illustrated his idea about measuring efficiency with figure as:

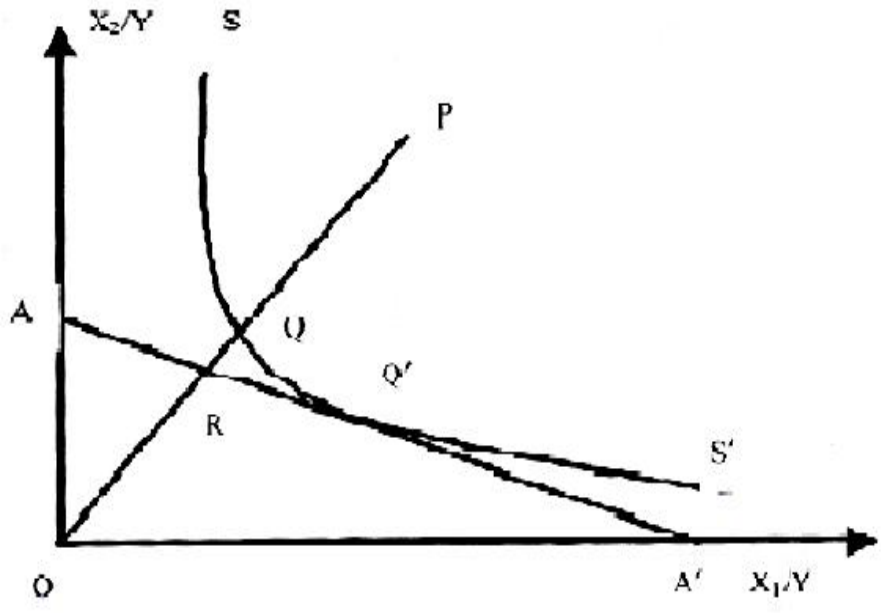

Figure 1. Input oriented measures of efficiencies

The SS' is an isoquant, representing technically efficient combinations of inputs X_1 and X_2 used in producing output Q. SS' is also known as the best practice production frontier. AA' is an iso-cost line, which shows all combinations of inputs X_1 and X_2 to be used in

such a way that the total cost of inputs are equal at all points. However, any firm intending to maximize profits has to produce at Q', which is a point of tangency and representing the least cost combination of X_1 and X_2 in production of Q. At point Q' the producer is economically efficient.

Assuming constant returns to scale (CRS) as Farrell (1957) initially done in his paper, the technological set is fully described by the unit isoquant SS' that captures the minimum combination of inputs per unit of output needed to produce a unit of output. Thus, under this framework, every package of inputs along the unit isoquant is considered as technically efficient while any point above and to the right of it, such as point P, defines a technically inefficient producer since the input package that is being used is more than enough to produce a unit of output. Hence, the distance QP along the ray OP measures the technical inefficiency of producer located at point P. This distance represents the amount by which all inputs can be divided without decreasing the amount of output. Geometrically, the technical inefficiency level associated to package P can be expressed by the ratio QP/OP, and therefore; the technical efficiency (TE) of the producer under analysis (1-QP/OP) would be given by the ratio OQ/OP.

If information on market prices is known and a particular behavioral objective such as cost minimization is assumed in such a way that the input price ratio is reflected by the slope of the iso- cost line AA', allocative inefficiency can also be derived from the unit isoquant plotted in Figure 1. In this case, the relevant distance is given by the line segment RQ, which in relative terms would be the ratio RQ/OQ. With respect to the least cost combination of inputs given by point Q', the above ratio indicates the cost reduction that a producer would be able to reach if it moved from a technically but not allocatively efficient input package (R) to a both technically and allocatively efficient one (Q'). Therefore, the allocative efficiency (AE) that characterizes the producer at point P is given by the ratio OR/OQ. Together with the concepts of technical efficiency and allocative efficiency, Farrell (1957) describes a measure of what he termed overall efficiency and later literature has renamed economic efficiency (EE). This measure comes from the multiplicative interaction of both technical and allocative components,

$$EE = TE * AE \tag{2.1}$$

$$EE = \frac{OQ}{OP} * \frac{OR}{OQ}$$

$$EE = \frac{OR}{OP}$$

Where, the distance involved in its definition (RP) can also be analyzed in terms of cost reduction.

2.1.2.2. Output oriented approach of measuring efficiency

The output oriented approach deals with the question; by how much output could be expanded from a given level of inputs? Or the output oriented approach tells considering the ability to avoid waste by using as little input as output production allows, i.e. we evaluate the ability to maximize outputs keeping inputs fixed. In the output oriented perspective, efficiency is evaluated keeping inputs constant. According to Farrell (1957), output oriented measures can be illustrated by considering the case where production involves two outputs (Y_1 and Y_2) and a single input. If the input quantity is held fixed at a particular level, the technology can be represented by a production possibility curve in two dimensions as follows:

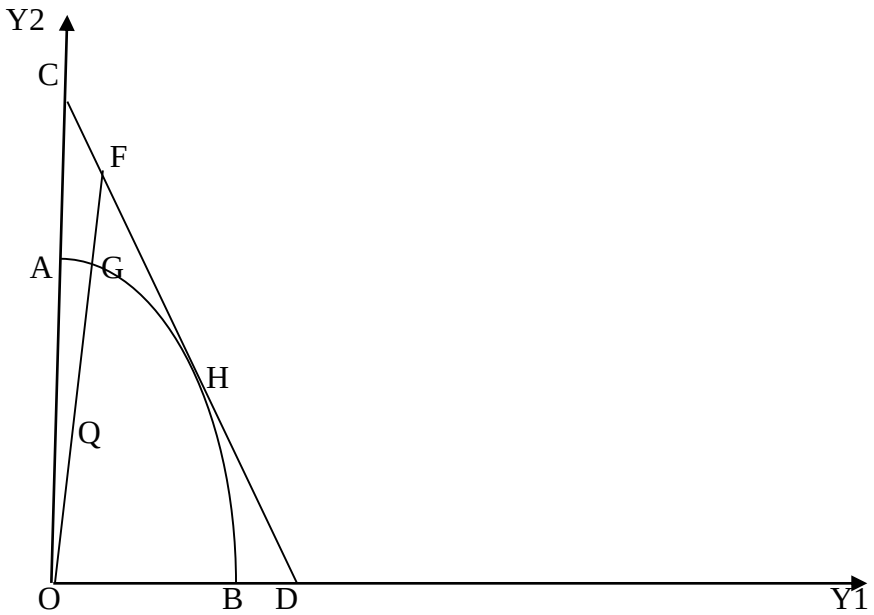

Figure 2. Output oriented measures of efficiencies

The production possibility curve is represented by the curve AB in Figure 2, which represents technically efficient combinations of production of outputs Y_1 and Y_2. Given same level of input, it is not efficient to produce at point Q. considering a firm situated at point Q, the TE can be calculated as OQ/OG. Alternatively, all farmers producing along the production possibility curve are 100% technically efficient. If we have price information then we can draw the iso- revenue line CD and define the allocative efficiency

to be; AE= OG/OF which has a revenue increasing interpretation (similar to the cost reducing interpretation of allocative inefficiency in the input oriented case). Furthermore, one can define overall economic efficiency as the product of these two measures. EE= (TE * AE) = (OQ/OG)*(OG/OF) = OQ/OF. Again all of these measures are bounded by 0 and 1. Therefore, it is possible to measure the efficiencies of production using input oriented and/or output oriented approaches and in this study both input-oriented and output oriented analysis was applied.

2.1.3. Models for estimating efficiency

Starting from the first empirical application of Farrell (1957) several different approaches of frontier estimation and efficiency score calculation have been developed. Essentially, there are two main methodologies for measuring efficiency: the econometric (parametric) approach, and the mathematical (non-parametric) approach (Coelli *et al.*, 1998). Hence, parametric approach was used in this study. Because, most agricultural products are affected by different natural catastrophes such as weather conditions, rainfall, the effects of pest and diseases, and measurement errors in the output variables beyond the control of the farmers in addition to their inefficiency.

2.1.3.1. Non- parametric frontier models

The non-parametric methods of measuring productive inefficiency using linear programming technique are broadly speaking dependent upon classification of quantitative and qualitative variables under the well-known methodology of Data Envelopment Analysis (Burhan *et al.*, 2009). The characterizing feature and main advantage of the non-parametric approach, (also called Data Envelopment Analysis or DEA), is that no explicit functional form needs to be imposed on the data while its main drawback is extremely sensitive to outlying observations (van den Broeck *et al.*, 1994).

DEA involves the use of linear programming techniques to construct a non-parametric piecewise surface or frontiers over the data so as to be able to calculate efficiency relative to this frontier. DEA differs fundamentally from the econometric approach in its interpretation of the data-generating mechanism but, close enough in its philosophical underpinnings to merit at least some consideration here. Its main strength may be its lack of parameterization; it requires no assumptions about the form of the technology therefore less sensitive to model misspecification. DEA method is also not subject to assumptions on

the distribution of the error term and imposes minimal assumptions on production behavior. The main drawback is that shared with the other deterministic frontier estimators which is any deviation of an observation from the frontier must be attributed to inefficiency making it sensitive to measurement errors and data noises. Furthermore, DEA is known to be sensitive to outliers (Greene, 2003).

The DEA method of modeling technical and allocative efficiency is largely a theoretical and it is a body of techniques for analyzing production, cost, revenue, and profit data, essentially, without parameterizing the technology. This constitutes a growth industry in the management science literature, and appears with some frequency in economics, as a result the study much less interested on it.

2.1.3.2. Parametric frontier model

The parametric models are estimated based on econometric methods (Coelli *et al.,* 1998) and it can further be classified into deterministic and Stochastic Frontier Production (SFP) model. Aigner and Chu (1968) specified a non-stochastic or deterministic frontier model of Cobb Douglas production function for a sample of N firms as:

$$\text{Ln}(Y_i) = F(X_i; B_i) - U_i, \quad i = 1, 2, 3 \ldots N \qquad (2.1)$$

Where *Yi* is the output of the i^{th} firm; *Xi* is the vector of input quantities used by the i^{th} firm; β_i is a vector of unknown parameters to be estimated; *F* (.) denotes an appropriate functional form (Cobb Douglas or translog); and U_i is a non-negative variable representing the inefficiency in production.

According to Coelli (1995), this model does not take in to account the possible influences of measurement errors and other noises up on the shape and positioning of the estimated frontier. Alternatively, any deviation from the frontier will be taken as inefficiency. Non-stochastic/deterministic production frontier can be estimated using linear programming or econometric techniques such as Corrected Ordinary Least Square (COLS). Application of this model, especially in cases where there is high probability of measurement risk, will exaggerate the inefficiency estimates as compared to the models which decompose the error term in to two components.

Unlike the deterministic model, SFP function has a disturbance term with two components; the error component (v) and the stochastic noise (u). The other merit of the SFP function over the former (deterministic) is that the estimation of standard errors and tests of

hypothesis is possible, which the deterministic model fails to fulfill because of the violation of the maximum likelihood regularity conditions (Coelli, 1995). Stochastic frontier production function can be estimated using Maximum likelihood (ML) or COLS method. Unless one uses COLS for its simplicity, the ML method is asymptotically efficient and hence recommended to be used than COLS (Coelli *et al.*, 1998). The main strength of the stochastic frontier function approach (SFAF) is its incorporation of stochastic error, and therefore permitting hypothetical testing. The disadvantage of this approach is the imposition of an explicit functional form and distribution assumption of the error term. Stochastic frontier method also sensitive to the functional form chosen. This model take in to consideration different factors beyond the capacity of farmers' inefficiency there for stochastic frontier model is applied in this paper because barley production vulnerable to external shocks like that of frost, erratic rainfall, soil erosion and whether condition.

2.1.4. Estimation approaches of inefficiency variables

There are two approaches to analyze socioeconomic and institutional factors that determine technical inefficiency. These are two-stage and one-stage estimation approach.

Single stage estimation approach investigates the parameters of the frontier production function simultaneously with various socioeconomic variables of technical inefficiency (Battese and Coelli, 1995). The technical inefficiency variance function can be specified as: $Y_i = f(\beta_i; x_i) + v_i - (\delta_i z_i)$ (2.2)

Where Yi is the output, x_i is the inputs for the production function and β_i is the coefficient of parameter estimate of input variables. Z_i is a vector of explanatory variables and δ_i is a vector of unknown parameters to be estimated for the inefficiency variable.

In two stage estimation approach first, the efficiency scores are estimated by using the frontier model. Second, efficiency scores are regressed against a number of explanatory variables that is hypothesized to affect technical efficiency or inefficiency.

$$Y_i = f(\beta_i; x_i) + v_i - (\delta_i z_i) \quad (2.3)$$

$$\mu_i = \delta_i z_i + \varepsilon_i \quad (2.4)$$

Where μ_i is technical inefficiency scores,

Kumbhakar *et al.* (1991) and Battese and Coelli (1995) criticized this approach and they argued that, the socio-economic variables should be incorporated directly into the estimation of production frontier model because such variables may have a direct influence on the production efficiency. It is possible to overcome this problem by the use of a single stage maximum likelihood approach.

Since, it is difficult to estimate allocative and economic inefficiency variables with cost and production function of barley output simultaneously. So, in this study single step estimation approach is used for technical inefficiency variables and two-step for allocative and economic inefficiency variables.

2.2. Functional Forms of Production Function

2.2.1 Cobb- Douglas production function

The Cobb-Douglas form was developed and tested against statistical evidence by Charles Cobb and Paul Douglas during 1927–1947 which is a particular functional form of the production function, widely used to represent the technological relationship between the amounts of two or more inputs, particularly physical capital and labor, and the amount of output that can be produced by those inputs. Sometimes the term has a more restricted meaning, requiring that the function display constant returns to scale. The standard form of Cobb-Douglas function with a single good and two factor inputs are represented as:

$$Y = AL^{\alpha}K^{\beta} \qquad (2.5)$$

Where, Y is the total production (the real value of all goods produced in a year)

L = labor input (the total number of person-hours worked in a year)

K = capital input (the real value of all machinery, equipment, and buildings)

A = total factor productivity and

α and β are the output elasticity's of labor and capital, respectively.

Output elasticity measures the responsiveness of output to a change in levels of either labor or capital used in production. The production function has constant returns to scale, meaning that doubling the usage of capital K and labor L will also double output Y. If $\alpha + \beta < 1$, returns to scale are decreasing, and if $\alpha + \beta > 1$, returns to scale are increasing. Cobb

and Douglas were influenced by statistical evidence that appeared to show that labor and capital shares of total output were constant over time in developed countries; they explained this by statistical fitting least-squares regression of their production function. There is now doubt over whether constancy over time exists. The main advantages of Cobb-Douglas are it is easy to interpret and requires estimation of few parameters: K+3 while its demerits are simplistic - assumes all firms have same production elasticity's and that substitution elasticity equal to 1 (Debertin, 2012).

2.2.2. Trans logarithmic functional form

The first form of trans-log production may be considered the proposal made in 1967 by J. Kmenta for the approximation of the CES production function with a second order Taylor series, when the elasticity of substitution is very close to the unitary value, which is the case of Cobb-Douglas production function. After that there were improvements and model development by scholars such as, Grilichs and Ringstad proposed new forms of production function and Sargant also was called a log-quadratic one in 1971. Transcendental logarithmic production function "was proposed by Christiansen, Jorgensn and Lau in two papers published in 1971 and 1973, which dealt with the problems of strong additivity and homogeneity of Cobb-Douglas and CES production functions and their implications for the production frontier. The generalized form of trans-log functional form was;

$$\ln Y_i = \ln \beta_0 + \sum_{i=1}^{n} \beta_i * \ln x_{ik} + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} * \ln x_{ik} * \ln x_{jk} + \varepsilon_i \qquad (2.6)$$

Transcendental logarithmic (trans-log) function is very commonly used and it is a generalization of the Cobb-Douglas functional form. One of the main advantages of the respective production function is its flexibility (Klacek *et al.*, 2007). Also, the concept of the trans-log production function permits to pass from a linear relationship between the output and the production factors, which are taken into account, to a nonlinear one. While, its disadvantage is that, the occurrences of collinearity especially if the OLS estimation method is used the probability of the occurrence of the harmful collinearity is very high (Pavelescu F. M., 2011).

