ST.MARY'S UNIVERSITY
SCHOOL OF GRADUATE STUDIES

ANALYSIS OF TECHNICAL EFFICIENCY OF LENTIL PRODUCTION: THE CASE OF MORETHA JIRU DISTRICT IN NORTH SHEWA ZONE OF AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

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Analysis of Technical Efficiency of Lentil Production: The Case of Moretha Jiru District in North Shewa Zone of Amhara National Regional State, Ethiopia

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DECLARATION

I hereby declare that this thesis is my own work and has never been presented in any other university. All sources of materials used for this thesis has been appropriately acknowledged.

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ENDORSEMENT

This Thesis has been advised by me and fulfils the requirements of the School of Graduate Studies St. Mary's University, recommended for open examination with my approval as a university advisor.

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APPROVAL SHEET

As members of the board of examining of the final MSc thesis open defense, we certify that we have read and evaluated the Thesis prepared by Mesfin Gudeta under the title " Analysis of Technical Efficiency of Lentil Production: The Case of Mo retina- JiruDistrict in North Shewa Zone of Amhara National Regional State, Ethiopia" we recommend that this Thesis be accepted as satisfying the thesis requirement for the Degree of Master of Science in Development Economics

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LIST OF ACRONYMS AND ABBREVIATIONS

ACS	Amhara Credit and Saving Institution
AE	Allocative Efficiency
ATVET	Agricultural Technical and Vocational Education and Training
BCC	Banker Charnes Cooper
CCR	Charnes Cooper Rhodes
CSA	Central Statistical Agency
CRS	Constant Return to scale
DEA	Data Envelopment Analysis
DMU	Decision Making Units
Das	Development Agents
DAP	Di Ammonium Phosphate
EE	Economic Efficiency
HHH	Household Head
GDP	Gross Domestic Production
KAs	Kebele Administrations
MD	Man-day
ML	Maximum Likelihood
MLE	Maximum Likelihood Estimation
FA	Farmers' Association
OD	Oxen Day
LR	Log likelihood Ratio
OLS	Ordinary Least Square
ETB	Ethiopia birr
Qt	Quintal
Kg	Kilogram
SFA	Stochastic Frontier Analysis
SPF	Stochastic Production Frontier
TE	Technical Efficiency
WOA	Woreda Office of Agriculture
UN	United Nations

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ABSTRACT

This study aims to estimate the level of technical efficiency of lentil production and its determinants in MO retina Jiru district North Showa Zone Amhara region of Ethiopia. The study was based on cross sectional data collected from a randomly selected 126 sample smallholder farmers. To analyze the data both descriptive and econometrics model were applied. Besides, stochastic model *was to estimate the level of technical efficiency score. The estimation result showed that the mean efficiency level of lentil farmers were 62.6%, with the minimum and maximum efficiency level of about 12.9 and 98%, respectively. Among inputs considered, land, seed, Fertilizer and Human labor were found as positive and in significant determinants of lentil production. The positive coefficients of these parameters indicate that increased use of these inputs will increase the production level. The estimated inefficiency factors model shows that fertility status of the age of farmer, lentil farmer expediency, extension service, access to credit; off/non-farm activity, cooperative membership, and household size are significant determinants of inefficiency of the farmers in the study area. Negative coefficient of fertility status, age of farmer, access to credit, Household size, off/non-farmer activity, and cooperative membership indicates that improvement in these factors results in a significant decrease in level of inefficiency and access to training, sex of household and market and price conduction are not significance level. Besides, positive coefficients of land size, Extension service, education and lentil farmer experience indicate that as size of land increases, efficiency will decreases. The results suggest that policy makers should focus on providing improved seed, extension and credit services, improving fertility of land and creating means of income generation for the excess lab our in the household. Such measures may, in turn, reduce the food security problem and enhance the export of the commodity.*

Key words: *Technical Efficiency of Lentil, North Shewa Zone of Amhara, Ethiopia*

CHAPTER ONE

1.1.Background of the study

Agriculture in Ethiopia accounts of 85 % of employment about 36.7 % of the annual GDP and 85 of the foreign earnings. The issue of improving agricultural productivity has always been among the key development agenda of the Ethiopian government due to, among others considerable increase in population and food price. Given fixed or declining supply of agricultural land, labor and other inputs, economic growth in countries like Ethiopia can hardly depend only on agriculture. Crop production Morteina- Jiru Woreda in North Shaw Zone of central Ethiopia highlands is constrained by technical, economic and environmental factors. These factors made the productivity of wheat, faba bean and lentil very low. The existence of production inefficiency at farm level, lack of and inexistence of improved production technologies are accountable for the low productivity of selected four crops, among others. Yet, there is no any reliable data or information on the level of productivity and/or efficiency per unit of the limiting factors.

Previous empirical efficiency studies in Ethiopia such as study by Sarafraz (2004) focused on analysis of technical efficiency of wheat farmers in the mixed farming system and attested that access to improved agricultural technologies and farm inputs is a long-lasting challenge Ethiopian farmers have been living with. Hence, measuring level of production efficiency and the extent of resource use inefficiency given the existing technology and input levels is critically important. Therefore, a question arises as to how farmers are using or combining the available scarce resources to produce the maximum output and sources of inefficiency differentials among farm households. These are key issues whose investigation can be useful for the formulation of policies to strengthen and improve the efficiency of crop production in the study areas. This focuses on taking a step towards filling the above mentioned problems by collecting cross-sectional data form smallholder farmers of central highlands of Ethiopia.

In Ethiopia, the private peasant holders grow Lentils primarily for the seed which has relatively higher contents of protein; carbohydrate and calories compared to legumes and is the most desired

Because of its high average protein content, fast cooking characteristics (S. Kumer, S. Bar Pete, Kumer, P.Gubta and A.Sarker, 2013). It provides important economic advantages to the small scale farm households in providing food, feed, cash income, soil improvement and

Foreign currency earnings (Ma t n y on, 2015; Daniel. A, Firew M, and A snake F, 2015**).**
On the other hand, lentils one of the heavily consumed legumes crops in Ethiopia and is a popular ingredient of every day diet in the majority of households. Besides being rich in protein, the ability of crop to use atmospheric nitrogen through biological nitrogen fixation (BNF) is economically appealing and environmentally friendly. It is also well adapted to various soil types and also considered as drought-resistant crop. It is widely grown in areas having an altitude range of 1,700-2,400 meters above sea level with annual rainfall ranging from 700-2,000 mm in Ethiopia (David Karanja, 2016; A snake F, 1996) Lentils are grown in different volumes across the country. Lentils grown in 2015/16 (2008 E.C.) covered 6.1% (100,692.74 hectares) of the legumes crop area produced by 68,6415 private peasant land holders and 5% (about 1,339,336.41 quintals) of the legumes production was drawn from the lentil crop in Ethiopia. This is concentrated in the Amhara and Oromia regions with 54% and 36% producers, respectively, engaged in production. The two regions account for 93% of the total area occupied by lentil (CSA, 2016). Lentil production is mainly depends on soil type, altitude and agro ecologic conditions in Ethiopia, its production is not mechanized and produced by small holder farmers with fragmented plots of land mainly for household consumption.
In Morteina-Jiru woreda north Shewa zone of central Ethiopia highlands huge gap of productivity difference between farmer's field and on station is due to variability of crop husbandry practices such as soil, crop fertilizer and weed management. Constrained technical, economic and environmental factors made the productivity of lentil less. The existence of production is less efficiency at farm level, lack of and in existence of improved production technologies are accounts able for the low productivity of selected crop, among others. The production of lentil makes a significant contribution to the farm household food security status (Frederick et al., 2006; Sacker and Kumar, 2011).

The question remains as to how farmers will survive when production units are not efficiently used on the farm; traditional cereal farming is not only low-yielding but also results in the mining of plant nutrients from the soil. After harvest materials the traditional farmers remove the straws for livestock feed. These practices leave no crop reside to restore soil nutrients and organic matter. With dwindling land resources and population increase increased food production Has to come mainly from technological innovation to increasing productivity particularly of small holders who are the main food producers in developing countries. The growth of lentil production by small scale producer depends on the need to improve productivity of farm lands. It is evident that productivity growth may be achieved through either technological progress or efficiency improvement, such as improved farmer education to ensure that farmers use the existing resources more efficiently (Coelli, 1995) .Many factors are contributing to trap Ethiopia in the current state of food insecurity and poverty. These include production fluctuations, low non-farm employment, low income, regional fragmentation of markets, high rate of natural degradation, low level of farm technology, high level of illiteracy and inadequate quality of basic education, poor health and sanitation, high population growth, poor governance and inter-state, intra-state military conflicts and wars. These factors impede the achievement of food security and sustainable economic development. It has one of the lowest per capita incomes in the world and high incidence of absolute poverty with 50% of the population below the poverty line (Asefa and Zegeye, 2003)

In general Morten Jiru Woreda in particular is largely traditional characterized by low input and lentil farming technology usage and focuses on management of indigenous breed types that have low lentil production yield. Have low lentil production yield. However, the traditional lentil production accounts for the greater proportion of lentil farming and lentil production in peri- rural and rural areas in or around.

1.2. Statement of the Problem

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

Gains in agricultural output through improvement of efficiency levels are becoming particularly important now a day. The opportunities to increase farm production by bringing additional forest land into cultivation or by increasing the utilization of the physical resources have been diminishing. In addition, eliminating existing inefficiency among formers can prove to be more cost effective than introducing new technologies as a means of increasing agricultural output and farm household income (Wondimu et al., 2014)

In Morteina – Jiru Woreda north Shewa zone central Ethiopia, at farm-level, the most important problem in lentil production disease, among which rust, root rots and fusarium wilt are the major ones, individual land holding ranges between 0.5 and 5hectares, large family sizes, input costs, weed infestation and high amount of rain fall (more than 20 days) and the type of soil is black soil this soil is contain high amount of water at his time the root of lentil is rots. Lentil usually matures in three and half months and harvested between mid-September and October. Therefore, an ever increasing population pressure and environmental degradation followed by declining productivity and expansion of marginal agricultural lands necessitate[s] farmers either to use modern technologies or need to use resources efficiently in order to optimize outputs in the North Eastern Ethiopia (Mekonnen et al., 2015)

According to previous researches in Ethiopia for example Getachew et al., 2014; Musa et al., 2014; Hessen, 2014 Wondimu and Hassen, 2014) there also exists a wide cereal yield gap among the farmers that might be attributed to many factors' such as lack of knowledge and information on how to use new crop technologies. Poor management, include both biotic and abiotic (insects, diseases and weeds), a biotic (climate, soil fertility) factors and more others (Mesay et al., 2013; Sisay et al., 2015). Because of the scanty resources that are on ground, recently it is getting importance to use these resources at the optimum level which can be determined by efficiency searches (Gebregziabher et al., 2012). Thus, increasing crop production and productivity among smallholder producers requires a good knowledge of the current efficiency/ inefficiency level inherent in the sector as well as factors responsible for this level of efficiency / inefficiency (Essa et al., 2012). Though there have been various empirical studies conducted to measure efficiency of agricultural production in Ethiopia, for example, Lentil is amongst the principal cool season food legumes in Ethiopia too(Joseph, 2014). it is widely grown in areas having altitudinal range of 1700-2400 ,enters above sea level with annual Rainfall ranging from 700-2000mm in Ethiopia (Korbu, 2009) lentil is commonly sown towards end of July or in August Ethiopia and particularly grown as an important crop in Amara Or Omiya and Tigre Regions and some parts of Sothern nations nationalities and peoples region (Korbu, 2009) it is usually well adapted to various soil types ranging from sandy to clay loam when there is good internal drainage (Ozdemir, 2002). It appears very sensitive to water logged field conditions and, even with short period of exposure to water logging can cause the crop to die easily (Brenna et al., 2002). It performs best on deep, sandy loam soils with high phosphorus and potassium contents. High humidity with excessive rainfall during growing season promotes vegetative growth and caused loading, which reduces later good yield and seed quality although the lentil crop has evolved appropriate stress tolerance strategies, they are largely affected by global climate change that in turn brought a number of environmental challenges.

Now a day in Ethiopia there has been increasing focus by policy makers on investments on modern technologies rather than efforts targeted at improving the efficiency of in efficiency farmers theoretically, introducing modern technologies can increase agricultural productivity and production. However, in areas where there is inefficiency in which the existing input and technologies are note efficiently utilized trying to introduce new technologies may not have the expected results. Obviously, the level of farmers, technical efficiency has paramount implications for country's choice of development strategy (Zeneb et al .2005)

Despite its potential, in Mo retina – Jiru Woreda agricultural productivity is decaling (CSA, 2012). Therefore, the need for the efficient allocation of productive resources cannot be overemphasized. However, in areas where there is inefficiency training to introduce new technology may not bring the expected impact unless factors associated with inefficiency among farmers are identified and acted upon. The existence of inefficiency in production comes from inefficient use of scarce resources. The measurement of efficiency in agricultural production is important issue for agricultural development and it gives useful information for making relevant decision in the use of these scare resources and for reformulating agricultural policies. Thus this study has attempted to generate information for policy implication by identifying factors that are associated with technical efficiency in lentil production in in MO retina –Jiru Woreda. Therefore, the study filled this information and knowledge gap at the study area.

1.3. Objectives of the Study

1.3.1. General objective of the study

The general objective of the study was to analyze the level of technical efficiency of lentil Production in Moretha Jiru district North Showa Zone Amara region of Ethiopia.