2.3. Trends of Barley Production in Meket District

Meket district has a total of 48,393 household from them 18,036 households are barley producer in the year 2015/16. The major cereals grow in the district were Barley, wheat, *teff* and sorghum. Among those cereals, barley production takes the lion share in terms of area coverage and total production. In 2015/16 production season, the total production of wheat was 138.39 thousand quintals, for *teff* was 133.89 thousand of quintals and that of sorghum was 125.78 quintals while its yield was 22.34, 21.61 and 17.56, respectively. The yield of barley was much lower than the figure attained at national level (19.25) and also lower as compared to the yield of wheat and *teff* which implied that, farmers had a possibility to increase their yield level more and more through efficient use of the existing limited resource. The total land covered by barley in 2014/15 production year in the district was 8.8 thousand hectares that produce a total output of 159160 quintals. Unfortunately, in 2015/16 production season total output decline to 148716 quintals (that is by 7.02%) and its yield were 18 quintal per hectares (MWBARD, 2016).

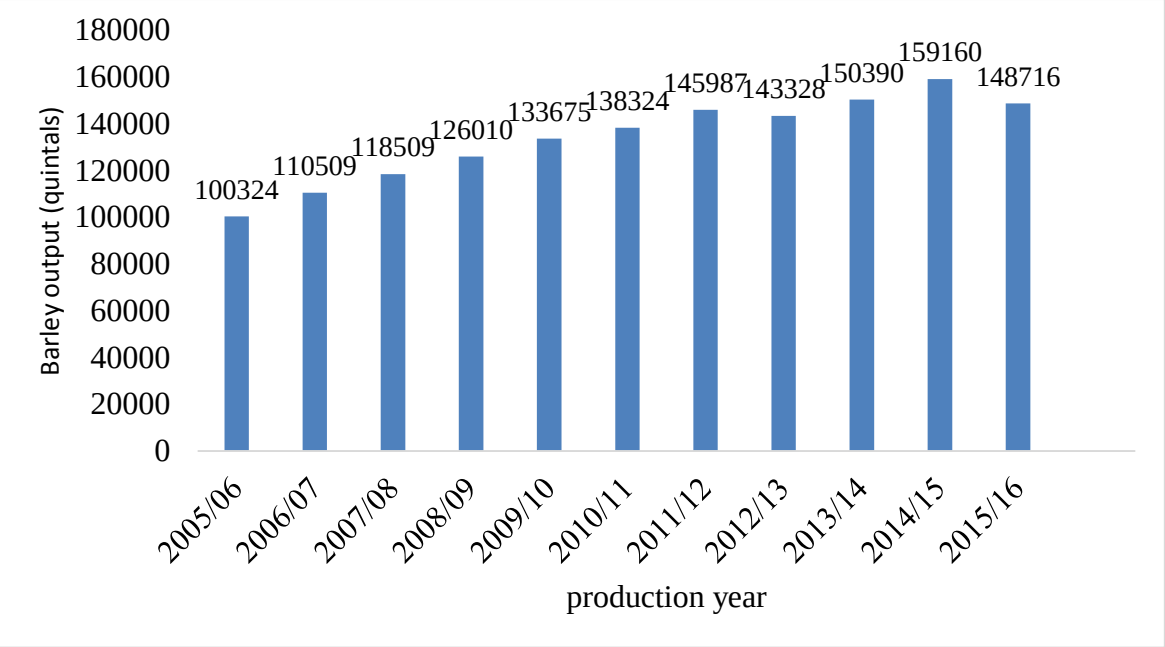

Figure 3. Trends of barley production in Meket district from 2005/06 to 2015/16

Source: MWBARD (2016)

The raw data of barley production for the last one decade started from 2004/05 production year indicated that, the total production of barley in the district increase in an increasing rate from the benchmark year (2005/06 year) to the year 2011/12 but, it fails in 2012/13

production year. The figure depicted above also showed that, in 2015/16 the total production of barley increased by 48% from the last one decade.

2.4. Empirical Review of Related Studies

2.4.1. Studies outside Ethiopia

Ali *et al*. (2012) estimated the economic efficiency of wheat and faba bean production for small-scale farmers in Northern State-Sudan using the stochastic frontier production and cost functions. Result of the study showed that the mean technical efficiencies of wheat were 0.75 and 0.66 in Dongola and Ed-Abba, respectively, while for faba bean were 0.65 and 0.71. The overall mean allocative efficiencies of wheat in the two localities were 0.72 and 0.68, whereas, they were 0.86 and 0.84 for faba bean. The predicated overall mean of economic efficiencies that estimated as inverse of their cost efficiencies of wheat were 0.41 and 0.45 in the two localities, while in faba bean production they were 0.57 and 0.62 in Dongola and Ed-Abba, respectively. That means farmers who cultivated faba bean were more economically efficient than farmers who cultivated wheat in the two localities and their allocative efficiencies were sources of gain. Their result also indicated that, age, experience and the cross product of school years and experience had negatively affect inefficiencies level.

Mburu *et al*. (2014) had examined the effect of farm size on economic efficiency among wheat producers and estimated the levels of technical, allocative, and economic efficiencies among the sampled 130 large and small scale wheat producers in Nakuru District. Results of the Cobb- Douglas stochastic model indicated that the mean technical, allocative, and economic efficiency indices of small scale wheat farmers were 85%, 96%, and 84%, respectively. The corresponding figures for the large scale farmers were 91%, 94%, and 88%, respectively. The output of Tobit model also revealed that, the number of years of school a farmer has had in formal education and the size of the farm had positive effect while, distance to extension advice had strong and negative influence on the efficiency levels. They recommended that, efforts should be made to improve extension services, access to high yielding seed varieties, and proper cop husbandry methods.

Sihlongonyane *et al*. (2014), had conducted the study by using a sample of 188 maize farmers to determine the economic efficiency of maize production in Swaziland by applied Cobb-Douglas production function. The results indicated that the mean technical,

allocative and economic efficiencies were 64.7%, 99.52% and 64.3%, respectively. The result also showed that famers can still improve economic efficiency by improving their technical efficiency. The result obtained from Tobit regression disclosed that, household size, formal education and education were the significant variables that affect farmer's efficiency level. The study also recommended that farmers should improve their technical efficiency by increasing productivity, and increasing amount of fertilizer applied per hectare. The implication of the study was that, there is a need for government to subsidize inputs for farmers and to continue with subsidizing the tractor hire services.

Souleymane (2015) seeks to deal with the issue of technical and economic efficiencies of rice producers in the Kou valley, located in the region of the high basins in the western part of Burkina Faso. He was used stochastic frontier approach to estimate the production function, from a Cobb-Douglas stochastic frontier function and its dual which allow the estimation of the technical, allocative and economic efficiencies. He was collected the data from randomly chosen 130 rice producers. The 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 explain the total production cost, and that is in accordance with the economic theory. The technical, allocative and economic efficiencies of producers are on average, 80.15%, 92.7% and 74.43%, respectively. A 25% improvement of rice production is possible if producers optimize their economic efficiency.

2.4.2. Studies within Ethiopia

Mustefa (2014) done a study aimed to analyzing the economic efficiency of barley production in Chole district, Ethiopia using cross sectional data collected from 150 randomly selected sample households during 2012/13 production season. He applied the Cobb-Douglas production function with stochastic production frontier approach to estimate technical, allocative and economic efficiencies level and also he used Tobit model to identify factors affecting efficiency levels of the sample farmer. The results indicated that there was a significant inefficiency in barley production in the study area. According to his expression the mean technical, allocative and economic efficiencies of barley producer farmers were 78.20%, 46.05% and 35.26%, respectively. In his study, results of the Tobit model revealed that age, education, training, family size, off/non-farm income, crop rotation and livestock ownership were found to have positive and significant effect on

economic efficiency in barley production. The results of the study also indicated that there was a room to increase the efficiency of barley producers in the study area through policies and strategies directed towards the above mentioned determinants.

Ermiyas *et al.* (2015) conduct a research aimed to measure the levels of technical, allocative and economic efficiencies of sesame producer and identify factors affecting them in selamago district of south Omo zone, Southern Ethiopia. The study was based on the cross-sectional data collected in 2011/12 production season from 120 randomly selected farm households. He used stochastic production frontier model to estimate technical, allocative and economic efficiency levels and Tobit model to identify factors affecting efficiency levels. The results of the study revealed that, the mean technical, allocative and economic efficiencies of sample households were 67.1%, 67.25% and 45.14%, respectively. Labor and seed were the variables that positively affected the production of sesame. Results of the Tobit model revealed that soil fertility, non-farm income and credit access positively and significantly affect economic positively and extension contact negatively. They recommended that, government authorities and other concerned bodies should take into consideration the above mentioned socio economic and institutional factors to improve productivity of sesame in the study area.

Awol (2014) also conducted the study aimed to estimate overall efficiency and identifying the factors that explain variation in efficiencies of wheat producing farmers using cross-sectional data. He applied Cobb-Douglas stochastic frontier production function and the result clearly showed the significant positive elasticities of land, labor, fertilizer and oxen implying that increase in each of these inputs will increase wheat output. The study also found that the mean indices of TE, AE and EE were 72.49%, 42.7% and 31.65%, respectively. The result of Tobit model found that, sex of the household heads, slope and oxen number positively and significantly affect technical, allocative and economic efficiencies level. A policy implication of his study was farmers had enough potential to increase wheat production by increasing of ploughing oxen ownership and by considering the positive impacts of livestock market besides crop production, livestock raring should get more attention.

Sisay *et al*. (2015), had conducted a study on technical, allocative, and economic efficiencies among smallholder maize farmers in Southwestern Ethiopia by using parametric stochastic frontier production function (Cobb-Douglas). The results showed that

the mean technical, allocative and economic efficiency scores of 62.3%, 57.1% and 39%, respectively, indicating a substantial level of inefficiency in maize production. The result of two-limit Tobit model depicted that important factors that affected technical, allocative and economic efficiency as family size, level of education, extension service, cooperative membership, farm size, livestock holding and use of mobile.

Musa (2013), measured the technical, allocative and economic efficiencies of maize production in the central rift valley of Ethiopia using cross sectional data collected from randomly selected 138 sample households. The estimated results reveal that the mean technical, allocative and economic efficiencies of 84.87%, 37.47% and 31.62%, respectively. Among factors hypothesized to determine 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 technical and economic efficiencies positively and distance to market affected technical efficiency negatively. The model output also indicated that soil fertility was among significant variables in determining technical efficiency in the study area. His result indicated that there is a room to increase the efficiency of maize producers in the study area.

The above empirical studies which were employed within and without Ethiopia in different agro-climatic and socio-economic conditions indicated the existence of efficiency differentials among small-scale farmers at different time period. Moreover, these studies also showed considerable variation of factors of inefficiency which are responsible for efficiency differentials. However, in Meket district even in North Wollo zone there is no such type of research works conducted on economic efficiency of barely production. Researches on economic efficiency of smallholder agriculture are not extensive and the findings or conclusions of some of them are not consistent with one another because of, different agro ecological nature, farming system, and other factors. Therefore, policy implications drawn from some of the above empirical works may not allow in designing area specific policies to be compatible with its socio-economic as well as agro-ecologic conditions. Therefore, this study intends to fill these gaps.

2.5. Conceptual Framework

In general, all the reviewed literature shows that there is inefficiency of production caused by demographic, socio economic, institutional, farm related and environmental factors. The institutional factors included in this thesis are, distance of the nearest market, extension contact and access to credit. The factors related to the farmer's specific characteristics include farming experience, sex, expenditure, education level, livestock holding and participation on non-farm activities. The factors related to farm characteristics include the number of barley plots, average distance of plots, soil fertility status and crop rotation. These factors together affect the economy in general and production efficiency particularly either directly or in indirect way. Hence, productivity can be increased via the adoption of improved agricultural technologies, increasing production inputs and enhancing wise use of resource.

Increase the agricultural productivity helps to facilitate the flow of resources from one sector to another and contributes to economic growth, lower food prices for consumers, rise the income of producers, increases the welfare of the society and improves the competitive position of the sector (Jema, 2006).

Based on this the figure presented below shows the conceptual frameworks.

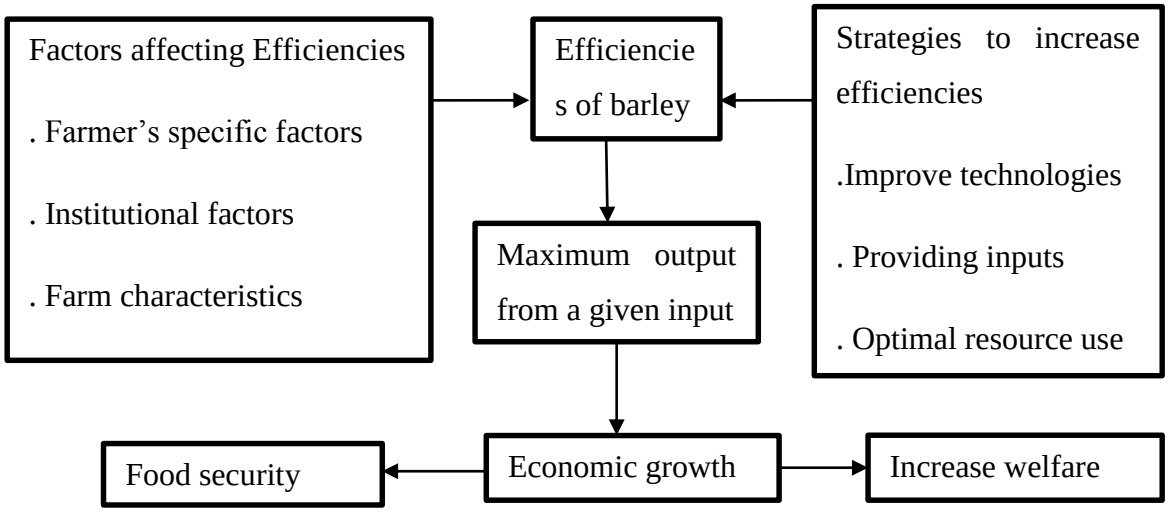

Figure 4. Conceptual frame work of the study

Source: Own sketch from literature review

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

Meket district is located 600 km north of Addis Ababa, in North Wollo zone of Amhara National Regional state. Meket is one of the districts in the Amhara Region of Ethiopia which is located on the western side of Woldia; bordered on the south by Wadla districts, on the west by Debub Gondar Zone, on the northwest by Bugna districts, on the north by Lasta, on the northeast by the Gidan districts and on the east by Guba-Lafto districts. The administrative center of Meket districts is Filakit (Seid, 2002).

There are four main agro-climatic zones in the district. These are the semi-arid lowlands less than 2,300 masl, the sub-humid midlands from 2,300 to 2,800 masl, the humid highlands 2,800 to 3,200 masl, and the very-humid high altitude plateau, which is over 3,200 masl, is often battered by frost and hail (SOS Sahel, 1997).

Meket district is one of the eleven districts in North Wollo zone of Amhara National Regional State which is the first populaces' district followed by Kobo district and Habru district at zonal level. Based on the 2007 national census conducted by the CSA of Ethiopia, Meket district has a total population of 227,338, an increase of 17.02% over the 1994 census, of whom 50.47% were men and 49.53% were women; among them only 5.18% were urban inhabitants while the majority 94.82% were rural residents. With an area of 1,909.25 square kilometers Meket has a population density of 118.71, which is less than the zonal average of 123.25 persons per square kilometer (CSA, 2008). Currently, the total population reached to 263,567 of them 51.67% were male and that of 48.33% were females. This shows that, there is a 15.91% increment from 2007 population census (MWHO, 2016).

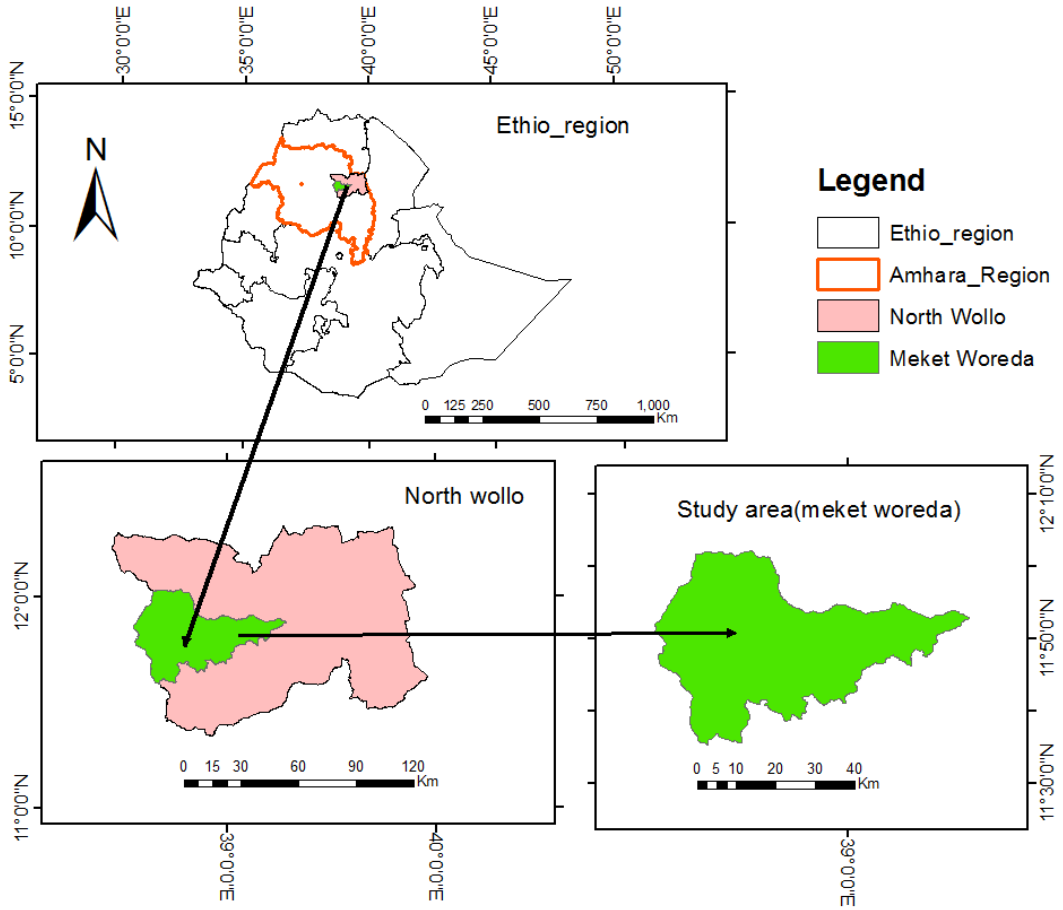

Figure 5. Map of the study area

3.2. Types, Sources and Methods of Data Collection

Both primary and secondary data were used for this study. Primary data were collected from a cross sectional sample representative 123 farm households from three rural *kebele's* through questionnaires. Secondary data sources were also governmental and non-governmental institutions including both published and unpublished documents.

In order to obtain the important data, firstly individuals who completed grade 10 were selected as enumerators and these enumerators took training and orientation with close supervision of the researcher. Then, they collect the required data through questionnaires, interview and focus group discussion. Secondary data also collected from different organization at zonal and district level regarding the baseline general information to support the primary data.

3.3. Sampling Technique and sample size

The sampling technique employed was two-stage sampling technique. Meket districts has a major barley producers and large extent of production in the zone. From the total 47 *kebeles* of Meket district only 21 *kebeles* produce barley. In the first stage, a total of three sample *kebeles* from 21 barley producer *kebeles* in the district were randomly selected. In the second stage, 123 sample farmers were selected by using simple random sampling technique from each *kebele* based on probability proportional to size.

The sample size of farmers was determined by applying Yamane's (1967) formula of calculating sample size with confidence interval of 95% and variability 0.5.

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

Where: n= the sample size, N= number of barley producer households in Meket district in 2015/16 production season (which is 18036), e= margin of error (which equals with 9%) then, n =122.6 but, the sample size held in this study was 123.

Table 1. Number of households selected from sample *kebeles*

Sample *kebeles*	Total number of farmers household	Sampled household	
		Numbers	%
Solonaj	1075	54	43.9
Warro	750	38	30.89
Estayish	630	31	25.2
Total	2455	123	100

Source: Meket district agricultural office and own computation, (2016).

3.4. Method of Data Analysis

Descriptive statistics and econometric models were employed to achieve the objective of the study. The descriptive statistics includes means, standard deviation, minimum, maximum, frequencies and percentage. Regarding the econometric model, different tests of hypothesis were considered to select the appropriate functional form and model which can fit to the data set. After conducting all the required hypothesis and make decision, a transcendental logarithmic functional form simultaneously with one stage estimation procedure of frontier model was used to analyze technical inefficiency variables while,

ordinary least square estimation technique was applied to show the source of allocative and economic inefficiencies variation among farmers. OLS estimation technique was applied due to the reason that the available data set on hand were more appropriate for OLS estimation technique than other models like Tobit model.

OLS estimation is mainly used if the inefficiency scores are not truncated or censored for a specific value. If the observation tends to be grouped close to the frontier with only a relatively small number in the extreme range, the error distribution will be highly skewed and we should expect the maximum likelihood estimator to be highly efficient than OLS (Greene, 1980). In the available data set, there was no the value of efficiency score one for some observations that shows the farmers are fully efficient or the value of zero for some observation which shows that they are inefficient. So, Tobit model cannot applied without censored or truncated values efficiency scores for some observation rather than ordinary least square estimation technique.

As the efficiency variable varies between 0 and 1, the significant power of coefficients will be weak so, the dependent variable (allocative and economic inefficiency score) would be transformed in to natural logarithmic form as;

$$\ln\left[\frac{Efficiencies}{1-Efficiencies}\right] \tag{2}$$

So that, the latter transformed variable facilitates estimation of the parameters by using the OLS technique (Bhende and Kalirajan, 2007**;** Aung, 2012). (To notice the difference of the significant power of the explanatory variables, the regression output without transformation or in level form is put under the appendix section). So based on this principle, allocative inefficiency was transformed in to $\ln\left[\frac{AIE}{1-AE}\right]$ and economic inefficiency as $\ln\left[\frac{EIE}{1-EE}\right]$. Where, AIE is allocative inefficiency and EIE is economic inefficiency.

The output of barley was modeling in terms of five major input variables namely, amount of fertilizer, amount of human labor, quantity of seeds, oxen power and land allocated for barley crop. The transcendental logarithmic functional forms of the production function were expressed as;

$$Y = F(X\beta)\exp\varepsilon \tag{3}$$

Where, Y= Barley output

X_i= Vector of input quantities

β_i = a vector parameters to be estimated

ε= It is composed error consisting of element U and V,

The random disturbance term V_i captures the effects of statistical noise on observed output outside the farmers control including measurement errors, climate change, topography, soil type, and others. The stochastic noise $U_i > 0$ is included to capture effects from technical inefficiency which distributed as half normal. Hence, both U and V are independent of each other (Aigner *et al.*, 1977).

According to Aigner *et al.* (1977), the advantage of this approach is we can estimate the variance of V_i and U_i, productive efficiency should be measured by the ratio of $\frac{Y_i}{[F(X_i;\beta)+V_i]}$ rather than by the ratio of $\frac{Y_i}{F(X_i;\beta)}$ and lastly it distinguish productive inefficiency from other source of disturbances that are beyond the farmers control.

In case of transcendental logarithmic functional form, if the number of production factors is equal to n, then the number of estimated parameters is equal to $n\left(\frac{n+3}{2}\right)$. Hence, the numbers of production factors are five then the estimated parameters will be 20. The implicit trans-log form of the stochastic frontier production model was specified as follows;

$$\ln Y_i = \ln \beta_0 + \sum_{i=1}^{20} \beta_i * \ln x_{ik} + \frac{1}{2}\sum_{i=1}^{20}\sum_{j=1}^{20} \beta_{ij} * \ln x_{ik} * \ln x_{jk} + \varepsilon_i \quad (4)$$

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + \beta_7 \ln X_{7i} + \beta_8 \ln X_{8i} + \beta_9 \ln X_{9i} + \beta_{10} \ln X_{10i} + \beta_{11} \ln X_{11i} + \beta_{12} \ln X_{12i} + \beta_{13} \ln X_{13i} + \beta_{14} \ln X_{14i} + \beta_{15} \ln X_{15i} + \beta_{16} \ln X_{16i} + \beta_{17} \ln X_{17i} + \beta_{18} \ln X_{18i} + \beta_{19} \ln X_{19i} + \beta_{20} \ln X_{20i} + \varepsilon \quad (5)$$

Where,

Ln= Logarithm to base e

βi = The unknown parameters estimated

i=1, 2, 3. . . n^{th} farmer

j=inputs of production used

Y_i= Output of barley

X_1= Land allocated for barley crop (ha)

X_2= Labor power (man-days)

X_3= Amount of barley seeds used (kg)

X_4= Oxen power (oxen days)

X_5= Quantity of fertilizer used in barley crop (kg)

X_6= Square of land allocated for barley crop in hectare

X_7= Square of total human labor used in man-days

X_8= Square of amount of seed used in kg

X_9= Square of oxen power in oxen days

X_{10}= Square of amount of inorganic fertilizer in kg

X_{11}= Cross product of both land allocated for barley crop and human labor

X_{12}= Interaction of land allocated for barley crop and seed

X_{13}= Interaction of land allocated for barley crop with oxen power

X_{14}= Cross product of both land allocated for barley crop and fertilizer

X_{15}= Interaction of human labor and seed

X_{16}= Cross product of both human labor with oxen power

X_{17}= Interaction of human labor with fertilizer

X_{18}= Cross product of both seed and oxen power

X_{19}= Interaction of seed with fertilizer

X_{20}= Cross product of both oxen power and fertilizer

ε = Random composed error-term (V-U)

n = sample size

Technical inefficiency scores were estimated on hypothesized farm related, socioeconomic and institutional factors using a one stage estimation procedure in frontier model simultaneously with the production function. The technical inefficiency model was specified as using:

$$Y_i = f(\beta_i; x_i) + v_i - (\delta_i z_i) \quad (6)$$

Where, Y_i is barley output and Z_i is different farm specific, socioeconomic and institutional variables that affect technical inefficiency.

$$Z_i = \alpha_0 + \alpha_1 p_{1i} + \alpha_2 p_{2i} + \alpha_3 p_{3i} + \alpha_4 \ln p_{4i} + \alpha_5 p_{5i} + \alpha_6 \ln p_{6i} + \alpha_7 p_{7i} + \alpha_8 p_{8i} + \alpha_9 p_{9i} + \alpha_{10} p_{10i} + \alpha_{11} p_{11i} + \alpha_{12} p_{12i} + \alpha_{13} p_{13i} + \varepsilon_i \quad (7)$$

Estimating cost function is a necessary thing to estimate allocative efficiency scores of the household farmers. Then, the total cost was regressed on each cost of inputs using trans-log

functional forms of cost function as:

$$\ln c = \alpha + \sum_{k=1}^{27} \beta_k \ln w_k + \frac{1}{2}\sum_{k=1}^{27}\sum_{m=1}^{27} yk_m \ln w_k \ln w_m + \sum_{s=1}^{l} \delta s \ln y_s + \frac{1}{2}\sum_{s=1}^{l}\sum_{t=1}^{l} \phi_{st} \ln y_s \ln y_t + \sum_{k=1}^{27}\sum_{s=1}^{l} \theta_{ks} \ln w_k \ln y_s + \varepsilon i \quad (8)$$

$$C_i = \alpha_0 + \alpha_1 \ln c_{1i} + \alpha_2 \ln c_{2i} + \alpha_3 \ln c_{3i} + \alpha_4 \ln c_{4i} + \alpha_5 \ln c_{5i} + \alpha_6 \ln y_{6i} + \alpha_7 \ln c_{7i} + \alpha_8 \ln c_{8i} + \alpha_9 \ln c_{9i} + \alpha_{10} \ln c_{10i} + \alpha_{11} \ln c_{11i} + \alpha_{12} \ln y_{12i} + \alpha_{13} \ln c_{13i} + \alpha_{14} \ln c_{14i} + \alpha_{15} \ln c_{15i} + \alpha_{16} \ln c_{16i} + \alpha_{17} \ln c_{17i} + \alpha_{18} \ln c_{18i} + \alpha_{19} \ln c_{19i} + \alpha_{20} \ln c_{20i} + \alpha_{21} \ln c_{21i} + \alpha_{22} \ln c_{22i} + \alpha_{23} \ln c_{23i} + \alpha_{24} \ln c_{24i} + \alpha_{25} \ln c_{25i} + \alpha_{26} \ln c_{26i} + \alpha_{27} \ln c_{27i} + \varepsilon_i \quad (9)$$

Where, Ci = Minimum costs of the i[th] farmers for the production of barley

C_1= Rental price of land in birr per year

C_2= Wage of human labor used in birr per man days

C_3= Price of fertilizer used in birr per kg

C_4= Price of oxen rent in birr per oxen days

C_5= Price of seeds applied in birr per kilogram

$\ln Y_6$= Output of barley in quintals

C_7= Square of rental price of land

C_8= Square of the wage of total human labor used (man-days)

C_9= Square of price of amount of seed used in kg

C_{10}= Square of the rent of Oxen power in oxen days

C_{11}= Square of price of amount of inorganic fertilizer in kg

$\ln Y_{12}$= Square of barley output

C_{13}= Cross product cost of both land under barley crop and human labor

C_{14}= Cross product cost of both area under barley crop and seed

C_{15}= Cross product cost of both area under barley crop and oxen

C_{16}= Cross product cost of both area under barley crop and fertilizer

C_{17}= Cross product cost of area under barley crop and output

C_{18}= Cross product cost of both human labor and seed

C_{19}= Cross product cost of both human labor and oxen

C_{20}= Cross product cost of both human labor and fertilizer

C_{21}= Cross product cost of human labor and output

C_{22}= Cross product cost of both seed and oxen

C_{23}= Cross product cost of both seed and fertilizer

C_{24}= Cross product cost of seed and output

C_{25}= Cross product cost of both oxen and fertilizer

C_{26}= Cross product cost of oxen and output

C_{27}= Cross product cost of fertilizer and output

A= Constant

ε= Random composed error term (V+U)