1.3.2 The specific objectives of the study

1. To estimate the level of technical efficiency of lentil production; and
2. To identify factors affecting the level of technical efficiency lentil production among farmers in the study area.

1.4. Research Questions

There is a great diversity among farmers in terms of resource endowment, know how about the existing technology, knowledge of arming practices and socio-economic variables. The presence of such differences among farmers may lead to variation in their technical efficiency. Therefore, some of the farmers may produce a higher level of output with a given technology and inputs and others may produce less. Hence, this study tries to address the following research question;

1. What are factors that affecting productivity of lentil producing farmers?

2. What is the level of technical in efficiency among lentil producing farmers?

3. Which farm/farmer-related and socio-economic variables affect technical inefficiencies of lentil producing farmers in the study area?

1.5. Scope of the Study

This study focused on technical efficiency in lentil production during Me her season in one Woreda from five selected ke beles using cross sectional data of the 2015/16 production year collected from 126 lentil producing smallholder farmers. The other limitation was related with the methodology used. The study does not show inter temporal differences in technical efficiency level of lentil producing farmers. In addition, the study is limited to the analysis of technical efficiency of lentil production without regard to other crops. Moreover, the study is limited to only MO retina –Jiru Woreda. North Showa Zone, Amhara National Regional State, Ethiopia

1.6. Limitation of the Study

Due to financial and time constraints, it will not feasible to cover the entire region during this study. For that reason, the study was limited to rural areas of the region: Mo retina –Jiru woreda. Data on lentil production and utilization for the study was limited to the past two months only Lentil production and utilization for the study was limited to the past two months only. This was to ensure accurate recall of production situations and associated revenues and costs which Is highly unlikely for an entire production year.

1.7. Significance of the Study

The study was focus on the issue of technical efficiency in lentil production and identifies factors associated with technical efficiency among farmers. It can play a significant role in providing useful information concerning technical inefficiencies in production and by identifying those factors, which were associated with inefficiencies that may exist. It can also indicate an entry point for further policy interventions to technical efficiency of smallholder farmers. Therefore, this study is expected to generate adequate understanding of the issues that might lead towards taking appropriate actions for improvement of efficiencies. Hence, the outcome of this piece of work can have important implications for the professionals and for the policy formulation purposes. Therefore, in the view of the above narrated importance of knowing the factors of inefficiency of production, the study will have significant important as follows rust, the result will provide useful information for the government and policy makers regarding the key factors affecting production. Thus, it will contribute to designing appropriate polices and strategies to increase lentil production. Secondly, the study will also contribute to useful information for other grain crops that usually have similar production processes for farm households and helps in designing lentil extension package in the context of the zone and region as well as the national level. Finally, it will serve as source for future empirical literature for scholars and students interested in the area of efficiency and in the field of agricultural economics and related fields.

1.8. Organization of the Thesis

The rest of the thesis is organized into the following. Chapter two contains the literature review part. Chapter three presents the methodologies adopted for this study together with brief description of the study area. Moreover, this section gives highlights about the physical and demographic features of study area, sampling procedure and sample size drawn for the study, methods of data collection and definition of variables and hypothesized effects of each determinant of efficiency. In the fourth chapter, both the descriptive and econometric results are presented and discussed in detail. The fifth chapter presents the summary, conclusions and recommendations of the study.

CHAPTER TWO

2. LITERATURREVIEW

2.1. Introduction

In this chapter, the details of literature review on the concept of efficiency and productivity, measurement issues of technical efficiency and agricultural efficiency studies conducted abroad as well as in Ethiopia are presented.

2.1.1. Theoretical review

2.1.1.1. Concept of productivity and efficiency

In economics, the term efficiency is commonly used in variety of settings which includes aspects such as efficient price, efficient markets and efficiency firms among others efficiency in production refers to scarce resources being used in an optimal fashion .in production economics, efficiency can be under stood in terms of affirms ability to convert inputs in to outputs and respond optimally to economic signals or prices. The question of efficiency in resource allocation in traditional agricultural is crucial it is widely held that efficiency is at the center of agricultural production. this is because the scope of agricultural production can be expanded and sustained by farmers through efficient use Of resources (Ali,1996;Udoh,2000; Hailu et al.,2005).for these reasons, efficiency has remained An important subject of empirical investigation particularly in developing economies were majority of the farmers are resource-poor(Umoh,2006).

The history of efficiency measurement in microeconomics goes back to Farrell(1957) who defined a simple measure of firm efficiency .in the approach, Farrell(1957) proposed that efficiency of any given firm is composed of technical and al locative efficiencies .according to Farrell(1957),technical efficiency (TE) is associated with the ability of affirm to produce on the i so-quant frontier while al locative efficiency (AE) refers to the ability of affirm to produce at a given level of output using the cost-minimizing in put ratios. Thus, economic efficiency (EE) can be defined as the capacity of affirm to produce a predetermined quantity output at a minimum cost fora given level of technology. Most often, many scholars used productivity and efficiency interchangeably and consider both as the measure of performance of a given firm. However, these two phenomena are not the same (Coelliet al.,1998).in simple term; productivity of farmer is producing a given level of output per unit of input. Productive efficiency represents the optimal in put mix to produce any given level of output that minimizes the cost of production (Forsund et al.,1980).

Productive efficiency consists of technical and allocative efficiency. Technical efficiency measures the relative ability of the farmers to get the maximum possible output at a given level of input or set of inputs. Technically efficient farmers are those that operate on the production frontier which represents maximum output attainable from each in put level. All feasible points below the frontier are technically in efficient points. According to Ellis(1988) technical efficiency is the extent to which the maximum possible output is produced from a given set of inputs. On the other hand, producer is said to be allocative efficient if production occurs in asset of economic region of the production possibility set. Thus, if a farmer has achieved both technical and allocative efficiencies, then the farmer can be said economically efficiency In simple term, productivity is the quantity of a given output of affirm (e.g. farmer) per unit of input.

Technical efficiency (that part of efficiency which explains the physical performance of a firm).measures the relative ability of farmer to get the maximum possible output at a given in put or set of input (Coelli et al., 1998). Rasmussen (2011), in his book of production economics; the basic theory of production optimization, states that the development in production and input factor consumption over time is often of considerable interest. The description of the increase or decrease in production can be presented in various ways and can e.g.be related to the factor consumption. Concepts such as productivity, efficiency, and technological changes are often used to discuss and evaluate changes in production and factor consumption. However, these concepts are often used without the speaker being entirely aware of their precise meaning. According to him, productivity can be briefly defined as production (output) divided by input. In a production where only one input x is used to produce one output y. the description is simple, as productivity will then be y/xi.e.

Productivity (p)= $^{y}/_{x}$

Then efficiency is expressed as $= \frac{y}{f(xo)}$

The degree of efficiency can be measured in two ways; one way is to measure the output and input dimensions.

According to Coelli et.al.(1998) efficiency consists of two main components; technical and Allocative efficiency ;and it is stated that technical occurs if a firm obtains maximum output from asset of inputs whereas allocative efficiency occurs when a firm chooses the optimal combination of input s ,given the level of prices and production technology the product of technical and allocative efficiency provide an overall efficiency which is achieving maximum output from a particular input level ,with utilization of inputs at least cost. Since technical in efficiency farms the basis of this paper ,it is important to present and explain the concept .the economic efficiency of a production system is made up of two components ,technical and allocative efficiency .crudely defined ,technical efficiency is the physical component of the production system which deals with the maximization of output from the physical combination of inputs ,and AL locative efficiency is the optimization of the production process which takes in to consideration in put-out put price relationship The relationship between technical efficiency and technical in efficiency as shown in equation

Technical in efficiency = 1- Technical efficiency.

2.1.1.2. Concepts of Efficiency Measurement

The farmers output can be increased through increased inputs, increasing productivity of inputs and the combination of the two. Hence, efficiency is a central issue in production economics helping as a guide for allocation of resources (Farrell, 1957). Productivity improvements can be achieved in two ways. One can either improve the state of the technology by inventing new technology which leads to an frontier or upward shift in the production alternatively one can improve efficiency of the farmers to use the existing technology more efficiently. This would be represented by the firms operating more closely to the existing frontier. Therefore, it is evident that increase in productivity achieved through either technological progress or efficiency improvement so that the policies required to address these two issues are likely to be quite different (Coelli, 1995).Basically there are two approaches in measuring efficiency: input oriented and output oriented. The output oriented approach deals with the question “by how much output could be expanded from a given level of inputs?” Alternatively one could ask “by how much can input of quantities be proportionally reduced without changing the output quantity produced?” This is an input oriented measure of efficiency. However, both measures will coincide when the technology exhibits constant returns to scale, but are likely to vary otherwise (Coelli and Bttese, 2005).

2.1.1.3. Input-oriented efficiency measures

The concept of input-oriented measures of efficiency of a firm which uses two inputs x1 Tand x2 to produce a single output y, under the assumption of constant return to scale can be illustrated in Figure1. Two inputs x1 and x2 are represented on horizontal and vertical axes respectively. EE* represents an iso-quant of a fully efficient firm. All points on this i so-quant represent technically efficient production. Assume a firm is producing at point A as shown in Figure 1; this firm produces the same level of output as is produced by the fully efficient firm. To define the technical efficiency (TE) of this firm, a line is drawn from the origin to the point A. This line crosses the iso-quant at the point C. In the case of a fully efficient firm, y* amount of output (y) is produced using inputs (x1 and x2) at point C whereas in case of the observed firm, operating at A, additional inputs are used to produce y* amount of output (y). Therefore, observed firm, operating at A, does not use inputs efficiently. The technical efficiency of the observed firm can be defined as the ratio of the distance from the point C to the origin over the distance of the point A from the origin:TE=$\frac{OC}{0A}$

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$TE = \frac{0C}{0A}$ X2

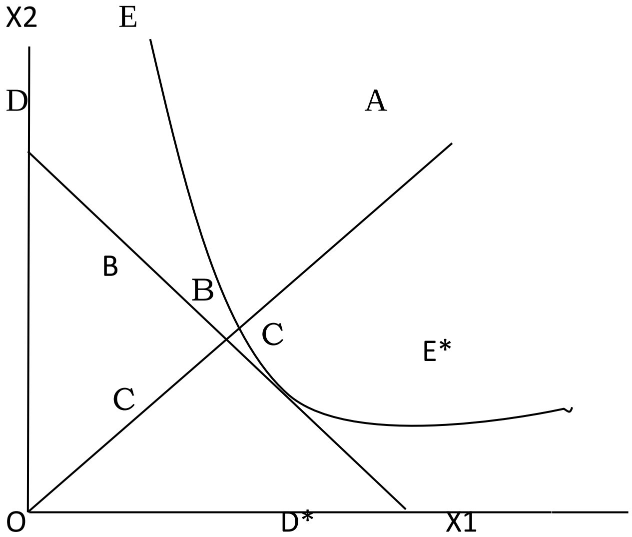


Figure 1: Input-oriented measures for technical, allocative and economic efficiencies

Source: Reproduced from Coelli et al. (1998).

The distance CA represents the technical inefficiency of the observed firm, which is the amount by which all inputs could be proportionally reduced without reduction in output. The value of TE lies between 0 and 1. A firm is technically efficient if it has TE equal to 1. If the value of TE is less than 1, the firm is technically inefficient. If input prices are given, allocative efficiency (AE) can also be calculated. A line DD* is drawn tangent to the iso-quant EE* at the point C*.The line DD* represents an iso-cost line showing all possible quantities of the two inputs, given their relative market prices that would cost the same amount to the firm. Slope of the iso-cost line represents the input price ratio. For output quantity produced at point C, the best use of inputs is at point C*, because it represents the minimum cost. The AL locative efficiency of the firm is defined as

$$AE=\frac{0B}{0C}$$

At point C* a farm is both technically and allocative efficient. Distance BC represents the reduction in production cost that would occur if production were to occur at allocative and technically efficient point C*, instead of at technically efficient but allocative inefficient point C. Value of allocative efficiency lies between 0 and 1. A value of 1 indicates that the firm is allocative fully efficient while value less than 1 indicates that the firm is allocative inefficient.

The economic efficiency (EE) is defined as the product of technical and allocative Efficiency.

EE=AE x TE

$$EE=\frac{0B}{0C} \quad X \quad \frac{0C}{0A}$$

$$EE=\frac{0B}{0A}$$

Value of economic efficiency is bounded between 0 and 1. Value of 1 indicates that the firm is economically fully efficient while value less than 1 indicates that the firm is economically inefficient.

2.1.1.4. Output-oriented efficiency measures

The output oriented measures of efficiency focuses on the changes in output of a firm that may be achieved when using the same quantity of inputs. The concept of output-oriented Measures of efficiency of a firm producing two outputs (y1 and y2) with one input can be illustrated using Figure 2. Two outputs y1 and y2 are represented on horizontal and vertical axes respectively. AA* is a production possibility curve showing different combinations of two outputs (y1 and y2) produced using a given level of input (x1). AA* production possibility curve represents a technically efficient practice. Any firm that is producing at this curve is said to be a technical efficient firm. A firm that is producing at point B is technically inefficient firm because it lies below the production possibility curve AA* that represents the upper bound of production possibilities. To define the technical efficiency of the observed firm producing at point B, a line is drawn from the origin to the point B. This line crosses the production possibility curve at point C. The observed firm uses the same input level as is used by the fully efficient firm, operating at point C

The technical efficiency of the observed firm is defined by the ratio of the distance of the point B to the origin over the distance from the point C to the origin. TE = OB/OC The distance BC represents the level of technical inefficiency. It is the amount by which outputs could be increased without requiring extra input.