Cost efficiency is the ratio of minimum cost and actual cost. If cost efficiency is less than one the farmer is said to be less cost inefficient while, if it is unity the farmer or producer is cost efficient. Since, allocative efficiency is the reciprocal of cost efficiency and it is regressed on socio-economic, demographic and institutional inefficiency factors as:

$$Y_i^* = a_0 + a_1 Z_{1i} + a_2 Z_{2i} + a_3 Z_{3i} + a_4 \ln Z_{4i} + a_5 Z_{5i} + a_6 \ln Z_{6i} + a_7 Z_{7i} + a_8 Z_{8i} + a_9 Z_{9i} + \alpha_{10} Z_{10i} + \alpha_{11} X_{11i} + \alpha_{12} Z_{12i} + \alpha_{13} Z_{13i} + \varepsilon_i \quad (10)$$

Where Y* = Allocative inefficiency scores

According to Bravo- Ureta and Pinheiro (1997) economic efficiency is the product of technical efficiency and allocative efficiency. The economic efficiency of each farmer can be calculated as the product of allocative efficiency and technical efficiency. In measuring the factors affecting economic inefficiency levels, OLS estimation technique could be applied. The estimating inefficiency scores are regressed on the same set of farm related, institutional and socio-economic factors that are assumed to be important determinants of inefficiency as allocative and technical inefficiency.

$$U_i^* = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \beta_4 \ln X_{4i} + \beta_5 X_{5i} + \beta_6 \ln X_{6i} + \beta_7 X_{7i} + \beta_8 X_{8i} + \beta_9 x_{9i} + \beta_{10} X_{10i} + \beta_{11} X_{11i} + \beta_{12} X_{12i} + \beta_{13} X_{13i} + \varepsilon_i \quad (11)$$

Where U_i*= Economic inefficiency levels

The inefficiency variables denoted as P_1 to p_{13} in equation 7 and Z_1 to Z_{13} in equation 10 and X_1 to X_{13} in equation 11 are:

1. Farming experiences of farmers in barley production (years)
2. Farmer education level (years of schooling)
3. Frequency of extension contact (numbers)
4. Amount of credit taken (Ethiopian birr)
5. Number of barley plots (number)
6. Total expenditure of households (Ethiopian birr)
7. Crop rotation (0= if they practice crop rotation, 1 otherwise)

8. Participation on non-farm income (0= if yes and= 1 if no)
9. Livestock holding (TLU)
10. Fertility status of the soil (0=fertile, 1=infertile)
11. Distance to market (kilometers)
12. Gender (0 if the household headed are male and 1 other wise)
13. Distance of the plot from farmers home (walking minutes)

After all regression results, different post estimation tests or diagnostics were done including variance inflation factor, heteroscedasticity, omitted variable test and normality of the residuals for the models to ensure that the available data set meets the assumption of OLS regression and all these are presented under the appendix section.

3.5. Definitions of Basic Variables

3.5.1. Variables of production function

Barley output: It is the dependent variable which refers to the physical amount of barley produced in quintals in 2015/16 production season.

Land: It represents the piece of area or plot which is allocated to cultivate barley production measured in hectare.

Labor: A factor of production which consists of the effort and time of human beings engaged in barley production. Take in to account differences in sex and age among labor, man days equivalent would be used as a common conversion factor.

Seed: It is one of the inputs of barley production which is the amount of barley seed needed to produce barley measured in kilogram.

Oxen power: It is a male bovine animal or equine raised for the task of plough and threshing. It can be expressed by using the total amount of oxen days allocated for perform these activities of barley production in 2015/16.

Fertilizer: It is the total quantity of Urea and/or DAP applied on plot of land that covered by barley production in Kilogram. It is inorganic fertilizer that is applied to soils and to enhance the growth of barley.

3.5.2. Variables for cost function

Price of land (PLAND): Since land has no an economic value and farmers has no a right to sell and buy land rather they has only use right. For the rented land, the rental price of that land was taken while, for owned land average rent paid in the district (which is 2470 birr/hectare) was taken as the opportunity cost.

Price of labor (PLAB): It is the average wage in birr per day paid for hired labor and the wage paid to permanent labor in the locality was used to estimate the wage of family labor used in barley production. The average wage rate were 60 birr per man day.

Price of oxen power (POX): Since, oxen is not rented in the study. But, in the study area those farmers who have no oxen, produce their crops by substituting their human labor for oxen owner. That is the farmers work two days on the field or any other nonfarm related activities for the oxen owners then on return the oxen owners give his or her oxen for only one day. So, the monetary value of oxen power in the study area was equal to the wage of human labor for two days which is 120 birr per oxen days used in to produce barley output.

Price of fertilizer (PFERT): It is the payment in Birr/kg for fertilizer applied by each farmer in Barley yield in the study area. In the production season, the prices of Urea in kg were 12.65 and for DAP it was 14.5 birr. So, the mean of the two was 13.57 birr per kg.

Price of seed (PSEED): It is the price of seed in Birr/kg used for barley yield in the study area. Hence, in the study area the local unit of measurement used to measure seed is *tasa* which is equivalent with three kilogram and has a value of 18 birr. This means that the price of barley seed during that period was 6 birr per kilogram.

3.5.3. Variables for the determinants of inefficiency

There are so many variables that affect or determine the inefficiency of barley producers in the study area. But, this study mainly focused on the major factors that causes variation among barley producers in Meket district are hypothesized as given below;

Farming Experience (FEXPR): It is a continuous variable which refers to years of the household head which mainly exercise barley production measured in years. As the farmers got more experience, he/she learn from his/her past lessons, adopt the real situation and accumulate optimal combination of resource. Souleymane (2015) found that farming

experience had a positive and significant effect on efficiency level. So, in this study the variable was hypothesized as having negative effect on inefficiency level of farmers.

Education Level (LEDUCN): This is a continuous variable which represents educational level of the household head measured in years of schooling and it is used as a proxy variable for managerial ability of farmers. Educated farmers are more responsive to improved farming techniques and they have a higher level of efficiency than farmers with less education. Assa *et al.* (2012) found that, increasing of educational background could decrease the level of inefficiency among farmers. So, this study hypothesized that education level and inefficiency has inverse relationship.

Frequency of extension contact (FRQEXT): It is continuous variables that refer to the frequency of contacts between extensions agents and household head farmers measured in numbers per production season. Extension contact increase efficiency by disseminating of new technologies to farmers. In addition, households who get more extension services by extension workers appear to be more efficient than those who get less extension service (Musa *et al*., 2015). So, this study expected the inverse relationship between inefficiency of farmers and extension contact.

Amount of credit taken (CRDT): It is continues variables which represent the amount of money that the household head borrows from different lending institutions measured in Ethiopian birr. Since, Credit availability shifts the cash constraint outwards and enables farmers to make timely purchases of those required inputs that they cannot provide from their own sources (Musa *et al*., 2015). Therefore, it was hypothesized that farmers who get more credit will be less inefficient, and then it had a negative relation.

Number of barley plots (NBPLOTS): This is a continuous variable and defined as the total number of plots that the farmer managed for cultivation of barley in different location during the 2015/16 production season. Higher number of plots leads to inefficiency by creating wastage of time and other resources that should have been available at the same time (Wondimu, 2010). Hence, in this study it was hypothesized as it had a positive effect on inefficiency of farmers.

Crop rotation (CROPRTN): It is a dummy variable which represents whether the farmer practiced crop rotation or not during the 2015/16 production season. It took the value of zero if the farmer practiced it and one, otherwise. Musa (2013) argued that farmers who

practiced crop rotation could be less inefficient than his/her counter-parts as it helps to increase output by recycling and restoring nutrients required for barley production. So, it was hypothesized to have invers relation with inefficiency.

Non-farm income (OFFINCOM): This is also a dummy variable which is measured as 0 if one of the household members participates in non-farm activity in the 2015/16 barley production season or 1 otherwise. The availability of non-farm income shifts the cash constraint outwards and enables farmers to make timely purchases of those inputs which they cannot provide from on farm income (Mustefa, 2014). So, the expected sign was negative to affect inefficiency.

Livestock ownership (TLU): Livestock could support crop production in many ways; it can be source of cash, draft power and manure that will be used to maintain soil fertility (Wassie 2012). But, to avoid double counting it excludes the number of Oxen's, horses and Mules. Accordingly, in this study the effect of livestock ownership on inefficiency was assumed to be negative.

Distance to the market (DMKT): It is also the distance of farms located from input and output market measured in kilometers. Kenneth (2012) disclosed that, a farm located far from the market incurs more costs to transport farm inputs from the market, compared to the one closer to the market. This in turn, hinders the optimal application of farm inputs and leads to inefficiency. So, they had positive relationship with inefficiency.

Sex (SEX): It is a dummy variable that is 0 if the household is male headed and 1 other wise. Male farmers are more likely to attend meetings, frequent follow-ups and supervisions of their farms than females. Therefore, male farmers accumulate more knowledge than women in terms of new cultivation techniques and crop management practices (Awol, 2014). Therefore, it was hypothesized as they had negative relationship between male headed and their inefficiency.

Total expenditure of the household (TEXPR): It includes all expenditures of the household on consumption, education, medication and social obligation measured in birr. But, this does not include expenses related to purchase of agricultural inputs to avoid double counting. Since this competes with the limited cash available, it was hypothesized to have a negative effect on efficiency (Mustefa, 2014).

Fertility of soil (FERT): It is treated as a dummy variable that takes a value of 1 if the household head perceives his plots as infertile and 0 otherwise. The more the land is fertile, the better is the gain (Mustefa, 2014). Therefore, it was hypothesized that a farmer with a fertile land is less inefficient than the farmer with infertile land and assumed to affect inefficiency negative.

Distance of the farm from the residence of farmers (DHOME): It is the average distances between the residences of the household to the farm plots measured in walking minutes. The furthest the distance from the farmer field, the less the supervision then inefficiency of farmers increases as the distance between farm and homestead increases. Farmer living nearly to his/ her farm would be more efficient than the one living at the farthest distant (Mustefa, 2014).

4. RESULTS AND DISCUSSIONS

This chapter presents and discussed the results by dividing the section into two main sub-sections; descriptive statistics and econometric results. The descriptive statistics presents the farmers and farm related characteristics, institutional and socio-economic variables in the study area. While, the second sub-section was all about the econometric results of the study describing the mean level of technical, allocative and economic efficiencies of barley producers and identify the factors that cause inefficiencies variation among them in the study area.

4.1. Descriptive Results

Before embarking on presenting and discussing the results obtained from the econometric model, it was better to justify descriptive statistics. Mainly, this sub section would help to draw a general road map about the study area and sample farm households by briefly presenting different features using descriptive statistical tools such as mean, maximum, minimum, percent and frequencies.

4.1.1. Demographic characteristics of the sample households

Household size and age composition: The average household members that live in one house for the sample households were about 2.74 persons that ranging between 1 and 7 persons. The average age of the sample household heads was 46.58 years with maximum of 80 and minimum of 20 years old. This showed that the mean ages of the sampled households were within the range of economically active age and they were more energetic.

Table 2. Age, education level, household size and farming experience

Variables	Mean	Standard Deviation	Minimum	Maximum
Household size	2.74	1.45	1	7
Age	46.58	15.78	20	80
Farming Experience	33.62	12.48	5	62
Education level	2.54	3.02	0	10

Source: Own computation (2016)

The average farming experience of the sample farmers in barley production were 33.62 years with a minimum of 5 years to that of a maximum of 62 years. This indicated that they have a long farming experience in barley crop. The mean education level of the sample household in the study area was 2.54 ranging from 0 to grade 10. Table (2) told that the educational levels of the sample household were very low.

Sample respondents were composed of both male and female household heads. Out of the total sampled household head farmers about 80.49% were male headed and the remaining 19.51% were female headed households. Among the sample households in the study area majority of them (that is about 59%) were married, 9.76% were single, where as 16% were divorced and the remaining 14.63% were widowed (Table 3) below.

Table 3. Sex and Marital status of the sample household farmers

Characteristics	Frequency	Percent	Cumulative
Sex			
Male	99	80.49	80.49
Female	24	19.51	100.00
Marital status			
Married	73	59.35	75.61
Single	12	9.76	85.37
Divorced	20	16.26	16.26
Widowed	18	14.63	100.00
Total	123	100.00	

Source: Own computation (2016)

4.1.2. Land holding, cropping system and major crops grown

In the study area, farmers practice mixed farming system and used land for cultivation of both crops and range land for animals. In the study area, most of the farmers practice share cropping. From a total of sample households 58.53% of them produced barley crop on their own land and shared-in cropping system but, 38.21% of them were shared-out their land the whole or in part due to mainly lack of human labor and oxen power.

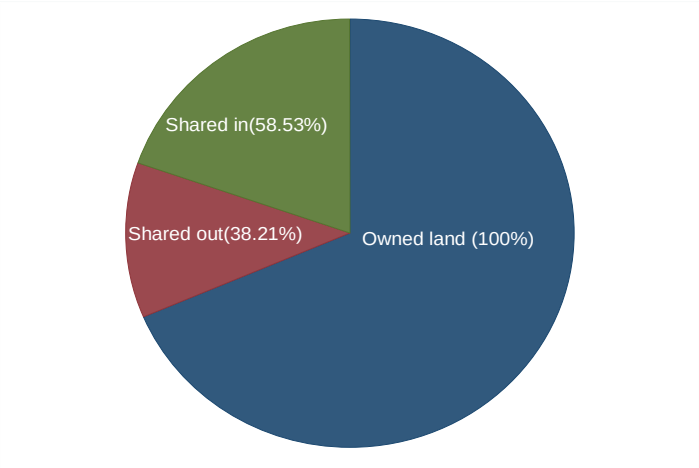

Figure 6. Land holding of sample household farmers

Source: Own sketch from survey (2016)

NB: The sum of percentage in the above figure is not 100% because of multiple response

Table 4. Major crops grown with total output and number of growers

Crop type	Output	Growers	
	Quintal	Number	Percentage
Barley	2084	123	100
Linseed	227	92	74.79
Wheat	1570	120	97.56
Pea	250	50	40.65
Bean	455	123	100

Source: Own computation (2016)

All of the sample household head produced barley output and bean with a total of 2084 and 455 quintal respectively. Nearly 97.6% of them were growers of wheat producing a total of 1570 quintal. In addition, the total 40.65% growers of pea produces only 250 quintal and 74.79% growers produce 227 quintals of linseed.

Figure (4) showed that the small holder farmers allocate majority of their land for barley production in 2015/16 production season with an average of 1.49 hectare followed by wheat 0.57 hectare and bean 0.41 hectare. The average land allocated for pea and linseed were 0.23 and 0.27 hectare, respectively.

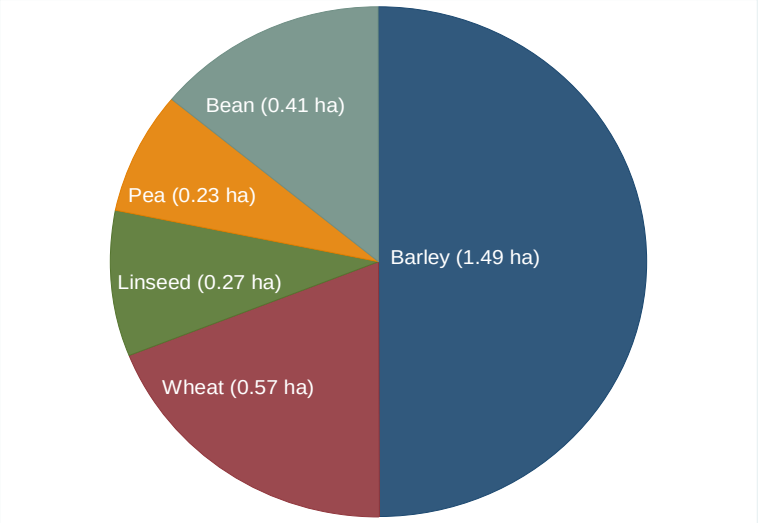

Figure 7. Major crops in hectare

Source: Own sketch from survey (2016)

4.1.3 Characteristics of barley farms

Crop rotation reduces weed, crop disease and insects that causes losses of outputs and helps to reduce the amount of chemical fertilizer applied. As it was presented in Table (5), 19.51% of the sample households were not practicing crop rotation. This indicated, that they may practice fallowing as a means to increase the soil fertility of the land in addition to the application of fertilizers while, the remaining 80.49% was adopted the practice of crop rotation.