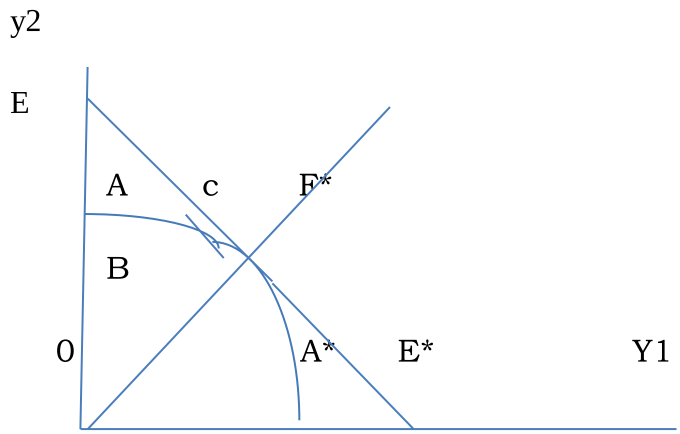


Figure 2: Output-oriented measures for technical, allocative and economic efficiencies
Source: Reproduced from Coelli et al. (1998)

If there is price information it is possible to calculate allocative efficiency. Line EE* represents an iso-revenue curve which is drawn tangent to the production possibility curve at F*. The line OB meets it at point D. The allocative efficiency of the observed firm is defined by the ratio of the distance of point C to the origin over the distance of point D to the origin.

$$AE = \frac{0C}{0D}$$

The economic efficiency of the observed firm is defined as:

$$EE = \frac{0B}{0C} x \frac{0C}{0D}$$

$$EE = \frac{0B}{0D}$$

According to the literature, the efficiency of a farm (production unit) can be measured either with respect to its normatively desired performance or with the performance of another farm. Thus, measures of efficiency are essentially computed by comparing observed performance with some specified standard notion of performance. The "production frontier" serves as one such standard in the case of TE. TE can be defined as the ability and willingness of a production unit to obtain the maximum possible output with a specified endowment of inputs (represented by a frontier production function), given the surrounding technology and environmental conditions. Suppose that a farm has a production plan (Y^0, X^0), where the first argument is the set of outputs and the second represents the set of inputs. Given a production function f (.), the farm is technically efficient if Y^0=f (X^0) and technically inefficiency Y^0<f (X^0). Therefore, the TE can be measured by the ratio $0 \leq Y^0/f(X^0) \leq 1$.

Farrell (1957) carried out the first empirical study to measure TE for a cross-section of production units by using a deterministic/non-parametric frontier approach and, consequently, frontier efficiency comparisons have become synonymous with the term “Farrell efficiency measurement”. This measure assumes that the production function of the fully efficient unit is known in some manner. Since the actual production function is never known in practice, Farrell suggests that it can be estimated from the sample data using either a non-parametric piece-wise linear technology or by a parametric function such as the

Cobb-Douglas form. Aigner and Chu (1968) followed the latter method and estimated a deterministic parametric frontier using a homogeneous Cobb-Douglas production function. Later, Trimmer (1971) converted the deterministic frontier into a probabilistic frontier method. However, this approach has some limitations. All farms share a common frontier and any variations in farm efficiency are measured relative to this frontier. This approach ignores any random factors that can influence the efficiency of a farm (such as climate). Moreover, the results of this approach are highly sensitive to variable selection and data errors. Later, Aigner et al. (1977) and Meeusen and Broeck (1977), independently developed a stochastic frontier approach to measure TE.This approach introduces as a multiplicative (neutral) shift variable within a production function framework. This means that the input coefficients of the conventional production function and that of the frontier function are the same and only the intercept term changes. In practice, with cross-section data, the distribution of the TE term must be specified - as half-normal, truncated normal, or otherwise. As suggested Several methods can be used to quantify technical efficiency. All of them broadly follow the same logic: identifying the share of productivity growth resulting from efficiency changes through the measurement of the distance between observed productivity and a theoretical, optimal or average productivity. Based on figure 1, measuring technical efficiency entails determining the distance between R and P a technically efficient input-output combination. In practice, the ratio OR/OP is the measure of technical efficiency or, equivalently, OR/OP is a measure of technical inefficiency.

The methods to measure technical efficiency differ essentially on the way this distance is defined and estimated and whether auxiliary information is used. Most of these methods can provide farm-level estimates of technical efficiency. Traditionally, measurement methods are classified based on whether they rely on assumptions on the functional form of the production frontier: the ones that rely on those assumptions are considered to be "parametric" while the ones that do not rely on the assumptions are considered to be "non-parametric". For example, Malmquist-type approaches using Data Envelopment Analysis (DEA) are non-parametric, while approaches based on the econometric estimation of a production function are parametric.

Although these methods rely on different computation methods and assumptions, it is interesting to note that the results are often not significantly different from each other. For example, Neff et al. (1993) and Sharma et al. (1997) found that estimates derived from DEA are not statistically different from other frontier estimation methods. This finding may put into perspective theoretical debates over the appropriate measurement methods, which is presented succinctly below and contribute to putting additional emphasis on the quality and completeness of the basic data on which these methods are based.

2.1.2. Models of Efficiency Measurement

2.1.3. Non-Parametric Frontier Model

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

2.1.4. Parametric Frontier Models

With respect to parametric approaches, these can be subdivided into deterministic and stochastic models. The first are also termed 'full frontier' models. They envelope all the observations, identifying the distance between the observed production and the maximum production, defined by the frontier and the available technology, as technical inefficiency. The deterministic model assumes that any deviation from the frontier is due to inefficiency, while the stochastic approach allows for statistical noise. A further classification of frontier models can be made according to the tools used to solve them, namely the distinction between mathematical programming and econometric approaches. The deterministic frontier functions can be solved either by using mathematical programming or by means of econometric techniques. The stochastic specifications are estimated by means of econometric techniques only. According to Coelli et al. (1998) recommended that stochastic frontier analysis is more appropriate than Data Envelopment Analysis and deterministic models in agricultural applications, especially in developing countries, where the data are heavily influenced by measurement errors, and the effect of weather, disease, and the like play significant role

2.1.4.1. Deterministic models

The parametric deterministic models used for measuring technical efficiency. We assume that production can be modeled as;

$Yi = \alpha + \beta xi - ui$ Where $ui \geq 0$ represents inefficiency and all variables are specified in logarithms. In this case,

$D Fi = ex p (-u i)$ It is the Debreu-Farrell measure of technical efficiency. It is not necessary to restrict the production function to Cobb-Douglas. This functional form is chosen to be consistent with Aigner and Chu (1968) for convenience.

Alternatively, the flexible Tran slog production function, which is linear in the parameters, can be specified. This technique is considered deterministic because the stochastic component is completely generated by inefficiency and measurement error is assumed away. Following Greene (1980) the deterministic model can be estimated using OLS. In this case, the slope parameters are estimated consistently, but the intercept is biased. Greene shows that a consistent estimate can be obtained by shifting the OLS line upward so that the largest adjusted residual is zero. If the true error term is composed of a normally distributed noise term and a non-negatively distributed inefficiency term, then OLS is not maximum likelihood but still produces unbiased and consistent estimates of the slope parameters. Hence, there will be minor differences between the estimated slope parameters from the stochastic frontier and OLS regressions. Correcting the intercept from an OLS regression is only one deterministic approach.

Aligner and Chu (1968) developed linear and quadratic programming alternatives. The deterministic specification, therefore, assumes that all deviations from the efficient frontier are under the control of some circumstances out of the agent's control that can also determine the suboptimal performance of units. Regulatory-competitive environments, weather, luck, socio-economic and demographic factors, uncertainty, etc., should not properly be considered as technical efficiency. The deterministic approach does so, however. Moreover, any specification problem is also considered as inefficiency from the point of view of deterministic techniques. On the contrary, stochastic frontier procedures model both specification failures and uncontrollable factors independently of the technical inefficiency component by introducing a double-sided random err into the specification of .the frontier model.

2.1.4.1.1. Stochastic frontier model

A production function defines the technological relationship between the level of inputs and the resulting level of outputs. If estimated econometrically from data on observed outputs and input usage, it indicates the average level of outputs that can be produced from a given level of inputs (Schmidt, 1986). A number of studies have estimated the relative contributions of the factors of production through estimating production functions at either the individual boat level or total fishery level. These include Cobb-Douglas production functions (Hannes son, 1983), CES production functions (Campbell and Lindner, 1990) and Trans log production functions (Squires, 1987; Pascoe and Robinson, 1998

An implicit assumption of production functions is that all firms are producing in a technically efficient manner, and the representative (average) firm therefore defines the frontier. Variations from the frontier are thus assumed to be random, and are likely to be associated with mis- or un-measured production factors. In contrast, estimation of the production frontier assumes that the boundary of the production function is defined by "best practice" firms. It therefore indicates the maximum potential output for a given set of inputs along a ray from the origin point. Some white noise is accommodated, since the estimation procedures are stochastic, but an additional one-sided error represents any other reason firms would be away from (within) the boundary. Observations within the frontier are deemed "inefficient", so from an estimated production frontier it is possible to measure the relative efficiency of certain groups or a set of practices from the relationship between observed production and some ideal or potential production (Greene, 1993). A general stochastic production frontier model can be given by:

$\ln q_j = f(\ln x) + V_j - u_j$ (1)

Where q j is the output produced by firm j, x is a vector of factor inputs, v j is the stochastic (white noise) error term and u j is a one-sided error representing the technical inefficiency of firm j. Both v j and uj are assumed to be independently and identically distributed (iid) with variance σ^2_v and σ^2_u respectively.

Given that the production of each firm j can be estimated as:

$\ln q_j = f(\ln x) - u_j$ (2)

While the efficient level of production (i.e. no inefficiency) is defined as:

$\ln q_j = f(\ln x)$ (3)

Then technical efficiency (TE) can be given by:

$\ln TE_j = \ln q_j - \ln q^* = -u_j$

Hence, TE $j = e^{-Uj}$nd is constrained to be between zero and one in value. If uj equals zero, then TE equals one, and production is said to be technically efficient. Technical efficiency of the jth firm is therefore a relative measure of its output as a proportion of the corresponding frontier output. A firm is technically efficient if its output level is on the frontier, which implies that q/q* equals one in value. While the techniques have been developed primarily to estimate efficiency, they can be readily modified to represent capacity utilization. In estimating the full utilization production frontier, a distinction must be made between inputs comprising the capacity base (usually capital inputs), and variable inputs (usually days, or variable "effort"). If capacity is defined only in terms of capital inputs, the implied variation in output, and thus variable effort, from its full utilization level is sometimes termed an indicator of capital utilization.

If variable inputs are assumed to be approximated by the number of hours or days fished (i.e. nominal units of effort), estimating the potential output producible from the capacity base with variable inputs "unconstrained" implies removing this variable from the estimation of the frontier. The resulting production frontier is thus defined only in terms of the fixed factors of production, or K. In particular, it will be supported by observations for the boats that have the greatest catch per unit of fixed input (which generally corresponds to the boats that employ the greatest level of nominal effort for a particular level of K). The resulting measure of technical efficiency is equivalent to the technically efficient capacity utilization (TECU); accommodating both the impacts of technical inefficiency and deviations from full utilization of the capacity base. That is, it represents the ratio of the potential capacity output that could be achieved if all fixed inputs were being utilized efficiently and fully to observed output. Only limited attempts to estimate stochastic production frontiers for fisheries have been undertaken (Kirkley, Squires and Strand, 1995, 1998, Coglan, Pascoe and Harris, 1999, Sharma and Leung, 1999, Squires and Kirkley, 1999; Pascoe, Andersen and de Wilde, 2001; Pascoe and Coglan, 2002). These have focused upon an estimation of efficiency rather than capacity, although the capacity problem has recently been addressed by Kirkley, Morrison and Squires (2001) and Tingley and Pascoe (2003) using SPF procedures. The techniques used and problems encountered are similar, and distinction between the utilization and efficiency components - thus providing an unbiased estimate of capacity utilization - requires first computing the more standard inefficiency measure.

2.1.4.1.2. Functional forms for the production function

Estimation of the SPF requires a particular functional form of the production function to be imposed. A range of functional forms for the production function frontier are available, with the most frequently used being a trans log function, which is a second order (all cross-terms included) log-linear form. This is a relatively flexible functional form, as it does not impose assumptions about constant elasticity of production nor elasticity of substitution between inputs. It thus allows the data to indicate the actual curvature of the function, rather than imposing a priori assumptions. In general terms, this can be expressed as:

$$\text{Ln } Q_{j,t} = \beta_0 + \sum_i \beta_i \ \text{In } X_{j,i,t} + \frac{1}{2}\sum_i \sum_k \beta_{i,k} \ \text{In } X_{j,i,t} - \cup i + + v\, i, t \quad (5)$$

Where $Q_{j,t}$ is the output of the vessel j in period t and $X_{j,i,t}$ and $X_{j,k,t}$ are the variable and fixed vessel inputs (i, k) to the production process. As noted above, the error term is separated into two components, where $v_{j,t}$ is the stochastic error term and $u_{j,t}$ is an estimate of technical inefficiency. Alternative production functions include the Cobb-Douglas and CES (Constant Elasticity of Substitution) production functions. The Cobb-Douglas production function is given by:

$$\text{Ln } Q_{j,t} = \beta_0 + \sum_i \beta_i \ \text{In } X_{j,i,t} - u_{j,t} + v_{j,t} \quad (6)$$

As can be seen, the Cobb-Douglas is a special case of the Trans log production function where all bi, k = 0. The production function imposes more stringent assumptions on the data than the Tran slog, because the elasticity of substitution has a constant value of 1 (i.e. the functional form assumption imposes a fixed degree of substitutability on all inputs). And the elasticity of production is constant for all inputs (i.e. a 1 percent change in input level will produce the same percentage change in output, irrespective of any other arguments of the function).