Table 5. Crop rotation, soil fertility status and non-farm income

Dummy variables	Frequency	Percent
Practice crop rotation	99	80.49
Not practice crop rotation	24	19.51
Has fertile land	93	75.61
Has infertile land	30	24.39
Has non-farm income	72	58.54
Has no non-farm income	51	41.46

Source: Own computation from survey (2016)

Based on their perceptions, about 24.39% of the respondents classified the fertility status of their barley plot on average as infertile class while, 75.61% respondents graded it as

fertile. The same table also told that, majority (which is 58.54%) of the farmers had participated on different non-farm income activities while about 41.46% were had not any source of non-farm income.

4.1.4. Farm operations

Farmers produce barley by using labor intensive technologies and used both family labor and oxen power for performing different farming operations such as ploughing, harrowing, sowing, manuring, weeding, plant protecting, harvesting and threshing. On average, farmers plough their plot land three times ranging from a mid of February until first week of July with a minimum of 3 times to a maximum of 5 times per production season Table (6). Within this time interval, farmers practiced different farm related operation starting from first ploughing until sowing. Farmers used hand weeding practice and the average weeding time of barley crop was twice per production season mostly exercised on third week of July and fourth week of August.

4.1.5. Farm and farmers related factors

Table 6. Farm and farmers related factors

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Number of ploughing	123	3.18	0.48	3	5
Number of barley plots	123	2.21	0.77	1	4
Distance to home	123	56.78	30.18	6	120
Livestock ownership	123	3.29	2.29	0.815	15
Total expenditure	123	1279.92	634.90	300	5000

Source: Own survey (2016)

It was also found that, the mean number of plots allocated for barley crop was 2.21 located at maximum of 4 plots in different location or site. In addition, the average distance between the plot under barley crop and the farmer's residence were 57 minutes ranging from a minimum of 6 minutes up to a maximum of 120 minute. The table indicated that, on average a farmers must walk one hour to reach on their farm plot and it was more or less had a long distance between the barley farm and farmers residence.

In mixed farming system, it is impossible to rear livestock's without crop production and practice crop production without livestock's because; the by-product of crops used for feed and livestock are used as a source of drought power, means of transportation, source of food from products and by-products of cattle and small ruminants, source of income, for preparation of organic manure to maintain soil fertility. Hence, on average livestock population of the sample household farmers measured in tropical livestock unit was 3.29 with a minimum of 0.815 to a maximum of 15.

The mean total expenditure of the sample households was 1279.92 birr within the range of 300 birr and 5000 birr Table (6).

4.1.6. Institutional factors

The mean frequency of extension contact was relatively nine times with a minimum of twice to a maximum of 18 times per barley production season.

The mean amount of credit obtained from different sources was 1775.61 birr ranging from null to 7000 birr. Major source of credit was Amhara Saving and Credit Institution followed by informal credit source such as borrowing from their neighbors, friends and relatives.

Market is one of the basic institutions for the purchase of different farm input and to sell their outputs. The mean distances of the nearest market to the farmers was 5.31 km and is ranging between 2 km and 12 km.

Table 7. Three major institutional factors

Variables	Observation	Mean	Standard Deviation	Minimum	Maximum
Extension contact (No.)	123	9.31	3.14	2	18
Credit (Ethiopian birr)	123	1775.61	1760	0	7000
Distance to market(km)	123	5.31	2.35	2	12

Source: Own computation (2016)

4.1.7. Barley output and input usage

Output of barley was the dependent variable in the production function and estimated mainly with five important inputs which are fertilizer, seed, labor, oxen power and land.

The mean of barley output for the sample household in the study area in the 2015/16 production season was relatively 17 quintal with a minimum of 4 quintal to a maximum of 45 quintals.

Inorganic fertilizers (Urea and DAP) applied in the study area for the production of cereals mostly for wheat and barley. Generally, the average inorganic fertilizer application for the production of barley among the respondent was 40.52 kilogram with a minimum of zero and a maximum of 200 kilogram.

Unfortunately, there is no user of improved barley seed among the respondents. This is mainly due to, limited supply of improved barley seed and even the limited quota was unfairly distributed throughout the district. Due to this reason, all sample households apply only local barley seed with an average of nearly 83.5 kilogram and the range was from a minimum of 18 kilogram to a maximum of 180 kg which was lower than the forecasting way of recommended barley seed rate (120 kilogram /hectare).

Labor specifically family labor had a major role in the production of barley in activities like ploughing, sowing, weeding, plant-protection, fencing, harvesting and threshing. On average, a total of 54.1 man days were needed for performing all related activities of farming in man days with a minimum of 20 man days to a maximum of 80 man days for barley production.

Table 8. The mean of barley output produced with major inputs

Variable	Mean	Standard Deviation	Minimum	Maximum
Output(quintal)	16.94	9.22	4	45
Fertilizer amount (kg)	40.52	32.35	0	200
Seed amount (kg)	83.47	40.44	18	180
Human labor (MDs)	54.1	16.31	20	80
Oxen power (ODs)	34.88	8.91	20	50
Land under barley (ha)	1.49	0.78	0.25	5

Source: Own computation (2016)

Complement to labor, oxen and horse had a lion share for doing activities related to ploughing and threshing. Relatively, a mean of 35 oxen days were used by sample households for barley production and it ranged between a minimum of 20 oxen days and a maximum of 50 oxen days. Even if, their land is highly fragmented and the soil fertility is

low, the households allocated majority of land for barley crop in the production season. On average, the households allocated 1.49 hectare of their farm plot with a minimum of 0.25 hectare and a maximum of 5 hectare.

4.1.8. Cost of production

Table 9. The total cost of barley output

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Cost of barley output	123	9318.7	5071.38	2200	24750
Cost of fertilizer	123	549.86	439.03	0	2714
Cost of seed	123	500.83	242.63	108	1080
Cost of labor	123	3245.85	978.46	1200	4800
Cost of oxen	123	4185.36	1069.63	2400	6000
Cost of land	123	3684.92	1936.53	617.5	12350
Barley output	123	16.94	9.22	4	45

Source: own computation, (2016)

On average, farmers had required to invest 9318.7 amount of birr for the production of 17 quintals of barley output with a minimum of 2200 birr up to a maximum of 24750 birr. From their total income, the barley producing farmers had expected to spend higher amount of money for oxen power, land rent and wage (that is 4185.36, 3684.92 and 3245.85 birr), respectively. While, they spent less proportion of their expenditure which is 500.83 and 549.86 birr for application of seed and fertilizer, respectively.

4.1.9. Bottleneck problems in barley production

Barley is a highland crop which is grown in high altitudes with an elevation of above 1400 meters above sea level. This may be the reason that, majority of the sampled households (69.1%) reported higher amount of their barley output lost due to frost in the production season. Even if, frost is one of the major problems for their cultivation; untimely rainfall during harvesting time, high price of inputs, shortage of land and labor were reported as factors which adversely affected their crop output in the study area during the 2015/16 production season.

Table 10. Major constraints for barley production

Major constraints	frequencies	Percent
Frost	85	69.1
Untimely rainfall	76	61.79
High price of inputs	70	56.91
Shortage of land	55	44.71
Shortage of labor and oxen power	36	29.27

Source: own computation (2016)

4.2. Results of Econometric Models

4.2.1. Hypothesis testing

Before starting on discussions of the output of the model, different essential hypothesis testing were conducted to identify appropriate functional form, distributions and for the existence of technical inefficiency component of the composed error terms of the stochastic production function.

Table 11. Generalized likelihood ratio tests of hypothesis for the parameters of the SPF

Null hypothesizes	LH0	LH1	Calculated value	Critical value of $\chi^2(0.05)$	Decision
H0: β_{ij}=o	-84.25	-70.43	27.64	24.99	Reject H0
H0: γ=0			0.63		Reject H0
H0: $\delta_1=\delta_2=...=\delta_{13}=0$	-88.54	-70.43	36.22	22.36	Reject H0

Source: Own computation (2016)

The first hypothesis was that selecting the appropriate functional form which fits to the data set by using likelihood ratio test. The most commonly functional forms reviewed in most previous researches were Cobb-Douglas and Trans-log. The likelihood test statistic is calculated in the following way as;

$$LR = -2[lr(Cobb-Douglas) - lr(Trans\log)] \quad (4.1)$$

Which implies $LR = -2[(-84.25) - (-70.43)]$ which equal to 27.64. The statistic is distributed chi-squared with degrees of freedom equal to the number of variables added to

the alternative hypothesis in this case the degrees of freedom was 15. The calculated value (27.64) is higher than the upper 5% critical value of the $\chi 2$ with its respective 15 degree of freedom (that is 24.99). Therefore, the null hypothesis was rejected that says all coefficients of the square and the cross product or interaction terms in trans-log specification are equal to zero. This implies that the trans-log functional form adequately represented the data set.

The second hypothesis was conducted to decide whether the average production function without considering non-negative random error term best fits the data set or not. H0= γ =0 and H1= γ >0. The gamma (γ) parameter is defined as the ratio of the unexplained inefficiency error term (δu^2) to the total sum of errors ($\delta u^2+\delta v^2$) that is,

$$\gamma = \frac{\delta u^2}{\delta u^2 + \delta v^2} \tag{4.2}$$

If γ is near to zero deviations are resulted from random factors whereas, γ approaches to 1 indicated that deviations are resulted from inefficiency factors. The result of the output briefly showed that γ is 0.63 implying that 63% of the total deviation of barley output from the frontier level was due to existence of technical inefficiency. While, the remaining 37% of the total variation of barley output is due to random noises like unexpected rainfall, frost and other natural factors beyond the control of the farmers. Generally, this indicated that there was technical inefficiency so, the traditional production function is not an adequate representation of barley production in this study.

The third hypothesis was about deciding on whether the explanatory variables associated with inefficiency effects are simultaneously equal to zero (H0: $\delta 1=\delta 2\ldots= \delta 13 = 0$) or not. The null hypothesis say that a model without explanatory variables of inefficiency effects while, the alternative hypothesis says the full frontier model with explanatory variables are supposed to determine inefficiency. Likewise, $LR = -2[(-88.54) - (-70.43)] = 36.22$ which is greater than the critical value of 22.36 at 13 degree of freedom implying that, the null hypothesis that explanatory variables are simultaneously equal to zero was rejected at 5% significance level. Therefore, explanatory variables of technical inefficiency can together determine variation in production of barley output in the study area.

4.2.2. Estimation of production function

The dependent variable in estimation of stochastic production function was barley outputs produced in quintals analyzed on the five major inputs with their square and interaction terms. The major five inputs were land under barley, amount of barley seed, quantity of fertilizer, human labor and oxen power. The stochastic frontier model estimates both the trans-log functional forms of production function and variables of technical inefficiency simultaneously by using the first stage estimation approach.

As it presented in Table (12) looking from the output of the model below, seed had negative and significant effect on the output of barley at 5% level of significance. The negative effect was might be due to the reason that, the farmers use low quality local seed below the recommended rate (120 kg/hectare) and they did not apply improved barley seed that improves the quantity of barley output in the study area. As a result other things kept constant, a 1% increment in seed quantity in kg will leads to a 0.48% decrement in barley output. Hence, it might be better to use improved and certified barley seed to increase their barley output. Fertilizer is one of the necessary inputs to improve barley output by maintaining soil fertility and it was significant at 5% level of significant. Hence, a farmer who increased the application of fertilizers in turn earns more output of barley. So, as the farmers increase the application of chemical fertilizer by 1% until the recommended rate, his or her output of barley increased up by 0.31% holding the effect of other inputs fixed.

Labor had a positive sign and significantly affected barley output at 1% level of significance. In order to increase their barley output farmers must increase their family or hired labor for performing different farming operation on the field. As a result, if the farmers increased labor man days by 1%, his or her output of barley increased by 0.43% other factors constant. In most developing countries like Ethiopia, oxen are the main source of draft power to perform activities like ploughing and sowing crops. In line to this, oxen power had a significant and positive effect on farmers barley output in the study area. Ceteris paribus, as the farmers increased the oxen days by 1%, their output of barley raised by 0.36%. Holding all other inputs constant, if the farmers simultaneously raise his application of chemical fertilizer with quantity of seed by 1% at the same time, his/her output will increase by 2.01%. This means that the output of barley in the study area also sensitive and responsive for the interaction of fertilizer and seed.

Table 12. Production and dual cost function model

Ln output	Coefficient (Standard error)	Cost of ln output	Coefficient (standard error)
Ln of fertilizer	0.313**(0.156)	Price of ln fertilizer	-0.058(0.79)
Ln of seed	-0.48**(0.222)	Price of ln seed	0.003(0.92)
Ln of labor	0.436***(0.158)	Price of ln labor	3.520*(1.92)
Ln of oxen	0.364*(0.205)	Price of ln oxen	2.329(1.42)
Ln of land	0.168(0.265)	Price of ln land	0.016(0.09)
Ln of fertilizer square	-0.672(0.520)	Price of ln fertilizer square	5.884(4.22)
Ln of seed square	0.413(0.487)	Price of ln seed square	0.216(0.39)
Ln of labor square	-0.185(0.540)	Price of ln labor square	0.654***(0.22)
Ln of oxen square	1.603***(0.346)	Cost of ln Oxen square	0.704(0.80)
Ln of land square	-0.044(0.168)	Price of ln Land square	-0.418(0.57)
Ln of fertilizer*seed	2.011**(0.980)	Price of ln fertilizer*seed	-0.080 (0.24)
Ln of fertilizer*labor	-0.232(0.514)	Price of ln fertilizer*labor	-0.962**(0.41)
Ln of fertilizer*oxen	-0.827*(0.490)	Price of ln fertilizer*oxen	0.325(0.59)
Ln of fertilizer*land	0.095(0.242)	Price of ln fertilizer*land	0.625(0.46)
Ln of seed*labor	-0.739(0.794)	Price of ln seed*labor	-0.737*(0.41)
Ln of seed*oxen	-2.524***(0.697)	Price of ln seed*oxen	-0.589(0.67)
Ln of seed*land	-0.063(0.205)	Price of ln seed*land	0.810***(0.31)
Ln of labor*oxen	1.173*(0.645)	Price of ln labor*oxen	-0.219(0.16)
Ln of labor*land	-0.190(0.125)	Price of ln labor*land	-0.232(0.14)-
Ln of oxen*land	-0.008(0.015)	Price of ln oxen*land	-0.369(1.29)
		Ln output	5.884(4.22)
		Ln output square	-0.142*(0.07)
		Price of fertilizer*ln output	0.086(0.32)
		Price of seed*ln output	0.044(0.37)
		Price of labor*ln output	-0.096(0.09)
		Price of oxen*ln output	-0.340*(0.19)
		Price of land* ln output	-0.210(0.14)
Constant	-1.32 (2.25)	-	-19.69 (15.75)
Diagnostic tests			
Gamma	0.63	Gamma	0.68
Log likelihood	-70.43	Log likelihood	-68.33
Wald chi2(20)	70.12	Wald chi2(27)	214.96
Lambda	1.32	Lambda	1.46

Source: Model output (2016)

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

The square of oxen input was also had a positive and significant effect at 1% level of significance. Other inputs remain constant, if the smallholder barley producers increase the square of oxen days by 1%, their output would increase by 1.6%. The output of barley was

more sensitive to the interaction of both seed and oxen power than others but, their interaction is negatively significant at 1% level of significance. Ceteris paribus, as the farmers increased both quantities of seed with oxen power and the interaction of fertilizer with oxen by 1%, his/her barley output would shrink by 2.52% and 0.82%, respectively.