The CES production function is given by:

$$Q_{j,t}=\gamma[\delta X_{i,j,t}+(1-\delta)X_{2,j,t}]^{-1/\theta}-u_{j,t}+v_{j,t} \quad (7)$$

Where q is the substitution parameter related to the elasticity of substitution (i.e. q = (1/s)-1 where s is the elasticity of substitution) and d is the distribution parameter.

The CES production function is limited to two variables, and is not possible to estimate in the form given in (7) in maximum likelihood estimation (MLE) (making it unsuitable for use as the basis of a production frontier). However, a Taylor series expansion of the function yields a functional form of the model that can be estimated, given as.

$$\text{Ln}\left(\frac{Q_{j,t}}{X_{2,j,t}}\right)=\text{Ln}\,\gamma+(u-1)\text{Ln}\,X_{2,j,t}+u\delta ln\left(\frac{X_{1,j,t}}{X_{2,j,t}}\right)-\frac{1}{2}u\theta\delta(1-\delta)\left[\ln\left(\frac{X_{1,j,t}}{X_{2,j,t}}\right)\right]^2-u_{j,t}+v_{j,t} \quad (8)$$

The model can be estimated as a standard or frontier production function, and the parameter values derived through manipulation of the regression coefficients. The functional form in (8) can be shown to be a special case of the trans log function where bi, i = b k, k = -0.5bi,k.

Given that both the Cobb-Douglas and CES production functions are special cases of the trans log, ideally the trans log should be estimated first and the restrictions outlined above, tested. However, the large number of variables required in the process of estimating the trans log may cause problems if a sufficient data series is not available, resulting in degree of freedom problems. In such a case, more restrictive assumptions must be imposed.

To estimate the stochastic production frontier, an appropriate functional form is assumed (i.e. Cobb-Douglas, CES or Tran slog production function) and the parameters of the model (including S^2v and S^2u) are estimated by MLE.

Estimation of the maximum value of the logged likelihood function is based on a joint density function for the split error term e j = v j- u j (Stevenson, 1980). From this, technical efficient capacity utilization (TECU) can be calculated for the individual firm, given by:

$$\sigma A=\sqrt{\gamma(1-\gamma)\,\sigma^{2}s}\;E\,[\exp(-u\,j)|\,\varepsilon\,j] \quad (9)$$

Where, $\sigma^2_s = \sigma^2_u + \sigma^2_v$, $\gamma = \sigma^2_u / \sigma^2_s$, and F(.) is the density function of a standard normal random variable (Battese and Coelli, 1988). From this, if g = 0,

These parameters can be expressed in terms of the variance parameters of the stochastic frontier, sigma squared σ^2_s and the inefficiency effects gamma (γ), that is, the variance ratio given by, $\gamma = \sigma^2_u / \sigma^2_s$, where $\sigma^2_s = \sigma^2_v + \sigma^2_u$. This variance parameter (γ and σ^2_u), coefficients are the diagnostic statistics that indicate the relevance of the use of the stochastic frontier function and the correctness of the assumptions made on the distribution form of the composed error term (that is, for both U_i and V_i) respectively. The γ parameter measures technical inefficiency effect in lentil production for the variation of observed output from the optimal one, and it has a value between zero and one as stated in Battes

2.1.4.1.3. Inefficiency models

Trendy many studies of technical efficiency, the results are used to estimate the effects of various factors on inefficiency. These may be estimated using either a one-step or two-step process. In the two-step procedure, the production frontier is first estimated and the technical efficiency of each firm, derived. These are subsequently regressed against a set of variables, Zit, which are hypothesized to influence the firm's efficiency. This approach has been adopted in a range of studies (e.g. Kalijaran, 1981; Pitt and Lee, 1981).

A problem with the two-stage procedure is a lack of consistency in assumptions about the distribution of the inefficiencies. In the first stage, inefficiencies are assumed be independently and identically distributed (iid) in order to estimate their values. However, in the second stage, estimated inefficiencies are assumed to be a function of a number of firm-specific factors, and hence are not identically distributed (Coelli, Rao and Battese, 1998). Kumbhakar, Ghosh and McGuckin (1991) and Reifschneider and Stevenson (1991) estimated all of the parameters in one step to overcome this inconsistency. The inefficiency effects were defined as a function of the firm-specific factors (as in the two-stage approach), but were incorporated directly into the MLE. Battese and Coelli (1995) also suggested a one-step procedure for using the model (now accounting for time), such that:

$$\text{In } q_{j,t} = f(\text{Inx}) + V_{j,t} - u_{j,t} \qquad (12)$$

and the mean inefficiency is a function of firm-specific factors, such that:

$$M\ j,\ t = ZX + W_{j,t} (13)$$

Where Z is the vector of firm-specific variables which may influence the firm's efficiency, d is the associated matrix of coefficients and W j, t is an iid random error term

Huang and Liu (1994) proposed a non-neutral stochastic frontier model. This is estimated by regressing the inefficiency term upon two sets of variables, Zit and Zit*, the first representing some firm-specific variables which may influence the firm's efficiency and the latter variables representing the interactions between Zit and the input variables in the stochastic frontier, such that:

$$Y_{j,t} = \beta x_{i,t} + (\mathbf{V}\ \mathbf{i},_{,t} - \mathbf{U}_{i,t} \text{ and } \mathbf{U}_{k,t} = \mathbf{Z}_{i,t}\mathbf{X} + \boldsymbol{Z}^*_{i,t}\mathbf{X}^* + \mathbf{W}_{I,t} (14)$$

This allows movement of the function to be biased towards certain inputs. However, it again imposes an assumption that the inefficiency determinants are linearly related to efficiency. The various approaches discussed thus far raise the question of whether or not these determinants of efficiency should be accommodated in the production function specification itself, or as determinants of measured inefficiency. We would think that it would be preferable to consider as many production determinants as possible in the technological specification, rather than in the stochastic specification, to represent their productive effects (marginal products) directly. This reduces the potential for calling something "inefficiency" when it may be explainable by the effective level of the productive inputs. This is particularly important if the efficiency and utilization components of overall deviations from the frontier are to be distinguished separately, which is important for unbiased estimation of capacity utilization. Appropriate representation of the characteristics of inputs, such as those comprising the "power" embodied in the capacity base, is critical for interpretable and usable capacity and utilization estimates.

2.4. Empirical Studies on Technical Efficiency

Various studies have been conducted on efficiency and its determinants on various issues in Agriculture. In general, Darku et al. (2013) reviewed agricultural efficiency studies conducted from

2011 E.C with the focus of preparing a comprehensive report on the various methodologies used and important results relevant for agricultural policy formulation (Reform). Hence, the review of agricultural efficiency studies indicates that technical efficiency is related to economic factors, environmental factors locations, size of local market and agricultural policies, farm size matters for technical efficiency; different results for different econometric specifications; nonparametric deterministic models showed higher mean technical efficiency than parametric stochastic models; government supports has mixed effect on farm level efficiency; and efficiency improved over time; Family operated farms exhibited higher efficiency than farms with a greater share of hired labor, while the level of debt is positively related to technical efficiency. It is found that to improve sustainable efficiency, the strategy to maximize output given the input level is better than the strategy to minimize the input level given output; and education level appeared to have little significant or consistent impact, but age is negatively correlated with efficiency for both specifications.

The findings of the study point out that tractor hours, quantity of seed and labor have positive signs and are statistically significant in the Cobb-Douglas production function which represents output elasticity's. In addition to this age of the decision maker which is used as a proxy variable for experience in farming, Consultation with extension workers and total vegetable area have significant and negative influence on inefficiency. This indicates the variables have positive and significant influence for technical efficiency. However education and land ownership status have insignificant influence for inefficiency of farmers in the study

According to Farrell (1957), efficiency can be explained in terms of technical efficiency, allocative efficiency and economic efficiency. Technical efficiency refers to the minimum combination of inputs required to produce a given level of output. Allocative efficiency refers to the least cost combination of inputs required to produce a given level of output. Determination of allocative efficiency, in this case, requires knowledge of the market prices of all inputs used in the production process. A technically efficient way of production is not necessarily allocative efficient and an allocatively efficient way of production is not necessarily technically efficient. If the production Methodist both technically and allocatively efficient, we call it economically efficient. According to Abate et al. (2013), poverty alleviation and ensuring food security of small holder farmers is possible through augmenting productivity and commercialization. Improving productivity of small holder farmers can be achieved through better access to technology and extension services. Extension services enhance productivity of farmers through improving ethnical efficiency of farmers.

The stochastic frontier production model has been widely used to estimate the technical efficiency of farmers in agricultural researches. Several technical efficiency/inefficiency researches have been conducted in Ethiopian other countries. For instance, Bamlaku et al. (2007) have analyzed technical efficiency of farmers in three ecological zones in Ethiopia. Access to credit, literacy, proximity to market and livestock are found to have positive and significant effect while age, sex, extension service and off-farm activities are found to have insignificant effect on technical efficiency of farmers. Moreover, Endriaset al. (2012) have examined technical efficiency of maize farmers in Wolaita and Gamo Gofa zones. Based on their estimation, agro-ecology, oxen holding, farm size of improved maize variety are found to be significant whereas age, education, family size and access to credit are found to be insignificant determinants of technical efficiency.

2.5. Lentil Production System in Ethiopia

Although the lentil crop has evolved appropriate stress tolerance strategies .they are largely affected by global climate change that in turn brought number of environmental challenges .Except few finding (Getahun 2016) and review works (Abraham 2015) there are research works done in depth ,which evaluated the lentil genotypes under temperature and rainfall change and variability on the growth and yield performance in central high lands of Ethiopia .given the essentiality of this crop .lentil is grown for human consumption it s seed contains 1-2% fat ,24-32% proteins and minerals and vitamins and therefore. May correct important amino acid deficiencies of cereals when used in mixture with cereal crops .Abraham reported that the crop is important exported and cash crop that has highest price in domestic market compared to all other food legumes and cereals ;moreover ,lentil can fix at morphemic nitrogen through root nodules in association with Rhizobium bacteria.(lens culinarismedikus), a self-pollinating crop with an approximate genome size of 4gbp is an important legume which provides quality protein ,carbohydrates fiber and minerals for the humans and fodder for livestock. It is a moderately drought tolerant crop but the yields is drastically reduced with increased drought stress .as water availability is important for crop growth and productivity, drought stress at critical stage with high sever its can impose a threat to world food security. Globally, lentil is cultivated as rain fed crop in more than 52 countries covering about 3.85 m ha area with a production of 3.59 mt (Erskine et al. 2011). Canada, India, Turkey, Australia, U.S.A., Nepal, China, and Ethiopia are the major contributors (Reda 2015). It is commonly used as food and feed because of its protein rich grains (24-28%) with abundance of lysine, minerals and vita.

2.6. Conceptual Framework of the study

Conceptual framework is defined as network or a plane of interlinked concepts that together provide a comprehensive understanding of a phenomenon. In other words, it is a visual or written product that explains either graphically or in a narrative form, the main things to be studied (key factors, concepts, variables and the presumed relationships among them) (Miles and Huberman,1994). Figure 3 shows the interaction of various factors that were considered to have a various degrees and directions of impact on the level of Technical efficiency in smallholder lentils production. Studies, for instance, by Kalirajan and Shand (1988) and Haji (2006) showed that efficiency of production was determined by the host of socio-economic and institutional factors. These factors directly/indirectly affect the quality of management of the farm’s operator and, therefore, are believed to have impact on the level of technical and economic inefficiency of farms. According to Bakhsh (2007), a range of factors like distinctiveness of farms, management physical, institutional and environmental aspects could be the cause of inefficiencies in the production process of the farmers.

Policy and Institutional Factors Policy and institutional factors such as land tenure system, economic system and market infrastructure, credit and input accesses can have significant effect on the resource use efficiency of lentil production. According to Nossal and Goo day (2009) some policy regulations provide a disincentive for producers to be innovative and change practices in response to market developments. They also further indicated that policy reforms encouraging competition and reducing regulatory constraints will provide a stronger basis to enable productivity gains. On the other hand, Tchale (2009) explained that extension and access to markets are important policy and institutional variables that positively influence efficiency. They provide incentive and means to access improved crop technology via improving farmers' liquidity and the affordability of the inputs required for production. Therefore, improvement of efficiency hinges largely on improving the policy and institutional environment. The author also argues that efforts must be made to promote private market development (Tchale, 2009).

According to Wang et al. (1996) explained that reducing market distortions, allowing land use rights to transfer more freely and farmers' access to education can improve both technical and allocative efficiencies. Therefore, policies, programs and institutional arrangements which target access to credit, market infrastructure, access to education and land tenure systems among others are important variables that can substantially affect resource use efficiency and productivity.

2.6.1 Environmental Factors

Environmental factors such as climate change, weather condition, resource depletion, and population pressure can affect resource use efficiency in crops production. According to Nossal and Gooday (2009) climate change, resource depletion and other environmental pressures pose a major threat to productivity growth. Van Passel et al. (undated) explained that differences in efficiency between farmers can be explained by environmental characteristics, such as soil quality, vegetation cover, altitude, climate, rainfall and temperature among others. However, Dudu (2006) indicated that there may be a negative interaction between some agricultural practices and the environment. For instance excessive use of pesticides and fertilizers may affect both the environment and productivity of the basic factors of production. According to Ajibefun (2002), in Nigeria, as the population pressure increases, farmers are forced to produce more food. As a result people are being pushed to new agricultural lands and many into marginal lands. Therefore, environmental factors such as climate change, population pressure and resource depletion should be considered to address problems related to resource use efficiency and productivity of farmers.

2.6.2. Farmer Characteristics

Level of producer's education and years of experience influences the producer's management capacity. Quisumbing (1995) mentioned that farmers with more education, more land and farm tools are more likely to adopt new technologies. Moreover, Wang et al. (1996) explained that resource endowment and education level of farmers influence their allocative efficiency. In addition, the authors indicated that family size, per capita net income, and family members operating as village leaders are positively related to their production efficiency. Ajibefun (2002) indicated that education level of farmers and farming experience are important determinants of efficiency which can be incorporated into the agricultural policy. Thus, factors related to farmer characteristics are included in the analysis believing that they have effects on efficiency and productivity of the farmer.

2.6.3. Farm Characteristics

Efficiency variations between farms can also be explained by the farm location and environmental characteristics. Farm location is important since farms may operate under different climate or altitude conditions and different soil quality and availability of water. Moreover, farm geographical location which links to environmental characteristics can be one of the factors explaining differences in efficiency (Wang et al., 1996; O'Neill et al., 2001; Rezitis et al., 2002). Farm related variables are important because in most farming systems in sub-Saharan Africa there are significant variations in terms of plot-level biophysical and soil chemical characteristics (Tchale,2009).

2.6.4. Feedback Effect

The final element of the framework is the feedback effect of the interaction of various external (policy, institutional and environmental factors) and internal (farmer and farm characteristics) variables for further reforms. It indicates whether the interventions or changed practices have impacts in the society. According to Bruch et al. (2009) the feedback effects of targeted programs can be positive or negative; and such effects tend to be more positive when a policy's authority structure reflects democratic rather than paternalist principles. Moreover, Asselin (2003) indicated that the country circumstances will ultimately determine the strength of feedback effects for policy reform. Accordingly, the broken line in the figure shows such conditions in the economic and political system and effectiveness of research and extension system to respond for the feedback from the smallholder farmer.

Policy and Institutional factors

Land tenure system;

Research and extension services

Market and price

access to credit;

Cooperative membership; and

access to training.

Environmental factors

Climate change;

Pest and diseases infestation;

Resource depletion; and
Population Pressure, etc.

Farm Characteristics

(Socioeconomic factors)

Farm Location and distance; Soil fertility; Land size, Land soil, Land slope. Involvement in off/non-farm activities, use of labor and Availability of water, etc.

Farmer Characters

Level of education ,Sex and

age of household head

Family size, lentil farming

Experience

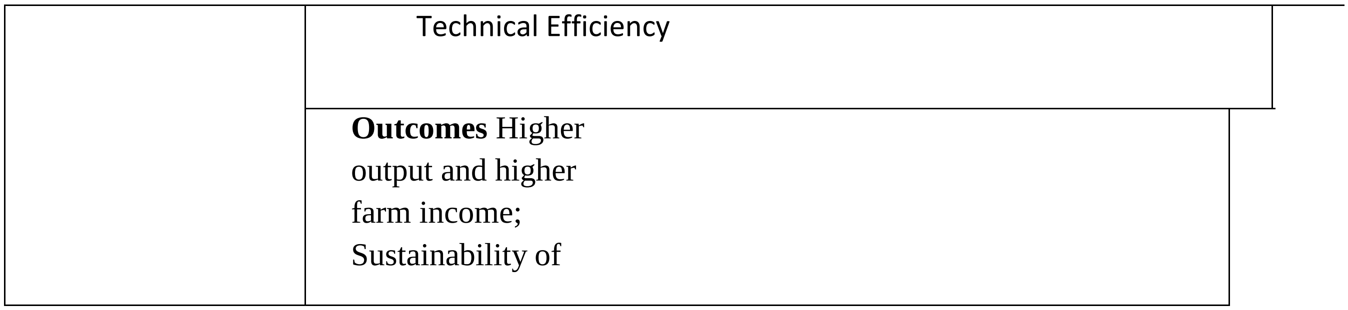


Figure 3: Conceptual Framework of Technical Efficiency of lentil Production

CHAPTER THREE

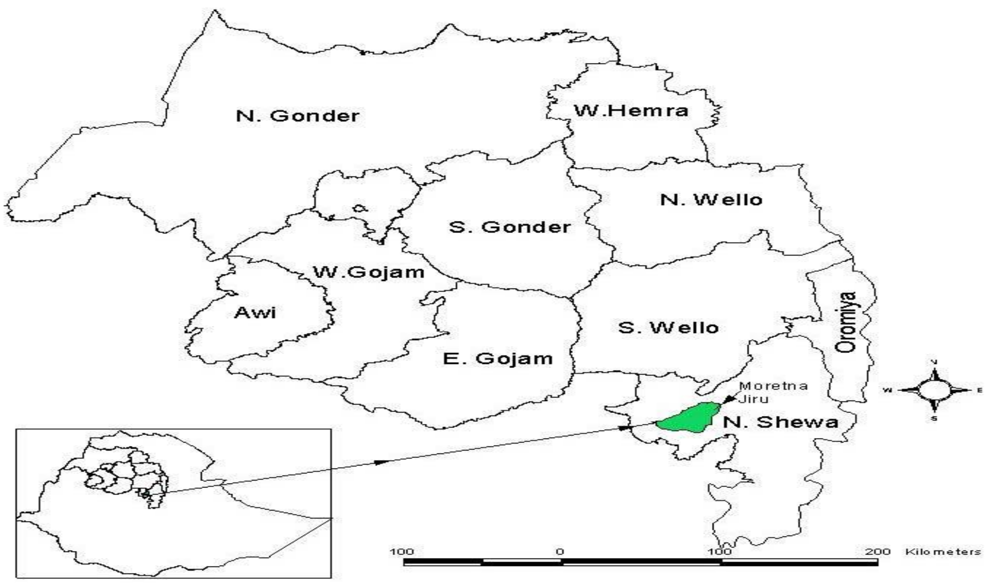
3. RESEARCH METHODOLOGY

3. Introduction

Theoretical and conceptual definition of the study along with its conceptual framework were presented and discussed in detail in the previous chapter. The main objective of this study was to assess the technical efficiency of lentil Producing far households in the study area.. In this chapter research design of the study is presented in which, target population, sample size and sampling technique, type and sources of data, methods of data analysis, research Model, operational definition of research variables used in this study are discussed in detail.

3.1 Description of the Study area

The study area, Moretina-Jirru is one of the districts of North Showa in the central Highlands of Ethiopia. Mo retina Jiru (Amharic "Moret and Jiru") is one of the woredas in the Amhara Region of Ethiopia. It is named in part after the historic district of Showa, Moret, which lay between the Jamma River and the district of Shewa Meda .Part of the Semien Shewa Zone, Moretna Jiru is bordered on the south by Siyadebrina Wayu, on the south west by Ensaro, on the northwest by Merhabiete, on the northeast by Menz Keya Gebreal, and on the east by Basona Werana. The administrative center of this woreda is Enewari; other towns in MoretnaJiru include Jihur.



Map1: Location of the Study District

3.2. Target Population

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), the study areas have an aggregate a total population of 92,937, an increase of 20.34% over the 1994 census, of whom 47,611 are men and 45,326 women; 9,015 or 9.70% are urban inhabitants. With an area of 661.16 square kilometers, Mo retina Jiru has a population density of 140.57, which is greater than the Zone average of 115.3 persons per square kilometer. A total of 21,281 households were counted in this woreda, resulting in an average of 4.37 persons to a household, and 20,283 housing units. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 99.43% reporting that as their religion. The 1994 national census reported a total population for this Woreda of 77,226, of whom 39,045 were men and 38,181 were women; 7,240 or 9.38% of its population are urban dwellers. The largest ethnic group reported in MO retina Jiru was the Amara (99.48%), and Amharic was spoken as a first language by 99.69%. The majority of the inhabitants practiced Ethiopian Orthodox Christianity, with 99.39% reporting that as their religion.

3.4. Sampling and Sampling Techniques

3.4.1. Sample Size

For this study generated data from 126 randomly selected smallholder farmers in the 2011 production season. a two stage sampling technique procedure will be used to select the lentil farms in the kebeles are identify out of twenty two kebeles are to selects five kebeles using simple random sampling. In the second stage will be taken the lentil produce farmers in the select kebeles are identifying in collaboration with woreda agricultural office experts in 2011 year in woreda agriculture bureau report. The total number of respondents is determining by using a formula develops by (Kothari, 2004). For sample size

$$n= \frac{N}{1+N(e^2)}=\frac{92937}{1+92937(0.089)^2} =126\text{Househoeled}$$

Where; n: is the required sample size

N: is the total number of lentil farm households in the study area.

e = is the level of precision which is assumed to be8. 9%. Hence, the total sample Size is 126. Finally, as presented in Table1, sample households in each kebele were determined based on proportions of lentil producer households of the respective kebeles. Simple random sampling technique was followed to identify sample farm

Table 1: Number of sample farmers selected per each kebele

NO	Name of selected kebele	Total lentil producer	Sample size	Percent
1	Kussaye	1812	41	32.5
2	Mangudo	757	16	13
3	Weyramba	1560	37	29
4	Biro	512	12	9.5
5	Bolo	898	20	16
Total		5539	126	100

3.4.2. Sampling Technique

The primary data used in this study were collected from randomly selected sample households from the selected FAs. The primary data are collect for the 2011 lentil production years through interview individual farm households by use structured questionnaires and well-train enumerators. The primary data collect for the study includes lentil production inputs such as; land are and, labor, types of lentil seed, the types of fertilizer, the type of chemicals (technologies) use and house hold. Moreover, variables on socio-economic, Farmer characteristics, and institutional characteristic such as, Access to credit, access to training rod infrastructure, extension service, distance to market and price condition of the output, group membership, farmers age, sex, farmer experience, education level family size, Oxen ownership, land size, soil fertility, farm activities, off/non-farm activities. The income and asset profiles. Secondary information that supports interpretation of primary data is collecting from woreda Agricultural office and different published and un published sources.

3.4.3. Methods of Data Analysis

Both descriptive statistics and econometric methods were used to analyze the data set. Descriptive statistics used were frequency, percentages, mean, standard deviation, an independent sample t-test, maximum, and minimum values. An econometric estimation method was done first by specifying production frontier using Cobb-Douglas stochastic model. The model estimated parameters of production frontier, level of efficiency, and significance level of the different variables in the determination of inefficiency of farmers. The various null hypotheses for parameters in the frontier production function and inefficiency model were tested by a t – distribution and $\chi 2$ distribution

3.4.4. Econometrics Model

Stochastic frontier is the most appropriate technique for efficiency studies which have a probability of being affected by factors beyond control of DMU. This is because of the fact that this technique accounts for measuring inefficiency as a result of these factors and technical errors occurring during measurement and observation. Lentil production at MO retina-Jiru Woreda is likely to be affected by natural hazards, unexpected weather conditions, which are beyond the control of the farmers. In addition, measurement and observational errors could also occur during the data collection. So as to capture effects of these errors, this study used stochastic frontier model. The model can be specified as, The (Nonlinear Models) Cobb-Douglas production function in this stochastic form. May be expressed as= $\beta oX1^{\beta 1}X2^{\beta 2}X3^{\beta 3}X4^{\beta 4}X5^{\beta 5}X6^{\beta 6}e^{vi-ui}$

The function of constant elasticity are can be transformed to linear logarithmic function

$$Ln(y)= \ln(\beta oX1^{\beta 1}X2^{\beta 2}X3^{\beta 3}X4^{\beta 4}X5^{\beta 5}X6^{\beta 6}e^{vi-ui})$$

$$=\ln(\beta o) + \beta 1 \ln X1+ \beta 2\ln x2 + \beta 3\ln x3 + \beta 4 \ln X4+ \beta 5\ln x5 + \beta 6\ln x6+ vi-ui$$

Where: ln y = is the total output of lentil obtained from the i^{th} farm in quintal.

Lentil land (X1)= the total size of land in hectare allocated for lentil crop by the household.

Fertilizer (x2)= The two mainly used fertilizers are DAP and Urea. in kilogram applied by the household.

Oxen (x3)= the total number of oxen days used by the it household.

Human labor (x1)= the total labor force (family, Exchange and hired) which are all measured in terms of Monday.

Seed (x5)= the total quantity of lentil seed used by the i^{th} household measured in kg.

Chemical (x6)= Chemicals such as herbicides or pesticides used as an input particularly in lentil due to serious weed, pest and disease attack by the i^{th} household.

(X1 - x6): Vector of explanatory variables of the i^{th} farm household

β0 is constant.

β1—β6 are parameters to be estimated and represents elasticity of production.vi and ui are as defined above.