In addition, the interaction terms of labor with oxen had a significant effect on barley output at 10% level of significance. Hence, if the farmers increased the interaction of labor with oxen by 1% simultaneously, his or her barley output would be increased by 1.17%.

4.2.3. Elasticity of production

In production function the last task is whether it exhibits constant returns to scale or not. Conceptually, returns to scale is the sum of coefficients of major five inputs of trans-log functions included in the production function. Hence in the study district, their overall sum was 0.801 which is less than one revealed that there was decreasing returns to scale. It can be interpreted as, when farmers increased all the inputs simultaneously incorporated in the production function by a unit, their barley output would increase by 0.801 units which is less than the proportionate increase in all inputs.

4.2.4. Cost of production function

In the cost of production function, the dependent variable was cost of barley output over estimated with the cost of all twenty seven variables. The price of; labor power, labor power square, the interaction of fertilizer with labor, the interaction of seed with land, the cross product of labor with seed and the interaction terms of oxen with barley output as well as, the square of barley output were the significant inputs at certain level of significance and affect the cost of barley output production either negatively or positively. Since, the price of barley output is more sensitive and responsive for the change in the price of human labor, the interaction terms of cost of fertilizer with cost of labor and the price of seed with land because their coefficient is higher relative to other cost of inputs. On the other hand, the square of barley output and the interaction of price of oxen power with barley output had less effect on the cost of barley output because, their coefficient was much lower as compared to the cost of other inputs.

Wage of human labor had a positive and significant effect on the cost of barley output at 10% probability level that is, as the wage of human labor increase by 1%, the farmers cost

of barley output also increased by 3.52% holding other factors fixed. The wage of human labor square also had a positive and significant influence on the cost of barley output at 1% significance level. Other things remain constant, a 1% increment in the cost of labor square is associated with an increment in the cost of output by 0.65%. The cost interaction of seed with land had positive and significant effect on the cost of barley output at 1% level of significance. As a result, if the farmers increased his/her expenditure by 1% on seed with land at the same time, his/her cost of production for barley output were increased by 0.81% holding other factors constant.

On the other hand, when the farmers invest more and more of his/her money simultaneously on either one of the application of interaction between; fertilizer with labor, seed with labor and oxen with barley output his/her cost of barley production would decreased by 0.96%, 0.74%, 0.34%, respectively. In addition, the square of barley output also had a negative and significant effect on cost of barley output at 10% level of significance. Hence, as the output of barley square increased by 1%, the farmers cost of production on barley output also decreased by 0.14% ceteris paribus.

The transcendental logarithmic functional form of the stochastic cost function also revealed that, about 68% variation in the total barley production cost was due to the difference in cost inefficiency among the farmers.

4.2.5. Technical, allocative and economic efficiencies scores of barley producers

The result of frontier model revealed that, the mean technical efficiency of the sample household farmers during the 2015/16 production season was 70.9% and it ranged from 14% to 95%. This indicated that, there is a wide gap variation among the sample barley producer farmers in the study area. It also told that, farmers could had more possibility to increase their current production of barely output on average by 29.1% without changing the existing inputs. In other word, farmers had an opportunities to decrease all the current input usage by 29.1% without decreasing the output of barley produced.

The mean level of allocative efficiency of the sample farmers in the study area was 68.6% which indicated that there is large gap to improve the current level of allocative efficiency and producers could reduce their cost of inputs by 31.4% without any change from optimum level of output obtained. The result also revealed that, farmers were not choose

the optimal combination of inputs with respective price so, there is a possibility to increase the optimal input combination at a lower price with the available technology.

Table 13. Technical, allocative and economic efficiencies of barley

Variables	Mean	Standard Deviation	Minimum	Maximum
Technical efficiency	0.709	0.16	0.14	0.95
Allocative efficiency	0.686	0.12	0.34	0.90
Economic efficiency	0.488	0.16	0.10	0.83

Source: Own computation (2016)

The mean value of economic efficiency indicated that, relative to their technical and allocative efficiencies the farmers were economically less efficient. The mean level of economic efficiency found in this study was 48.8% and ranged from 10% to 83% which disclosed that farmers in the study area also had a greater deviation. This means that, wisely and efficient utilization of the existing resource would decrease the production cost of barley producers by 51.2%. In other words it revealed that, there is a possibility of farmers to save 51.2% of resources by efficient allocating factors of production.

4.2.6 Distribution of efficiencies score

The distribution table of efficiency score presented below disclosed, majority of the sample barley producers in the study area face in which range. In a sense, around 34.96% of the technical efficient farmers were fail on the range of between 80% and 90% followed by 17.89% between the range of 70% and 80%. While less percentage of farmers were within the range of less than 20%. Hence, almost 61% of the sampled farmers attained the level of technically efficient above the mean level and the remaining 39% were below the mean technical efficiency level. This indicated that, relatively more farmers have the ability to produce maximum level of barley output with the existing level of inputs and technology.

The distribution of allocative efficiency revealed that, over 20% of the sampled barley producers were in the range of between 80% and 90% attained more allocatively efficient approach to the frontier line but, 39.84% were attained below the mean allocative efficiency level. Even if 60.16% were recorded their allocative efficiency score above the mean level, the study indicated that farmers had a room to reallocate inputs in a cost minimizing way to improve their allocative efficiency.

Table 14. Efficiencies distribution

	TE		AE		EE	
Efficiency level	Number	%	Number	%	Number	%
<= 0.1	0	0	0	0	0	0
0.1- 0.19	2	1.63	0	0	7	5.69
0.2- 0.29	4	3.25	0	0	11	8.94
0.3 – 0.39	6	4.88	2	1.62	15	12.2
0.4 – 0.49	6	4.88	9	7.32	29	23.58
0.5 – 0.59	13	10.57	21	17.08	26	21.14
0.6 – 0.69	15	12.19	23	18.7	26	21.14
0.7 – 0.79	22	17.89	43	34.96	8	6.50
0.8 – 0.89	43	34.96	25	20.32	1	0.81
>=0.9	12	9.75	0	0	0	0

Source: Own computation (2016)

The model result also revealed that, the distribution of farmer's economic efficiency was skewed to the right of the mean level which means that, 52.85% of the household farmers had economic efficiency greater than the mean level. Hence, 23.58% of the farmers in the study area failed between the range of 40% and 50% which is around the mean level.

4.2.7. Sources of inefficiency variation among barley producers

The second objective of the study was identifying the source of inefficiencies variation or disparity among barley producers in Meket district. Related to this, the economic, technical and allocative inefficiencies levels were regressed on the hypothesized variables that bring inefficiency disparity among the barley growers. These socio economic, farm related and institutional variables expected to affect all inefficiencies were farming experience, education level of the household head, number of extension contact, number of barley plots, crop rotation, non-farm income, livestock ownership, amount of credit obtained, distance of home to the nearest market, total expenditure of the household, soil fertility, farm distance from residence and sex of the household head. The technical inefficiency variables were estimated by using one stage estimation approach of frontier model while, allocative and economic inefficiency variables were regressed by using OLS estimation

technique. The same estimation technique also used by (Sharma *et al.*, 1999; Arega and Rashid, 2003; Komicha and Öhlmer, 2007; Susan, 2011).

Table 15. Source of technical, allocative and economic inefficiencies

	Technical inefficiency	Allocative inefficiency	Economic inefficiency
Inefficiency variables	Coefficient (S. error)	Coefficient (S. error)	Coefficient (S. E.)
Farming experience	-0.004(0.019)	0.004***(0.001)	0.011 **(0.005)
Education Level	-0.168*(0.098)	0.021***(0.006)	0.110*** (0.027)
Frequency of extension contact	-0.124*(0.074)	-0.011**(0.005)	-0.058*** (0.021)
Number of barley plots	-0.718**(0.33)	-0.021**(0.009)	-0.132*** (0.037)
Crop rotation	1.535**(0.65)	-0.062 (0.041)	0.051 (0.172)
Non-farm income	0.351(0.58)	0.126***(0.042)	0.672*** (0.172)
Livestock ownership	-0.017(0.12)	-0.025**(0.011)	-0.105**(0.046)
Ln credit	-0.008(0.02)	0.002 (0.002)	0.012(0.010)
Distance to market	0.191*(0.10)	0.014*(0.008)	0.108***(0.034)
Ln expenditure	1.984**(0.48)	0.014(0.042)	0.291*(0.174)
Soil fertility	1.366**(0.55)	0.045(0.045)	0.320*(0.188)
Distance to home	1.277**(0.57)	0.009(0.041)	-0.081(0.169)
Sex	-0.352(0.60)	-0.017(0.056)	-0.029(0.233)
_cons	-9.540**(4.03)	0.207 (0.323)	-2.071(1.338)
	Statistical tests		
F(13,109	-	4.03	6.21
Pro>F	-	0.00	0.00
R-squared	-	0.32	0.42
Adjusted R-squared	-	0.24	0.35
Observation	-	123	123

Source: Model output (2016)

***, **, * refers to 1%, 5% and 10% level of significance, respectively.

As it is presented in the table above; education level, frequency of extension contact, the practice of crop rotation, number of barley plots, distance of home to the plot, total expenditure, soil fertility of land and distance to home from the nearest market were the significant variables that affected the technical inefficiency of barley growing farmers in the study area. In addition, farming experience of farmers, education level of the household

head, extension contact, non-farm income, livestock ownership, distance to the nearest market and number of barley plots were the significant variables that determined the allocative inefficiency of barley producers in the study area. The result also released that, the farming experience of farmers in barley production, education level of the household head, frequency of extension contact, number of barley plots, non-farm income, livestock ownership, soil fertility, distances of home to the nearest market and total expenditure were significantly affected the level of economic inefficiency of barley producers in the study area.

More than this, the result of the model clearly disclosed the variables that simultaneously affect all technical, allocative and economic inefficiency levels were education level of farmers, frequency of extension contact, number of barley plots and distance to the nearest market. Identifying these variables will helps for policy makers and concerned bodies to take different measures and action to decrease the inefficiencies level of barley growing farmers in Meket district. Farming experience, participation on non-farm income and livestock ownership were the significant variables that had a significant effect on both allocative and economic inefficiencies while, total expenditure of the household and soil fertility had a positive and significant effect on technical and economic inefficiencies. Detailed interpretation and discussion of the statistically significant variables would be presented as follows:

Farming experience: Unexpectedly, the coefficient of farming experience of farmer's on barley production positively affected the allocative and economic inefficiencies of farmers significantly at 1% and 5% level of probability, respectively. Its positive sign might be due to the reason that those farmers having more experiences of farming may not responsive for modern inputs combination that minimize their costs. They may be experienced more on their traditional and backward technology which consumes more money and time. So, as the farming experience increased by one year, the allocative and economic inefficiencies of farmers also increased by 0.4% and 1.1%, respectively other factors kept constant. This result was similar with the result founded by Adeyemo *et al.* (2010).

Level of education: The education level of farmers had negative relation with technical inefficiency and unexpected positive relationship with allocative and economic inefficiencies significant at 1% significance level. For every increment in education level by one years of schooling, the technical inefficiency of farmers would decreased by 0.168

scores while, the allocative and economic inefficiency of farmers was increased by 2.1% and 11%, respectively other variables remain constant. The positive sign might be due to, as the farmer's education level increase they give less attention to agricultural activities and also invest more of their time, knowledge and money to participate on trading, service rendering and other non-agricultural activities. The result was convenient with the results founded by (Vu, 2008; Giang, 2013). Onumah *et al*. (2013) also stated in their paper as formal education is probably not increasing their efficiency, because the most important is knowledge and education related to agricultural practices itself.

Frequency of extension contact: As expected the coefficient was negative and significantly affected the level of technical, allocative and economic inefficiencies at 10%, 5% and 1% level of significance, respectively. This might be due to the reason that, the information that got from extension workers had a power to increase the awareness and know-how of farmers towards technologies and efficient utilization of the existing resource to decrease their inefficiency and wastage of resource use. As the extension workers frequently visit and follow up farmers more and more, farmers may obtained important and influential information to decrease their technical, allocative and economic inefficiencies level by 0.124 scores, 1.1% and 5.8%, respectively ceteris paribus. This finding was in-line with (Jude *et al.*, 2011; Mustefa, 2014).

Number of barley plots: On contrary to the expected sign it had negative relationship and significant at 5% for both technical and allocative inefficiencies and at 1% level of significance for economic inefficiencies. Other variables holding fixed, additional barley plot is associated with a decrement in technical, allocative and economic inefficiencies by a 0.718 score, 2.1% and 13.2%, respectively. It revealed that those farmers having barley farm plots more than one in different locations were more efficient. This might be due to the fact that, in the study area farmers cultivate barley by share-cropping system in addition to their own land. So, this enables them had more farm plots at different location and reduce inefficiencies associated with risks that come due to frost. In the study area, some plots locations are vulnerable for frost and others are not and it is a serious problem that aggravate their inefficiency of crop production. In addition, it might be due to difference in the soil fertility of barley farm plots at different location that is, on average fertile soils would help to earn higher output and improve efficiencies of farmers. This finding was consistent with the findings of (Tan *et al*., 2010; Yami *et al.*, 2013); Wudineh and Endrias, 2016).

Crop rotation: Its coefficient was positive and significant at 5% level of significance for technical inefficiency. As compared to those farmers who practice crop rotation, the technical inefficiency of not practicing crop rotation increased by 1.535 scores other factors fixed. Therefore, practicing crop rotation especially cereals with legume crops can restore and maintain soil fertility so as to decrease the technical inefficiency of barley producers by increasing its barley production. This finding was in line with (Musa, 2013).

Non-farm income: It affected positively for allocative and economic inefficiencies at 1% level of significance. This means that as compared to those farmers who had non-farm income sources, the allocative and economic inefficiencies of farmers had not participated on different non-farm income activities increased by 12% and 67%, respectively. This indicated that, farmers used the income earned from different non-farm activities to cover their budget constraint to purchase the required farm inputs. This result was in line with (collie *et al*, 2002; Shumet, 2011; Solomon, 2014).

Livestock ownership: It affected allocative and economic inefficiencies negatively at 5% level of probability. This means that, farmers increased their number of livestock holding by one TLU could decrease their allocative and economic inefficiencies by 2.5% and 10.5%, respectively. The result also disclosed that farmers having largest number of livestock holding helps to avoid cash constraint and to satisfy all needs of farmers in the study area. This finding was consistent with the result obtained from (Wassie, 2012).

Distance to the nearest market: As expected it affected all inefficiencies level positively and significantly. As the distance of the nearest market to the farmer's residence increased by one kilometer, the technical, allocative and economic inefficiencies of farmers also increased by 0.191 scores, 1.4% and 10.8%, respectively. This implies that as the farmers is far from market, their inefficiency increases because it incurs more cost to transport inputs and outputs, transaction costs and to get market information. The result was in line with (Hassen, 2011; Musa *et al.*, 2015).

Total expenditure of the household: The coefficient of total expenditure of the household had a positive sign and significant effect on both technical and economic inefficiencies at 5% and 10% levels of probability, respectively. Holding other variables constant, if expenditure of household increased by 1% farmers technical inefficiency also increased by 0.02 scores and 0.291% for economic inefficiency. This might be due to the reason that, during the survey period majority of their income is spend for consumption purpose to feed

their household and construction of houses. In turn, this causes cash deficiency to buy basic and required inputs to decrease their technical and economic inefficiencies. The result was in line with (Mustefa, 2014).