B1+ β2+ β3+ β4+ β5+ β6= returns scale

e=base of natural logarithm

The model is linear in the parameters β 0, β 1 β 2, β3, β4, β5an,d β 6 and is therefore a linear regression model .notice, though, it is nonlinear in the variables and but linear in logs these variables. In short is a Log-linear model(log-linear regression model) involving any number of variables the coefficients of each of the X variables measures the(partial) elasticity of the dependent variability with respect to that variable. In this study, a Cobb-Douglas model involving six input variables and sixteen variables for inefficiency model was used.

The term ε i (vi – ui) is a composed error term where vi represents statistical noise, which is deviation from the frontier due to factors beyond control of the farmer and ui represents deviation due to technical inefficiency and are assumed to be independent of each other.vi s are assumed to be independently and identically distributed normal random errors with(o, σ^2v), which captures inefficiency as a result of factors beyond control of the farmer.ui s are non-negative random variables independently and identically distributed as $N^{+}(\mu\ ,\ \sigma\ ^{2}u)$which captures technical effects of the farmer on the ith land of lentil. U i s are assumed to follow half normal distributions with mean μi and $\sigma\ ^{2}u$ where:

The technical inefficiency model was estimated as the equation given below.

$Ln= \delta\ 0+\sum_{z=1}^{16}\ \delta$ n Zni

Z i is the variable in the inefficiency model

The technical inefficiency μ i could be estimated by subtracting TE from unity. The

Function determining the technical inefficiency effect is defined in its general form as a linear function of socio-economic and management factors.

It can be defined in the following equation

$\cup i\ \ = \delta\ 0 + \sum_{z=1}^{16}\ \delta$ kZki

Where, ∪ i is the technical inefficiency effect

Z k is the coefficient of explanatory variables.

Parametric methods, like Stochastic Frontier Analysis (SFA), Thick Frontier Approach (TFA) and Distribution Free Approach (DFA).

Data Envelopment Analysis (DEA) is a non-parametric method and can easily handle multiple input and output

Cobb Douglas and Tran slog functional forms are most often used in stochastic frontier analysis

As a result the technical inefficiency was explained by the

Following determinants

Z1=Age of the farmer (years)

Z2=Crop specific farm experience

Z3=Education (number of years of schooling of the farmer)

Z4=Extension service (frequency of extension service during the farming season)

Z5=slope of land

Z6=Off/non-farm activities ((total amount of off/nonfarm income in birr);

Z7=Access to credit service (A dummy variable. It takes a value of 1 if yes, 0 otherwise);

Z8= Sex of the household head (a dummy variable. It takes a value of 1if male, 0 otherwise)

Z9= Soil fertility

Z10= Proximity to the nearest market center

Z 11= Market availability and price condition of the output

Z12=Cooperative membership

Z13=Household size :(total numbers of family member who lives in one roof)

Z14=Access to training (A dummy variable. It takes a value of 1 if yes, 0 otherwise);

Z15= Plowing frequency

Z16= Time of sowing

By using the parameterization of Battese and Corra (1977) the above models are estimated in terms of the variance parameters as:, $\sigma^2 = \sigma^2 v + \sigma^2 u$ and $\gamma = \frac{\sigma^2 u}{\sigma^2} = \frac{\sigma^2 u}{\sigma^2 v + \sigma^2 u}$The parameter γ measures the discrepancy between frontier and observed levels of output andis interpreted as the total variation in output from the frontier attributable to technical inefficiency. It has a value between zero and one. The value of zero indicates that the nonnegative random variable, ui is absent from the model while the value of one shows the absence of statistical “noise” from the model and hence low level of farm’s production compared to the” best “practice (the maximum output) of the other farm that is totally a result of farm specific inefficient

σ^2vis the variance parameter that denotes deviation from the frontier due to inefficiency;

σ^2v -is the variance parameter that denotes deviation from the frontier due to noise

σ^2- is the variance parameter that denotes the total deviation from the frontier.

3.4.4. Model Diagnostics

Before the final analysis, the data was checked for outliers and multi Collin ear its problem. For test of multi Collin ear it problem, Variance Inflation Factor (VIF) was used. According to Maddal (1992) VIF can be defined as:
VIF (Xi)=$\frac{1}{1-Ri^2}$and VIF(Xi)=$\frac{1}{TOL}$

Where $Ri^2$is the squared multiple correlation coefficient between Xi and other explanatory variables. The larger the value of VIF, the more troublesome it is as a rule of thumb, if the VIF of a variable exceeds 10 (this will happen if Ri2 exceeds 0.95), that variable is said to be highly collinear (Gujarati, 1995). On the other hand, A series of tests can be conducted to test the specification of the models. These are tested through imposing restrictions on the model and using the generalized likelihood ratio statistic (l) to determine the significance of the restriction. The generalized likelihood ratio statistic (also known as the LR test) is given by:

$$\lambda = -2\left[\ln\{L(H_0)\} - \ln\{L(H_1)\}\right] \quad (17)$$

Where Ln.{L(Ho)} and Ln.{L(H1)} are the values of the log-likelihood function under the null (Ho) and alternative (H1) hypotheses. The restrictions form the basis of the null hypothesis, with the unrestricted model being the alternative hypothesis. The value of l has a 2 distribution with the degrees of freedom given by the number of restrictions imposed.

A major test used to determine the existence of a frontier (i.e. Ho: g=0) is the one-sided generalized likelihood ratio test of Coelli (1995). Since the alternative hypothesis is that 0 < g < 1, the test has an asymptotic distribution, the critical values of which are given by Kidde and Palm (1986). If the hypothesis is accepted, there is no evidence of underutilization of capacity in the data and the production frontier is identical to a standard production function.

3.4.5. Definition of Input and Inefficiency Variables and their Hypothesis

Output (Y): It is the total lentil output in quintal. The gross value of lentil output was estimated in quintals which were converted to kilograms at a rate of quintal=100kg.Thequintalisameasure that is commonly used by smallholder farmers in Ethiopia (Seyoum et al. 1998).

Lentil land(X1): refers to total area of plot used for production of lentil during production year by each sample farmer. Lentil land is included in the model by converting the area measured in Qerti, local unit in to standard unit, hectare. Findings of the studies by Amaza and Maurice (2005) and Battese et al. (1996) show that a direct relationship between land and agricultural output.

Fertilizer (X2): a study by Ahmad et al. (2002) shows that fertilizer is the basic input for increment in the level of production. Here, it is refers to the cost incurred by the farmer for the purchase of fertilizer on lentil plot. The two mainly used fertilizers are DAP and Urea. After total fertilizer usage was converted into standard unit, they were multiplied by their respective prices and then included in the model as a value. Prices of these fertilizers were obtained from Rural and Agricultural Development Office of Mo retina Jiru Woreda. However, since there were farmers who didn't apply lentil in the production year, a problem has occurred associated with including zero values in to the Cob-Douglas production function. This is because of that the estimation of the production frontier is not possible with variables having a zero value. Battese (1997) suggested that it is possible to estimate production frontier by assigning very small value greater than zero for farmers who did not apply fertilizer. Thus, for those farmers who did not apply fertilizer a small value that approach zero, which is equal to 0.001, was assigned.

Number of draught animals (X3): It is the number of oxen days that the household applied lentil production. Draught animals are an important factor for different farm operations. The number of draught animal has positive and significant elasticity of production indicating that higher number of draught animals contributes for the increment in agricultural output (IFPRI, 2011). It was hypothesized to have positive influence on lentil output.

Chemicals(X4): such as herbicides input particularly in sorghum due to serious weed. Pesticides this also stands for total expenditure of the farmer for pesticide purchase for lentil production. Lentil production in the study area is highly affected by pests and disease attack by the it household so that lentil production is determined by how effective the farmer control pests. The most important type of pesticides used are, Dimethoate, Sulphate, Primicarb (Primer) 50% WP and Lamdex. The cost of these pesticides was computed by multiplying each pesticide in standard unit with their respective price. Then they were aggregated to be included in the mode

Type of seed(X5): farmers use improved and local seeds of lentil. Basic seed one, basic seedtwoand certified one up to certified three were taken as improved seed. Here, type of seed is a dummy variable. It takes the value of 1 for improved seed and 0 for local seed. Improved lentil seed matures earlier, and is more productive than the local seed. Thus, it was hypothesized that farmers who use improved seed are less inefficient than those farmers whose local seed.

Human Labor(X6): is an important input for agricultural production. Labor force utilization of sampled farmers on lentil plot was recorded during the survey. The record was done by the type of person participated on the given activity by categorizing as Hired labor, Family labor and Exchange labor Thus labor inputs for major activities were converted in to man-equivalent. The man equivalent was computed by taking into account the age and sex of the lab ours used and using standard conversion factor reported (Strock et al., 1991)

Age of the farmer (Z1): The variable was measured in years. As age increases the knowledge, skills as well as the physical capability of farmers is likely to increase. However, this tends to decrease after a certain age level (Shumet, 2011). Therefore, the variable was hypothesized to influence the inefficiency of farmers negatively.

Crop specific farm experience (Z2): It is the experience of the farm household head in production of lentil and is measured in terms of years. A well experienced farmer has good knowledge on farm operations required lentil production and improves the inefficiency of farmers (Ali et al., 2012). Hence, the variable was hypothesized to have a negative sign.

Education (Z3): education is an important tool which determines production efficiency. In most of technical efficiency studies like that of Amaza and Maurice (2005), Sarfraz (2004), Ahmad etal. (2002) and Seyoum et al. (1998), education is recognized as an important factor for efficiency differential between DMUs. Education has a role of improving one's way of understanding and knowledge. It is more likely that farmers with higher educational status have better perceptive to grasp agricultural expert advice. It also increases acceptance for improved technologies. Thus, it was hypothesized that as the number of schooling increases, inefficiency would decline significantly. In this study, it was taken as a continuous variable and measured by years of schooling of farmers.

Extension Service (Z4): extension service given to farmers was measured in number of days of contact with development agents during the production year. Studies by Seyoum et al. (1998)and Amaza and Maurice (2005) revealed that extension contact is a determinant factor for inefficiency of farmers' production. Extension service enhances farmer's efficiency by giving alternative ways of production, and by giving advice on adequate time and rates of weeding, sowing and plowing. Extension workers also help farmers to implement and adopt new technologies on their farm. Thus, it was expected that as the number of visits of the development agent increases, inefficiency decreases.

Slope (Z5): Since water logging is an important problem of lentil production in the study area, it is important to include slope as a factor of inefficiency. Relatively flat land reduces the output level of lentil production on have black soil because lentil is susceptible for water logging problem. Based on this, it was hypothesized that farmers who sow lentil on sloppy land are less in efficient than those with gentle or flat slope. Slope was taken as a dummy variable, where 1indicates that the land is sloppy and 0 otherwise in accordance with farmer's evaluation.

Off/non-farm activities (Z6): This is treated as a dummy variable and measured as 1 if the household is involved in off/non-farm activities and, 0 otherwise. The effect of this variable could be ambiguous. While on the one hand, it increases the income base of the farm household thus helping them to overcome credit and insurance constraints and increase either use of industrial inputs. On the other hand, it reduces the labor available for agricultural production especially if hiring agricultural labor incurs transaction costs and if hired labor is not as efficient as family labor (Feng, 2008). Since farmers who spend more time on off/non-farm activities are more likely to be less efficient in farming as they share their time between farming and other income-generating activities, the variable was hypothesized to increase technical inefficiency of farmers.

Credit accessibility (Z7): is a dummy variable which indicates accessibility of credit which is 1ifthe farmer can access credit, 0 otherwise. The findings of Ahmad et al. (2002) and Sarfraz (2004) shows accessibility of credit is a determining factor for farmer's efficiency. Farmers in the study area access credit from Amhara Credit and Saving Institution, Saving and Credit Cooperatives, Cooperative unions and Mo retina Jiru woreda Agricultural and Rural Development Office. Previously input credit was given by Amhara regional state but abandoned since the2011 production year. Farmers also get credit informally, from relatives or Idir4. Most farmers at individual and group discussions also indicated that the existence of a problem regarding higher interest rate. However, since access for credit is an important source of financing the agricultural activities of smallholder farmers, it was hypothesized that farmers with accessibility of credit are less inefficient.

Household size (Z8): members of household are the major source of labor supply. It is a continuous variable and was aggregated by employing adult-equivalent of Strock et al.(1991). This was done by first categorizing members of the household in to children, men and women and according to sex. The aggregation helps to know the available labor force from different sources. It was hypothesized that the farmer with smaller household size is more inefficient than farmers with larger household size

Soil fertility (Z9): It is considered dummy variable that takes a value of 1 if a household head perceives his plots as fertile, 0 otherwise without the application of any inorganic fertilizer. Since fertile lands under good management provide high yield and reduce the quantity of input cost than less fertile land, it is assuming to reduce the level of inefficiency of farmers.

Proximity to the nearest market center (Z10): It is the distance of the household head residence from the nearest main market center and it is measured in kilo meters. Distance relates to changes in transaction costs and in accessing farm inputs as well as accessing markets for the farm produce, which negatively affect efficient use of such resources and consequently less net returns from production (Owuro and Shem, 2009).Therefore, the variable was assumed to have a positive sign in the inefficiency model.

Market availability and price condition of the output (Z11): This is considered as a dummy variable that takes a value of 1 if the farmer perceived that market is available and the price is attractive, 0 otherwise. It is well-established fact that, access to input and output markets play a critical role in determining crop profitability, choosing appropriate production technologies and the supply of agricultural commodities. Hence, access to input and output markets have a significant contribution in reducing inefficiency of farmers (Messay et al,2013). Therefore the variable was hypothesized to have negative sign in the inefficiency model.

Cooperative membership (Z12): It is a variable that indicates the status of farm household membership in cooperative and is considered as a dummy variable that was given a value of 1,if the farm household head is a member and 0 otherwise. Being a member of a cooperative helps farmer, to adopt improved technologies which are related to access to inputs and information that cooperatives create for members. Similarly, the empowerment that cooperatives bring for farming households in terms of creating access to market and information is vitally important (Motuma et al., 2010). Hence, in this study it was hypothesized to reduce the technical inefficiency of farmers. The summary of variables used in the inefficiency model.

Training (Z13): in the study area, training service is given for farmers at their locality. Farmers received training on different aspects of production. Training is an important tool in building the managerial capacity of the farmer. Research findings of Stevena and Edward (2004) andof Fekadu and Bezabih (2009) show that training has a positive impact on the level of efficiency of farmers. Thus, it was hypothesized that trained farmers are less inefficient than untrained ones. In this study, training is defined using a dummy variable. A value of one indicates that the farmer received training on any of production activities. Whereas, the value of 0 indicates that the farmer didn't take any training on production activities.

Household size (Z14): members of household are the major source of labor supply. It is a continuous variable and was aggregated by employing adult-equivalent of Strock et al.(1991). This was done by first categorizing members of the household in to children, men and women and according to sex. The aggregation helps to know the available labor force from different sources. It was hypothesized that the farmer with smaller household size is more inefficient than farmers with larger household size.

Plowing frequency (Z15): frequency of plowing is continuous which denotes number of plowing before sowing. Plowing prevents weed infestation and improves aeration which favors a faster and healthier plant growth. The hypothesis was that the farmer who plows more frequently is less inefficient than the one who plows land less frequently.

Time of sowing (Z16): sowing time is a dummy variable where 1 indicates late sowing and 0, otherwise. Early sowing starts from mid-end of June and late sowing is to mean sowing which occurred in the beginning of September. Earlier sowing fevers moisture but growth may stagnate due to water logging problem. Late sowing minimizes the problem of water logging that constrains lentil production on have black soils. Late sowing time is preferred on a relatively gentle areas and Vertis soils. Early sowing is preferred on sandy soil and on relatively sloppy areas where water logging problem does not occur. However, about 75 % of the study district is covered with Vertis soils. Hence, it was hypothesized that farmers who sow lentil late are less inefficient.

Table 2: Definition, measurement and hypothesis of inefficiency variables

Variable	Description	Measurement	Expected sign
Efficiency index	Technical efficiency in lentil production	**Quintal**	
Independent			
Sex	Value of 1 for male and 0 otherwise	Dummy	-
Age	Age of household head	Year	+
Family size	total numbers of family member who lives in one roof	Adult equivalent	-
Education level	Number of years of schooling of the farmer	Years	-
farming experience	lentil production experience of the respondent	Years	-
Access to credit	Amount of credit received in the production year	Birr	-
Off/nonfarm	Involvement of respondents in off/non-farm activities	Dummy	-
Soil fertility	Fertility of the respondents land	Dummy	-
Access to Training	the respondents lands lope	dummy	-
Household size	the respondents land soil	Dummy	-
cooperative Membership	Respondents cooperative membership	Dummy	-
extension service	Frequency of extension service during the farming season	**Number**	-
Market availability and price condition of	Respondents perception on market availability and	Dummy	**-**

the output	price condition of lentil output

CHAPTER FOUR

4. RESULTS AND DISCUSSION

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

4.1. Descriptive Results

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

4.1.1. Demographic and Socio- Economic Characteristics of Sample Households

Household size: Total numbers of individuals within the household determine the availability of labor power needed in the farm production. Family labor plays an important part in the success of small-scale farming practices in that the farmer does not need to spend too much money on labor costs. In the study area, average household size for the sample farmers was about 6.2 adult equivalents per household. The largest household size was being 12 while the smallest size was 1 adult equivalent per household with standard deviation 3.37.

Age of the household head: it is one of the important factors which determine the farming experience of the farmer. Diminution in the size of cultivated area and subdivision of holding are phenomena of long period. Age of household is important to study such a long period phenomenon, related with the change in farm size and extent of sub division. All these contribute in determination of individual farm efficiency. The survey result showed that, the average age of the sample household heads was 46.37 years. Their age ranged from 28 to 70 years with standard deviations of 16.27.

Education status of the household head: education enhances the acquisition and utilization of information on improved technologies by farmers. Education together with increased experience could guide farmers to better manage their farm activities. Education upgrades the ability and changes the attitude of person in a given society.

Educated farmers were expected to adopt new agricultural technologies and had better managerial skill. An attempt was made to assess the educational status of the sample households who had informal and formal education (Lockheed et al., 1980). In the study area, the average years of formal schooling of sample farmers were found to be 4.2 years with of 3.7. the maximum educational achievement for the sample farmers was grade 11. From the total sample household heads, 34.1% of the total sample household heads have attended formal label of schooling (table 3)

Sex of the household head:- the survey result indicated the 7.94 percent of households are female –headed. It is understood that female-households face greater challenges in the agricultural production and marketing compared with their male-counterparts. This is due to the fact that female household heads in the rural Ethiopia hold various tasks including collecting of fire would from the field, fetching water, childrearing and household management obligations. In addition they have farm management tasks that increase the burden. Such multiple tasks combined with less resource accesses and ownership lead to more frequent and perhaps severe economic and social shocks particularly poverty and food insecurity.

Table 3: Demographic and socio –economic characteristics of sample households

Variable description	Mean	Std. deviation	Minimum	Maximum
Family size (adult equivalent)	6.2	3.37	0	12
Age of the HH	46.37	16.27	28	70
Education Level of the HH	4.2	3.68	0	11
Dummy variable	Response	Frequency	Percent	
Sex of the household head	Male	116	92.06	
	Female	10	7.94	

Source: Own survey, 2020

Marital status of the household head: Marital status of the household head with respect to lentil producer was surveyed. Among the given sample household, 9.52% households were single. But, 73.8% households were married. The rest divorced and widowed household heads covered 10.32%

and 6.35% respectively (Table 4) Females are head of households, when they were divorced, take responsibility and starting farming in addition to homemaking role.

Table 4: Distribution of sample households by their marital status

Marital Status	Male		Female		Total	
	N	%	N	%	N	%
Married	85	67.46	8	6.35	93	73.8
Single	12	9.52	0	0.00	12	9.52
Divorced	11	8.73	2	1.59	13	10.32
Widowed	8	6.35	0	0.00	8	6.35
Total	116	92.06	10	7.94	126	100.00

Source: Own survey, 2020

4.1.2. Labor Availability

Human lab our required for management and production of crops and animals is supplied almost entirely by members of the household. Farmers also deploy hired laborat an average wage rate of 150-250 ETB birr per day during peak season of agricultural production, i.e. weeding and cultivation, land preparation and planning and harvesting. There is also other type of labor resource management like labor exchange arrangements such as 'Debo' especially during seasons where there is shortage of labor. Family labor was the main source of labor for performing various farming activities for smallholder farmers. In the study area, it has been observed that there was a sort of labor division in various farm works between family members. Ploughing and planting were types of activities belonging to male whereas food preparation and child care were left to female. In most of other cases than these both female and male worked together Children participated in different farm and non-farm activities. In this specific study, labor availability of the sample household was calculated in man equivalent to examine the effect of variation in labor availability among the households. Because of differences in capacity and ability of performing a given activity between sex and different age groups, Labor force was standardized to a similar unit (man equivalent). The conversion factor used to standardize labor force has been given in appendix table 1. Majority of the sample households, 53.97% of the labor contribution was from family member and while the hired labor and Exchange labor contribute 29.37% and 16.67%, respectively. In general, the average labor demanded per hectare of lentil production was estimated to be 174.88 man days (table5)

Table 5: Labor use for lentil production by sample households in 2011/2012

Types of labor	Frequency	Percent	Mean	Std. dev.
Family labor	68	53.97	71.3	34.3
Hired labor	37	29.37	61.9	25.5
Exchange labor	21	16.67	40.9	22.8
Total	126	100.0	174.88	81.03

Source: Own survey, 2020

4.1.3. Household social-economic characteristics

4.1.3.1. Land and Average size of cultivated land holding by sample household heads

Land is crucial source of agricultural production on which the livelihood of the rural households depends. There are no communal or state farms in the study area. Pasture land and forestry are public resources. During the production year (2011), most of the sample household heads 91.27% operated on their Land from government. Farmers about 23.81% Land obtained by other means. In addition to acquisition of land through FA, farmers have other sources of land mainly through two informal arrangements, 55.56% sharecropping and 45.24% Leased land from others.

The share cropping system involves contribution of land by the land owner whereas the operator farmer convers almost all input expenses. The output is shared between the owner and operator farmer according to the predetermined contractual arrangement. On average, the owner of land obtains 50% of the output after the financial expenses (e.g. for chemical or fertilizer purchase) are deducted. Farmers rent – in land or share others land when they get enough money to cover all in put expenses and the renting price. On the other hand, farmers rent-out their land when they face financial problems to meet social or other obligations or engaged in other nonfarm activities.

An attempt was made to study the size of cultivated land holding by sample household heads, MO retina Jiru Woreda. To mitigate the challenge of land shortage, young farmers usually shared land with their parents and relatives during marriage or obtained land use access through share cropping and renting in land. The survey result indicates that 8.72% of the sample household had less than 0.5 hectare and 27.51% of household had more than 2 hectare of cultivated area. The analysis and pattern of cultivated land amongst sample households indicated that the average size of farm owned by the sample household heads were 1.48 ha (table 6). There were large variations in the distribution of the land holding among sample households. Above 40% of the households owned more than 1.48 ha of cultivated land.

Table 6: Descriptive statistics of land holding by source and fertility (ha/household)

Type of land		Male		Female		Total		X2-value	p-value
		No	%	No	%	No	%		
Land from government	Yes	108	85.7	7	5.56	115	91.57	6.1673	0.013
	No	8	6.35	3	2.38	11	8.73		
Share land	Yes	68	53.97	2	1.59	70	55.56	5.5614	0.018
	No	48	38.10	8	6.35	56	44.44		
Leased land from others	Yes	49	38.89	8	6.35	57	45.24	5.2983	0.021
	No	67	53.17	2	1.59	69	54.76		
Land obtained by other means	Yes	25	19.84	5	3.97	30	23.81	4.1072	0.043
	No	91	72.22	5	3.97	96	76.19		

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

Source: Survey result, 2020

4.1.3.2 Inputs and input Costs

Seed In the study area, farmers sow both local and improved seeds. As it can be seen from table 10, an average of 78.01 kg/ha and 90.39 kg/ha of farmers sow improved seed (Ale Maya) and Local seed (Black lentil) of lentil. This indicates that most of sample farmers utilize more of local variety than improved variety. The amount of seed used per ha also has important implication on productivity.

According to the reports MO retina Jiru woreda of Agricultural and Rural Development Office (2011E.C). Distribution of improved lentil seed in the production year was179 qt which was smaller than the previous year (684qt) by 73.83%. The same source also revealed the reduction in distribution of improved seed of all major crops produced in the district. This might be caused by inaccessibility of credit and supply problem in the production year. According to the discussions held with the farmers, there is no significant problem in supply of improved seed. Availability of cooperatives and road accessibility of the study area from Addis Ababa reduces the difficulty to acquire improved seeds. From all sample farmers who accessed improved seed in the production year, 75.40 % of them accessed improved seed from cooperatives, 17.6 % received it from the Ethiopian Seed Enterprise and the rest of farmers bought it from local market. Most of local seeds used in the area are used from the farmer's own store. The resistance behavior of Ale Maya variety (improved) is preferred to Local seed (Black lentil) which is more resistant to rust. Even the local seed is of variety Ale Maya. However, some farmers still prefer variety Ale Maya to Black lentil due to its resistance nature of water logging problem. In areas where the land is relatively sloppy, Ale Maya is sown from mid to end of June. However, in the FA where there is high water logging problem, it is sown August one to August twenty to reduce root- rot disease. The total amounts of DAP and urea were measured in kilograms while their costs were expressed in Ethiopian Birr (ETB). DAP and urea fertilizers were aggregated separately due to the fact that these inputs tend to have quantity and price difference. Similarly, the total cost of DAP and urea incurred by the farmer in ETB were calculated as the sum of money spent on each DAP and urea. On average, 150 kg /ha of DAP and 89.68 kg/ha of urea was used while the average cost of these inputs were 2100 ETB and 1165.9 ETB for DAP and urea, respectively. When we compare across Two years farmers' in 2011/2012.