Soil fertility: It had a positive as well as a significant influence on technical and economic inefficiencies level at 5% and 10% levels of significance, respectively. It means that, as compared to those individuals having fertile lands, the technical and economic inefficiencies of farmers having infertile land had increased by 1.36 scores and 32%, respectively hold other factors constant. Therefore, such policies to increase and maintain soil fertility of land must had a negative effect on inefficiency of barley production. The result was similar with the findings of (Alemayehu, 2010; Musa, 2013); Hailemaraim, 2015).

Distance to home: The average distance between the plots and farmers residence positively affected the technical inefficiency of barley producers at 5% levels of significance. Ceteris paribus, additional average distance between residence of farmer and his/her barley plot is associated with an increment of 1.277 technical inefficiency scores of the farmer. The distance between farm and farmers residence strongly affect their frequency of supervision, plant protection and application organic fertilizer especially animal dung. Because, all these factors strongly increase his/her technical inefficiency level. The result was similar with the findings of (Alemayehu, 2010).

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

This study was conducted with the objectives of estimating the mean level of efficiencies and identifying the sources of technical, allocative and economic inefficiencies variation among barley producers in Meket District, Amhara National Regional State of Ethiopia. In order to succeed these objectives, both primary and secondary data were used. Primary data was collected from 123 sample smallholder barley growing farmer respondents of three *kebeles* from a cross sectional data of 2015/16 production season via questionnaire. In addition, both published and unpublished secondary data were collected from agricultural office at Zonal and Woreda level.

The collected data were analyzed by applying both descriptive statistics and econometric model. The study employed stochastic frontier model with the specification of transcendental logarithmic functional forms of the production function to estimate the input variables of barley output and the technical inefficiency variables simultaneously using one-stage estimation approach. While, variables that cause allocative and economic inefficiencies disparity among barley growing farmers in the study area were regressed using ordinary least square estimation procedure. The trans-log production function showed that, inputs like inorganic fertilizer, labor, oxen power, square of oxen power, the interaction of both fertilizer with seed amount and labor with oxen affected the output of barley in the study area positively and significantly at different level of significance. But, the amount of barley seed, the interaction of barley seed with oxen power and fertilizer with oxen determine the output of barley negatively and significantly at 5%, 1% and 10% level of significance, respectively.

The trans-log functional form of the production function and its dual cost function revealed that, the mean technical efficiency of 70.9% and it ranging from the minimum of 14% to the maximum of 95%. This figure told that, there is a possibility to increase the technical efficiency of barely producers on average by 29.1% with the existing resources on hand if appropriate measures are taken in resource use. The mean level of allocative efficiency of the sampled farmers in the study area was 68.6% which showed that it is a must to improve the current level of allocative efficiency and they can reduced their cost by 31.4% without any change from optimum level of output. Lastly, the mean of economic efficiency was

48.8% with a minimum of 10% and a maximum of 83% which indicated that like the other mean efficiency level, the farmers in the study area also had a greater differential among them. The study also revealed that, there is a possibility of farmers to save 51.2% of resources by efficient allocating factors of production.

The one stage estimation technique of frontier model also clearly revealed that education level, frequency of extension contact and number of barley plots affected technical inefficiency negatively. With the same fashion, the practice of crop rotation by farmers, distance of the farmer's residence from the nearest market, total expenditure of household, soil fertility and distance of the plot from home had positive effects on technical inefficiency variation among the barley producer farmers.

The result from OLS estimate also disclosed that among thirteen socio economic, farm specific and institutional factors; farming experience, education level, non-farm income and distance from the nearest market affected allocative inefficiency positively while, frequency of extension contact, number of barley plots and livestock ownership were the significant variable that negatively determined the allocative inefficiency of barley producers in the study area. In addition, farming experience of farmers, education level, non-farm income, total expenditure, soil fertility and distance of home from the nearest market affected economic inefficiency positively. On the other hand, frequency of extension contact, number of barley plots and livestock ownership significantly and negatively affected the level of overall inefficiency of farmers in the study area. Generally, the negative coefficient of different socio-economic, farm related and institutional variables clearly showed that any improvements made on these variables would decrease the inefficiency levels of barley growing farmers. On the other hand, the positive sign of the coefficient of variable indicated that such policies and strategies aimed at encouragement and motivation of these variables would absolutely aggravated inefficiency disparity among farmers in the study area.

5.2. Recommendations

The main goal of this study was showing the degree of variation and identification of important variables that bring disparity of inefficiency among farmers. As expected, the result of the study clearly showed the presence of inefficiency variation among the farmers and identify which variables strongly affected their inefficiency level and also showed that

there is a huge opportunity to improve their efficiency level and increase barley output if appropriate measures are taken. Hopefully, this would help for concerned bodies and policy makers to intervene through different policies and strategies which minimize the inefficiency variation among them and bring all barley producers closer together at fully efficient level as much as possible with the available resource at their hand with the given technology and input at its disposal.

Based on the significant variables which affected all technical, allocative and economic inefficiencies level simultaneously, the following recommendations were forwarded. Because, appropriate actions and policies on these variables had a strong implication to narrow the gap of inefficiency variation among farmers and policy-makers who know why some farmers are relatively more inefficient than others will helps to choose the most likely array of development programs for improving institutional and socio-economic factors contributing towards decreasing inefficiency.

The result of the study indicated that, frequency of extension contact of farmers with extension agents was the significant variable and had a negative effect on all inefficiencies level. This means that any policy aimed to improve the capacity of development agents will decrease the inefficiency of farmers. Since, development agents had a pivotal role to disseminate new production information, technologies and inputs from the research field to the actual farmers on ground. Therefore, special emphasis and motivation should be given for those personnel so as to improve the efficiency level. This is possible by upgrading the development agents or extension workers by providing practical attachment training with the current agricultural production and as much as possible decrease ratio of development agents to the number of farmers so as to increase the number of extension contact and to make the number of farmers manageable to the extension agents.

The second important variable that requires serious emphasize was number of barley plots. It had a negative effect on technical, allocative and economic inefficiencies. This means that, farmers having more barley plots were less inefficient than farmers having small number of barley plots. The policy which addressed this issue must be, farmers extend or increase their barley farm plot either via practicing share cropping or renting land with rigorous use of available inputs and resources.

Thirdly, the result confirmed that education level of the household head negatively affected technical inefficiency while it positively affected allocative and economic inefficiencies.

Even if it had unexpected sign for allocative and economic inefficiencies, it calls a special emphasis to upgrade the managerial ability of farmers or farmers education by providing youth training center, practical training and creation of awareness and knowhow about the application of inputs and different farming system.

Fourthly, the other variable which had a positive effect on all inefficiencies level were the distance of the home from the nearest main market. The result suggested that policy makers would significantly decrease the inefficiency of sample farmers via the development of road and market infrastructure that reduce home to market distance. In addition, it is better to launching of new market around their residence exercising to purchase farm inputs and to sell their outputs with a minimum transaction cost.

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7. APPENDICES

Appendix 1. The likelihood ratio of trans-log and Cobb-Douglas functional form

Log likelihood =	-70.43	Log likelihood =	-84.25
Wald chi2 (20)=	70.12	Wald chi2 (5)=	20.77
Prob > chi2 =	0.0004	Prob > chi2 =	0.0060
Inputs	Coef. (Standard error) for trans log functional form	Coef.(Standard error) for Cobb Douglas functional form	
Ln of fertilizer	0.31**(0.156)	0.20(0.17)	
Ln of seed	-0.48**(0.222)	-0.40*(0.23)	
Ln of labor	0.436***(0.158)	0.45(0.16)	
Ln of oxen	0.364*(0.205)	0.33***(0.21)	
Ln of land	0.168(0.265)	-0.23***(0.07)	
Ln of fertilizer square	-0.672(0.520)		
Ln of seed square	0.413(0.487)		
Ln of labor square	-0.185(0.540)		
Ln of oxen square	1.603***(0.346)		
Ln of land square	-0.044(0.168)		
Ln of fertilizer*seed	2.011**(0.980)		
Ln of fertilizer*labor	-0.232(0.514)		
Ln of fertilizer*oxen	-0.827*(0.490)		
Ln of fertilizer*land	0.095(0.242)		
Ln of seed*labor	-0.739(0.794)		
Ln of seed*oxen	-2.524***(0.697)		
Ln of seed*land	-0.063(0.205)		
Ln of labor*oxen	1.173**(0.645)		
Ln of labor*land	-0.190(0.125)		
Ln of oxen*land	-0.008(0.015)		
Constant	-1.32 (2.25)	0.33(1.98)	

***, **, * indicated that, 1%, 5% and 10% level of significance, respectively.

Appendix 2. Exponential and truncated normal distribution of inefficiency variables

	Exponential distribution		Truncated normal distribution	
Inputs	Coefficient	Standard Error	Coefficient	Standard Error
Ln of fertilizer	0.304*	0.162	0.269***	0.087
Ln of seed	-0.500**	0.232	-0.179	0.185
Ln of labor	0.408**	0.163	0.482 ***	0.079
Ln of oxen	0.368*	0.205	0.900 ***	0.047
Ln of land	0.217	0.258	0.023	0.078
Ln of fertilizer square	-0.591	0.528	-0.261 ***	0.081
Ln of seed square	0.452	0.494	1.463***	0.020
Ln of labor square	-0.193	0.545	0.091	0.151
Ln of oxen square	1.562***	0.356	1.151***	0.068
Ln of land square	-0.042	0.188	-0.392 ***	0.050
Ln of fertilizer*seed	1.789*	1.00	0.490	-
Ln of fertilizer*labor	-0.134	0.517	-0.446	0.424
Ln of fertilizer*oxen	-0.777	0.518	0.217 ***	0.031
Ln of fertilizer*land	0.070	0.259	0.082	0.202
Ln of seed*labor	-0.649	0.798	-1.701 ***	0.177
Ln of seed*oxen	-2.427***	0.719	-3.027	-
Ln of seed*land	-0.041	0.217	0.0176	0.184
Ln of labor*oxen	0.989	0.642	2.288 ***	0.333
Ln of labor*land	-0.211	0.122	-0.154 ***	0.053
Ln of oxen*land	-0.007	0.016	0.002	0.004
Constant	-1.342	2.34	-6.146 ***	1.505
Log likelihood =	-71.31		Log likelihood = -72.12	
Wald chi2(20) =	58.39		Wald chi2(18) =	-
Prob > chi2 =	0.00		Prob > chi2 =	-

***, **, * indicated that, 1%, 5% and 10% level of significance, respectively.

Appendix 3. Hetroschedasticity test for allocative and economic inefficiency

Ho: Constant variance

	Allocative inefficiency	Economic inefficiency
chi2(1)	0.02	0.15
Prob > chi2	0.89	0.69

Appendix 4. Omitted variable tests for allocative and economic inefficiency

Ho: model has no omitted variables

	Allocative inefficiency	Economic inefficiency
F(3, 106) =	1.31	0.61
Prob > F =	0.27	0.60

Appendix 5. VIF test for allocative and economic inefficiencies variable

Variables	VIF	1/VIF
Sex	1.52	0.657
Soil fertility	1.48	0.675
Crop rotation	1.15	0.866
Non-farm income	1.15	0.870
Distance to market	1.07	0.935
Ln expenditure	1.19	0.843
Farming experience	1.12	0.892
Ln credit	1.14	0.876
Education level	1.09	0.917
Number of barley plots	1.11	0.899
Distance to home	1.11	0.904
Frequency of extension contact	1.07	0.936
Livestock holding	1.18	0.845
Mean VIF	1.18	

Appendix 6. Conversion factor of man equivalent and adult equivalent

Age group	Man equivalent		Adult equivalent	
	male	Female	male	Female
<10	0	0	0.6	0.6
10-13	0.2	0.2	0.9	0.8
14-16	0.5	0.4	1.0	0.75
17-50	1.00	0.8	1.0	0.75
>50	0.7	0.5	1.0	0.75

Source: Strock et al., 1991

Appendix 7. Conversion factors used to estimate Tropical Livestock Unit equivalents

Animal category	TLU
Calf	0.25
Donkey (young)	0.35
Donkey (adult)	0.70
Weaned calf	0.34
Camel	1.25
Heifer	0.75
Sheep and Goat (young)	0.06
Sheep and Goat (adult)	0.13
Cow and Ox	1.00
Horse	1.10
Chicken	0.013

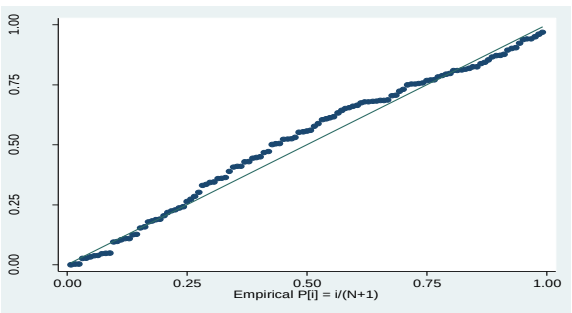
Source: Strock, *et al*. (1991).

Appendix 8. Estimation of technical inefficiency variables by using ordinary least square method

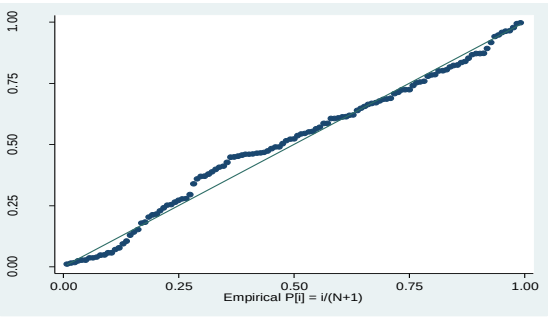
	Technical inefficiency	Allocative inefficiency	Economic inefficiency
Inefficiency variables	Coefficient (S. error)	Coefficient (S. error)	Coefficient(S.error)
Farming experience	-0.005(0.005)	0.002***(0.001)	0.003***(0.001)
Education level	0.024(0.028)	0.012*** (0.003	0.022*** (0.006)
Extension contact	-0.034(0.02)	-0.006**(0.002	-0.012*** (0.004)
Number of barley plots	-.007(0.04)	-0.012**(0.004)	-0.027*** (0.008)
Crop rotation	0.371**(0.18)	-0.035(0.021)	0.004(0.036)
Non-farm income	0.217(0.18)	0.061*** (0.021)	0.139*** (0.036)
Livestock ownership	0.001(0.05)	-0.014**(0.006)	-0.02**(0.01)
Ln credit	-0.009(0.01)	0.004(0.004)	0.020*** (0.01)
Distance to market	0.108***(0.04)	0.012(0.023)	0.061(0.039)
Ln expenditure	0.345*(0.18)	-0.027(0.021)	-0.018(0.035)
Soil fertility	0.112(0.19)	-0.002(0.029)	0.000(0.048)
Distance to home	0.144(0.18)	-0.002(0.022)	0.059(0.036)
Sex	0.171(0.24)	0.001(0.001)	0.003(0.002)
Constant	-4.198***(1.4)	0.350(0.165)	0.076(0.278)
		Statistical tests	
Adjusted R-squared	0.10	0.23	0.34

***, **, * indicated that, 1%, 5% and 10% level of significance, respectively.

Appendix figure 1. Normality of the residuals of allocative inefficiency and economic inefficiency respectively



Allocative inefficiency



economic inefficiency

Appendix 9. Individual efficiency scores of the sampled household farmers

1	0.875018	32	0.667013	63	0.710432	94	0.853314
2	0.725652	33	0.591575	64	0.202927	95	0.610854
3	0.899177	34	0.845522	65	0.826655	96	0.506574
4	0.336897	35	0.661549	66	0.701503	97	0.511608
5	0.923674	36	0.891904	67	0.948643	98	0.161311
6	0.844224	37	0.899541	68	0.559848	99	0.82172
7	0.823339	38	0.417372	69	0.761158	100	0.836042
8	0.611123	39	0.906654	70	0.724212	101	0.674977
9	0.677926	40	0.340724	71	0.875111	102	0.756195
10	0.865701	41	0.783277	72	0.899864	103	0.675665
11	0.90224	42	0.342342	73	0.750341	104	0.554076
12	0.539165	43	0.899984	74	0.86616	105	0.86248
13	0.87502	44	0.69393	75	0.873526	106	0.362551
14	0.869312	45	0.855873	76	0.655824	107	0.70935
15	0.77272	46	0.471224	77	0.382208	108	0.317212
16	0.908154	47	0.83987	78	0.822191	109	0.751788
17	0.574292	48	0.820426	79	0.597895	110	0.849527
18	0.598618	49	0.918751	80	0.65474	111	0.868948
19	0.876766	50	0.739822	81	0.241332	112	0.535984
20	0.653221	51	0.494552	82	0.541076	113	0.717837
21	0.904841	52	0.740265	83	0.70508	114	0.924242
22	0.824191	53	0.848826	84	0.830543	115	0.722852
23	0.86099	54	0.14255	85	0.900288	116	0.724421
24	0.777421	55	0.874184	86	0.849609	117	0.807987
25	0.824788	56	0.550933	87	0.443584	118	0.797777
26	0.875293	57	0.441286	88	0.775606	119	0.89888
27	0.83602	58	0.596024	89	0.914084	120	0.621823
28	0.8028	59	0.46213	90	0.909326	121	0.824543
29	0.939143	60	0.270564	91	0.23615	122	0.621628
30	0.65286	61	0.865783	92	0.761168	123	0.643126
31	0.868829	62	0.7984	93	0.82031	Mean	0.709422

Technical efficiency scores of the sample household farmers

1	0.71453	32	0.69848	63	0.66482	94	0.81416
2	0.70428	33	0.69327	64	0.5649	95	0.75696
3	0.7302	34	0.84168	65	0.79649	96	0.84805
4	0.74337	35	0.43697	66	0.69189	97	0.55805
5	0.89876	36	0.60796	67	0.65906	98	0.77781
6	0.42653	37	0.54236	68	0.82826	99	0.79457
7	0.80351	38	0.781	69	0.49683	100	0.61017
8	0.74233	39	0.85357	70	0.53374	101	0.51018
9	0.77271	40	0.58972	71	0.44596	102	0.53076
10	0.7741	41	0.51585	72	0.77364	103	0.59295
11	0.5377	42	0.4975	73	0.71626	104	0.84718
12	0.80062	43	0.72342	74	0.62946	105	0.79031
13	0.76182	44	0.60503	75	0.83016	106	0.80474
14	0.79092	45	0.86481	76	0.60542	107	0.71973
15	0.76444	46	0.5862	77	0.6476	108	0.72774
16	0.65448	47	0.79058	78	0.84005	109	0.71074
17	0.61328	48	0.52683	79	0.56865	110	0.64983
18	0.53779	49	0.70024	80	0.76977	111	0.70352
19	0.75806	50	0.70865	81	0.79861	112	0.77036
20	0.74413	51	0.40457	82	0.74582	113	0.82325
21	0.71584	52	0.80043	83	0.62725	114	0.69973
22	0.53071	53	0.74576	84	0.83934	115	0.84303
23	0.5707	54	0.73375	85	0.83119	116	0.8043
24	0.68069	55	0.80907	86	0.74032	117	0.64006
25	0.60894	56	0.74093	87	0.79474	118	0.62273
26	0.39229	57	0.78255	88	0.7121	119	0.54617
27	0.58588	58	0.84204	89	0.56754	120	0.80691
28	0.84308	59	0.44941	90	0.73725	121	0.34283
29	0.83703	60	0.58491	91	0.55977	122	0.72303
30	0.49029	61	0.6227	92	0.69139	123	0.6883
31	0.87181	62	0.7984	93	0.73142	Mean	0.68674

Allocative efficiency scores of the sample barley producers

1	0.625226	32	0.465895	63	0.472312	94	0.694731
2	0.51106	33	0.410121	64	0.114634	95	0.462391
3	0.656576	34	0.711663	65	0.658423	96	0.429598
4	0.25044	35	0.289075	66	0.485365	97	0.285501
5	0.83016	36	0.542239	67	0.625208	98	0.12547
6	0.36009	37	0.487877	68	0.463696	99	0.652912
7	0.661562	38	0.325966	69	0.378169	100	0.510126
8	0.453655	39	0.773891	70	0.386544	101	0.344361
9	0.523837	40	0.20093	71	0.390266	102	0.401359
10	0.670138	41	0.404056	72	0.696173	103	0.400635
11	0.485137	42	0.170315	73	0.537438	104	0.469404
12	0.431667	43	0.651068	74	0.545213	105	0.681625
13	0.666606	44	0.419847	75	0.725164	106	0.291761
14	0.687557	45	0.740163	76	0.397051	107	0.510539
15	0.590699	46	0.276232	77	0.247518	108	0.230849
16	0.594367	47	0.663982	78	0.690682	109	0.534325
17	0.352204	48	0.432221	79	0.339995	110	0.552052
18	0.321932	49	0.643342	80	0.504001	111	0.611324
19	0.664645	50	0.524275	81	0.192731	112	0.412898
20	0.486079	51	0.200078	82	0.403542	113	0.590962
21	0.647719	52	0.592534	83	0.442258	114	0.646719
22	0.437409	53	0.633022	84	0.697107	115	0.609388
23	0.491366	54	0.104596	85	0.74831	116	0.582648
24	0.529185	55	0.707276	86	0.628982	117	0.517164
25	0.50225	56	0.408205	87	0.352532	118	0.496803
26	0.343371	57	0.34533	88	0.552305	119	0.49094
27	0.489805	58	0.501877	89	0.518776	120	0.501753
28	0.676828	59	0.207686	90	0.670398	121	0.282678
29	0.786093	60	0.158256	91	0.13219	122	0.449456
30	0.32009	61	0.539122	92	0.526266	123	0.442664
31	0.757452	62	0.390953	93	0.599988	Mean	0.488322

Economic efficiency levels of the sample barley producers

Appendix 10. Questionnaires

Household questioner on: **Economic Efficiency of Barley Production**: The Case of smallholder farmers in Meket District, Amhara National Regional State of Ethiopia

General Instruction:

This questioner is mainly focus on obtaining important information only on the 2015/16 production years.

- Tell the purpose of the study and introduce yourself before starting the interview.
- For all closed questions encircle the appropriate you are interested in and use the space provided for open-ended questions.

Name of Enumerator _____ Date of interview----------

Identification Number ---------- Kebele……..

1. General Information about the Sample Household

1. Household number (code) _____

2. Name of household head_____ 3. Age _____

3. Sex: 1. male 2. Female

4. Keble _____Locality (Gote)_____

5. Marital status: 1 Married 2. Not married 3. Divorced 4. Widowed

6. Education level: 1) Illiterate 2) only read and write 3) Literate If, you attained in school indicate your educational level number in grade _____

7. Religion: 1. Orthodox 2. Muslims 3. Other specify

8. Farming experience _____years

9. For how many years did you cultivate Barley? _____

no.	Name of household member	age	sex	kinship	Edcn. Level	Non-farm income
1						
2						
3						

2. Input-Output information on barley production

1. How much of your land is covered by barley crop in 2007/8 production year?__ timad

2. On average at what time did you sow barley in 2007/8 production year? _____Week of _____month.

3. Do you use chemical fertilizer in barley field? 1. Yes 2. No

4. If yes, how many kgs of chemical fertilizer did you use? _____

5. How much money did you pay?_____

6. If you do not use fertilizer, why? a. Not timely available b. Not available at all c. Inconvenient to transport d. Not good to apply on barley field e. too expensive f. Others (specify)

7. Do you use pesticides and herbicides in barley field? 1. Yes 2. No

8. If yes, how much of them did you use in liters_____ and how much money did you pay?

9. If no, why? a. Too expensive b. Lack of knowledge c. Not timely available d. Not available at all e. Not effective f. Risky for animals' g. Other ---------

10. Do you practice fallowing? 1. Yes 2. No

11. If yes, after how many years of harvesting do you fallow your land? _____years

12. Then for how long you fallow your land? _____Years.

13. If no, why_____?

14. Is weeding barley crop a common practice? 1. Yes 2. No

15. If yes, when did you start weeding barley? _____Week of _____month

16. How many times did you weed your barley? _____times.

17. What method did you use for weeding? a. Hand weeding b. chemicals c. Others, specify

18. Did you use improved barley seed in 2007/8 production year? 1. Yes 2. No

19. If yes, how much in kg _____ and how much money did you pay in birr _____?

20. If no, why? a. Too expensive b. Not better than local varieties c. lack of awareness d. It is not easily accessible e. Other ----------

21. Did you practice crop rotation for barley production? 1. yes 2. no

22. If yes what kind of practice? a) Barley to other cereals b) barley to legume crops

23. If no why?

3. Information on costs of barley production

s.no	Material		Quantity		Unit price	Total expenditure
			Own	Purchase		
1	Seed	local				
2	Fertilizer	Dap				
		Urea				
3	Rent in land					
4	Rent for oxen					
5	Wage for labor					

4. Land holding and production

1. What are major annual crops you grow? a. Bean b. linseed c. Pea d. Barley e. Wheat

2. How many plots or locations do you have? _____

3. On how many plots do you sow *barley* this year? ----------

4. On average how many times do you plough your plot?

5. How much of your land is covered by *barley* crop this year? ----------timad

6. Total size of land covered by annual crops in 2007/8 EC---------timad

6 Total size of land rented in, in 2007/8 EC……...timad

8. Total size of own land rented out in 2007/8 EC……..timad

9. If the land is rented in, how much did you pay per timad? ----Birr

10. If the land is rented out, what is the price per timad? ----------

11. Total size of land share cropped out in 2007/8 EC ----------timad

12. Total size of land share cropped in in 2007/8 EC ----------timad

5. Barley Plot Characteristics

Plot No.	Plot name	Plot distance from home (km)	Crop grown on the plot last year	Soil fertility 1=fertile, 2=medium 3=infertile	Plot status 1=owned 2=rented in 3=shared in4=shared out
1					
2					
3					

6. Human labor input used for different farm operations

No.	Operations	Human Labor			Quantity	Total Expenditure	Oxen power		
		Type		Wage per worker			Type		Rate per oxen
		Family labor	Hired labor				own	rent	
1	Ploughing								
2	Harrowing								
3	Sowing								
4	Manuring								
5	Fertilizer Application								
6	Transporting								
7	Weeding								
8	Plant Protection								
9	Harvestng								
10	Threshing								
11	Others								

8. Annual income from agricultural production

No.	Type of annual crop	Area (timad)	Quantity produced (qt)	Quantity sold in qt.	Unit price	Total value
1						
2						
3						
4						
5						
6						

7. Information regarding livestock ownership

S. No.	Livestock name	No.	Purpose of maintaining A: sale B: consumption C: draught D: Others (wealth ,culture, social status, ...)	Livestock sold	Total income
1	Oxen				
2	Bulls				
3	Cows				
4	Heifer				
5	Calf				
6	Donkey				
7	Horse				
8	Mule				
9	Goat				
10	Sheep				
11	Total				

9. Information regarding efficiency factors

1. Did you have any sources of non-farm income for you and your family? If yes

Source	Number of days per month in 2007/08	Total annual amount in cash	In kind
Remittances			
Gifts			
Aid			
Wage employment			
Trading			
Hand crafting			
Service rendering			
Processing and resource extracting			
Others specify			

10. Responsibility

1. Do you have any responsibility in the community? 1. Yes 2. No

2. What is your responsibility in the community? a. Administrative b. Social

c. Religious d. Other specify_____

3. Do you think this responsibility have a negative impact in your farming activities?

1. Yes 2.No

4. How many hours per week do you spend on these responsibilities? a. four hours

b. eight hours c. twelve hours &above d. other specify_____

5. Who take care of the farming activities while you are doing these responsibilities?

a. Only Family members b. Hired workers and family members c. The traditional labor arrangements (*debo, wenifal,* etc) d. Other specify_____

11. on credit use

1. Do you have get access to credit? 1. yes 2. no

2. If your answer is yes how much did you borrow?

3. Credit taken and repayment situations of the farmer in the current production year of 2015/16

Credit & repayment condition	Purpose					
	UREA	DAP	Seed	chemicals	Other nonfarm credits	Sources
Amount taken(br)						
Amount taken (kg)						
Timely repaid						
Remained unpaid						

4. Which of these are the sources of your credit? A. Cooperative B. Amhara Credit and Saving Institution (ACSI) C. Agricultural and Rural development office

D. individual Money lenders E. Others (specify)

5. In your opinion what are the major problems in credit use

A. Inadequate amount of credit B. High interest rate C. Untimely credit supply

D. Other (specify)

12. Marketing conditions

1. How many quintals of barley did you produce in 2007/08 production year? _____

2. Purpose of production

A. all for sale B. all for consumption C. Partly for consumption and partly for sale

3. If your answer is choice 'C' how many quintals did you sell?

4. What was the average selling price? _____ birr/qt

5. Do you have unsold barley waiting for good market season? 1. Yes 2. No

6. If yes, how many? _____ Quintals.

7. In which month/s do you expect to sell_____ & at what price? _____birr/qt.

8. If yes, what marketing problems are you facing?

A. Low price B. High seasonal price fluctuation C. Inadequate demand

D. High marketing cost E. Lack of market information F. Credit sale

9. Again, if yes what do you think will be the solution? _____

10. How many kilometers you are far from the near main market.

13. Extension services:

1. Did you get an extension service? 1. Yes 2. No

2. If yes, average frequency of contact with DA and extension professions in 2007_____ times in week?

3. Is there farmer-training center in your area? 1. Yes 2. No

4. How many trainings have you taken so far? ____

5. Did you ever receive any information about barley production market access?

1 Yes 2. No

6. Did you get any practical training with regard to barley production? 1. Yes 2. No

7. How much barley you would have produced in 2007/08 had there not been an extension service? a. the same as I produce b. a little lower than I produce c. much lower than I produce d. totally impossible to produce without the extension service e. I could not determine this way

8. What are the major agricultural extension service problems in the area? _____

_____

9. What information did you obtained that influenced your barley production?

(a) _____

(b) _____

14. Constraints in barley enterprise

1. What are the major constraints of barley production? a. Weed infestation b. Crop disease c. Seed shortage d. Shortage of draft animal e. Shortage of labor f. frost g. Any other, please specify.....

2. What is your plan with regards to the area to be allocated for barley production in 2008/09 production seasons?

a. Increase b. Decrease c. No change

3. What is your reason for the response in the above question? _____

4. What is the selling price of one quintal of barley at harvest time in 2007/08 production year?

5. What is the selling price of one quintal of barley during the slack period 2007/08 production year?

6. What were some of the constraints you faced in barley farming?

A. During planting: _____

B. During harvesting:_____

C. During marketing and selling: _____

13. General household expenditure of the household in the year 2015 production season

Description	Annual expense	Remark
Consumption		Only cash expense for consumption
Medication		
School fee		
Closing		
Social obligation		
Others		

3.7. Distance from home of household to Infrastructure

No.	Type of infrastructure	Distance in km
1	Farmers training center	
2	Cooperatives	
3	Health center	
4	Nearest Market	