Chemicalssuchasherbicidesorpesticidesusedasainputparticularlyin Lentildueto serious weed, pest and disease attack by the i^{th} household. Pesticide: this also stands for total expenditure of the farmer for pesticide purchase for lentil production. Lentil production in the study area is highly affected by pests of lentil production is determined by how effective the farmer control pest

Table7: Inputs and input Costs

Variable	Amount of seed				Total cost of seed		
	Obs	Mean	Std. Err.	Std. Dev.	Mean	Std. Err.	Std. Dev.
Improved seed kg/ha	126	78.01	.922	10.35	3120.6	36.90	414.2
local seedkg/ha	126	90.35	.636	7.16	3615.87	25.45	285.77
Combined	252	88.05		10.83	3368.25	27.28	433.21
DAPkg/ha	126	150	1.78	20	2100	24.94	280
UREAkg/ha	126	89.68	1.4	15.89	1165.9	18.41	206.6

Combined	252	265.47	2.2	35.05	1632.9	33.293	528.5
Pesticides Lit/ha	126	2.166	.097	1.09	905.95	36.9	.4414
Herbicides Lit/ha	126	1.753	.064	.72	699.6	40.80	458.01
Combined	252	3.65	.059	1.14	802.77	28.22	447.983

Source: Survey result, 2020

4.1.3.3. Land preparation and planting

Farmers plow the land for an average of three times before sowing with an average of three month interval. About 70.40% of farmers sow lentil after they plow land one times 28.00% of farmers plow their land for two times and 1.60 % of farmers plow their land for three times and more than one times before sowing. The gap between each ploughing is determined by amount of rain. If there is a high rainfall, the gap will be shorter to prevent weed infestation. The level of yield of lentil might be determined by how good the farmer manages weed before sowing and the farmer used to Herbicide (Liter/ha). Therefore, farmers weed their land within the interval between consecutive ploughs. Lentil also has to be weeded immediately after it starts growing. However, if the farmer leaves the plot until lentil is flowering, it may be entirely damaged by weeds. Lentil is sown 51.20% from August one up to August twenty. 36.00% from Early (mid to end of June), 8.00 % from lately (beginning September), 1.60% from end of August and harvested from October 26 up to November 28. Especially on sandy soils, it is sown early to protect the production from shortage of water in area where the slope of land 40.80% is gentle (flat –slope), lentil farmers sow 51.20% August one up to August twenty to prevent root-rot disease which is caused by water logging. Farmers also use ridge and furrow system to drain excess water from lentil field to avoid water logging problems especially on vertisols. The Ale Maya variety is highly susceptible to water logging problem. So, on areas with gentle slope or flat, it is sowed after August one up to August twenty after the water is drained.

Table 8: land preparation and planting

Type of land		Male		Female		Total		X2-value	p-value
		No	%	No	%	No	%		
Land slope	Gentle (flat slope	49	39.40	2	1.60	51	40.80	8.1727	0.040
	Sloppy	9	7.20	3	2.40	12	9.60		
	Relatively flat	49	39.20	3	2.40	51	40.80		
	Other specify	8	6.40	2	1.60	10	8.00		
Plowing frequency	One times	83	66.40	5	4.00	88	70.40	5.9950	0.048
	Two times	31	24.80	4	3.20	35	27.00		
	Three times	1	0.80	1	0.80	2	1.60		
Sowing time	Early (mid-end of June)	42	33.60	3	2.40	45	36.00	8.2512	0.040
	Lately (beginning September	8	6.40	2	1.60	10	8.00		
	August on up to August twenty	61	48.80	3	2.40	64	51.20		
	End of August	4	3.20	2	1.60	6	1.60		

Source: Survey result, 2020

4.1.3.4. Level of oxen power utilization by sample household heads

Oxen power was found as an important factor of production in the study area. Oxen power utilization by sample households was computed by assuming working of 8 hours by pair of oxen per day. Average oxen power used by the sample households in lentil production was 22.71 oxen days with standard deviation of 12.26 (table 9). Almost in all sample Keble's, farmer's average ploughed their land one to three times for production of lentil. Usually the land preparation started from the first commencement of rain and they continued ploughing each month until sowing of the crop.

Weed infestation was found to be a serious problem in the area due to the high rain fall from the month of June to August. It was also observed that the sample farmers in the study are more emphasis to ploughing as compared to weeding which is the major challenge for improving productivity. Given the above fact, 6.35% of the sample respondent had no oxen while 60.32% of them owned one pair of oxen. On the other hand, only 7.94% of the sample farmers owned more than two pair of oxen (table8)

Table 9, Distribution of sample household head by number of oxen and lentil crop coverage

Number of oxen	Average area coverage under lentil	Number of farmers	Percent
0	1	8	6.35
1	1.13	15	11.90
2	1.07	76	60.32
3	1.05	17	13.49
4 or more	1.1	10	7.94
Total	1.07	126	100.00

Source: Own survey, 2020

4.4.3.3. Off/Non-farm activities

Farmers in the study area are engaged in various off/non-farm activities in parallel with the main farming activities during the farming season. Some of these activities are; grinding mills, handicraft, Tailor, carpenter and selling of local drinks. The income they desperately need to obtain from such off/non-farm activities may substantiate the low income that is usually obtained from farming activities. In this study, the average amount of off/nonfarm income was birr 1256.5 with standard deviation of 1548.3 (table 10)

Table10: Off/non-farm activities

Variables	Mean	Std. Dev.
Off/non-farm Income	1256.5	1548.3

Source: Own survey, 2020

4.1.4. Cropping system

The dominant farming system of the district is mixed crop-livestock. Crop production of the district is limited to Me her season and the major types of crop that are produced include Teff, wheat lentil beans and Barley and chick pea from pulses. Though modern input application especially fertilizer is there, the performance of major crops in terms of yield is not encouraging. The productivity level of major crops in 2011/2012 production year is presented in table 10. The result indicated that on average sample farmers obtained 5 qt of lentil with minimum and maximum of 38 qt during a given production year, respectively. The result also indicated that sample households were obtaining average output of wheat and Teff of 28.75 Qt and 17 Qt, respectively. On the hand the average output of Bean and chickpea obtained by sample households in 2011/12 production year were 5.3 Qt and 7.57 Qt, respectively (Table 11)

Table 11: Average yield obtained by sample farmers in 2011/2012 production year

Crop types	Minimum	Maximum	Mean	S.D
Teff	12	17	17	4.06
Wheat	20	28.75	28.75	6.89
Bean	2	5.3	5.3	1.97
Lentil	5	24.3	24.3	7.9
Barley and Chick pea	6	7.57	7.57	1.13

Source: Own survey, 2020

4.1.5 Description of production function and variables

This part present summary statistics results of production variables (both the physical input used in the production of lentil output) used for analysis in the stochastic production frontier model. The production function for this study was estimated using six input variable. To draw some picture about the distribution and level of inputs, the mean and range of input variables is presented in Table 12 below the result of analysis for output variable indicates that on average a household produced 24.3Qt of lentil output that ranges from 5 Qt to 38Qt with standard deviation 7.9 of among the sample farmers in 2011/2012 production year (table 12). In the study area, lentil production is produced one times per annum. The land allocated for lentil production, by sample households during the survey period, ranges from 5 to 5 ha with average land size and standard deviation of 3 ha and 1.14 respectively. In the study area, farmers use both Urea and Dap fertilizers for lentil production. The average amount of fertilizers applied in the production of lentil by sample households were 265.47 Kg per hectare during 2011/12 lentil production season. There was high variation of fertilizer utilization (both urea and Dap) in lentil production by sample households. Like other inputs human labor and oxen power inputs were also decisive in the study area. Sample households, on average, use 123.8 man days per ha of labor for the production of lentil during 2011/12 production season. In the production process labor input is used for major farming activities such as land preparation and planting. Weeding and cultivation, Harvesting, sowing, chemical application and fertilizer applications and other activities, for lentil and preparation oxen power was used by the sample households. Field survey result showed that about 97% sample households use oxen power for ploughing their lentil land, and this oxen powers computed to oxen days, the average oxen power used by sample households was 63.2 oxen days per ha with standard deviations of 38.58. the other very important variable, out of which production is impossible, is seed. The amount of seed sample households' used was 88.04 Kg, on average with standard deviation of 8.2 (Table 12). There are different Lentil seed varieties used by households in the study area. On average, sample households applied 3.6 liter of chemical such as herbicides or pesticides per hectare in the study area for the protection of lentil farms during 2011 production year.

Table 12: Output and input Variables used to estimate the production function

Variables	Minimum	Maximum	Mean	Std. deviation
Lentil output (q t/Ha)	5	38	24.3	7.9
Seed (kg/ha)	73	95	88.05	8.2
Land (ha)	5	5	3	1.14
Human labor (MDs/Ha)	30	180	123.8	41.56
Oxen power (ODS/Ha)	15	120	63.2	38.58
Fertilizer)kg/ha)	200	300	265.47	35.05
Chemicals (Lit/Ha)	2	6	3.65	1.13

Source: Own computation result, 2012

4.1.6. Major lentil Production Constraints Faced by Sample Household Heads

The **Constraints** that were found to operate in Lentil production in the study area were presented in table 11Unfavorable weather condition. Rust root rot and occurrence of fusarium were the most important problems that affect lentil production. Farmers rank rust, root rot and fusarium as the most an important problem which hinders productivity of lentil, about 36.51 % of the sample farmers rank rust, root rot and fusarium first. And 16.67% of farmers rank water logging 3rd problem and 21.43% Unfavorable weather condition a second problem, 7.14% Low fertility of the land 6th problem, 8.73% poor land preparation, due to shortage of oxen 5th problem, 9.52% weeding festation and insects 4th problem were ranked as important problems by the sample farmers. About 98% of the sample farmers pointed out that occurrence of natural or artificial hazards are rare.

Table 13 Constraints of lentil production as ranked by sample farmers during production year

Constraints of lentil production	Frequency	%	Ranking
Rust ,root and fusarium	46	36.51	1st
Water logging	21	16.67	3rd
Low fertility of the land	9	7.14	6th
Poor land preparation due to shortage of oxen	11	8.73	5th
Weeding festationa and insects	12	9.52	4th
Unfavorable weather condition	27	21.43	2nd
Total	126	100.00	

Source: Own survey, 2020

Training: an appropriate training given to the farmers may improve productivity by enhancing their management capacity. In the study area, farmers were getting training from surrounding research centers and other governmental and nongovernmental organizations. Among the sample farmers, 11.90 and 3.9% of farmers were male and female respondents respectively trained on different lentil related aspect and the rest 80.16% and 3.97% were male and female respondents respectively had not received any training on the subject matter previously. This indicates that majority of the sample farmers were received (table 13). Finally, the test statistic shows that there is significant difference in access to institutional services between male and female respondents in the study area.

Table 14: Institutional Characteristics of the sample household

Variables		Male		Female		Total		X2-value	**P-value**
		No	%	No	%	No	%		
Access to credit service	Yes	50	39.68	9	7.14	59	46.83	8.1	0.004
	No	66	52.38	1	0.79	67	53.17		
	Total	116	92.06	10	7.49	126	100.00		
Access to extension services	Yes	15	11.90	5	3.97	20	15.87	9.47	0.001
	No	101	80.16	5	3.97	106	84.13		
	Total	116	92.06	10	7.94	126	100.00		
Cooperative membership	Yes	85	67.46	10	7.94	95	75.40	3.5	0.060
	No	31	24.60	0	0.00	31	24.60		
	Total	126	92.06	10	7.94	126	100.00		
Access to training programmed	Yes	15	11.90	5	3.97	20	15.87	9.47	0.002
	No	101	80.16	5	3.97	106	84.13		
	Total	116	92.06	10	3.97	126	100.00		

Note: *** and 88 shows a significant at 1 and 5% level of significance respectively

Source: Own survey, 2020

4.1.8. Source of credit and purpose of credit services

Credit (in cash and in kind) is an important institutional service to finance and facilitate farmer's agricultural operations. There exist both formal and informal lending institutions to provide credit. The formal sources of credit in the study area are Amhara Credit and Saving Institution (ACSI) and local cooperatives, whereas friends, Banks, relatives, Merchants and the like are informal sources from which farmers could get credit. As far as the access to credit is concerned on average birr 1890.5 from either source when they are in need of it provided that they fulfill the requirements set by the lending institutions (formal or informal) with standard deviation of 1969.9 (table 14). Nevertheless, the requirements and procedure to use credit from the formal institutions were not as easy as the local co-operatives and informal institutions. For instance, in the case of ACSI farmers were asked to form a group of ten toe acquire credit. If any one of the group members was unable to pay back the amount he/she acquire, the remaining group members would be obliged to repay the total amount. Some of the time farmers face food shortage before the next new harvesting season.

As presented in Table 14, the main source for the majority (61.11%) of the respondents was Cooperatives 58.73 and 38% were male and female respondents respectively, Banks 0.79 and 0.79% were male and female respondents respectively, Relatives 4.76 and 0.79% were male and female respondents respectively, Merchants 10.32 and 1.59% were male and female respondents respectively. In addition credit and saving institution 17.46 and 2.38% were male and female respondents respectively in the study area. The x2 statistic test indicates that 10% there is no significant difference between male and female farmers respondents source of credit service providers in the study area.

Purpose of credit purchase seed 13.49 and 0.79% were male and female respondents respectively purchase fertilizer, 15.87 and 0.79% were male and female respondents respectively animal husbandry improvement 19.84 and 1.59% were male and female respondents respectively, consumption 15.08 and 0.79% were male and female respondents respectively, To hire oxen power and to hire human labor 12.70 and 2.38% were male and female respondents respectively. The x2 statistic test indicates that there is no significant difference between male and female farmers respondents purpose of credit service providers in the study area.

Table 15: Source of credit and purpose of credit services.

		Male		Female		Total		X2-value
		No	%	No	%	No	%	
Source credit	Banks	1	0.79	1	0.79	2	1.59	8.1126
	Relatives	6	4.76	1	0.79	7	5.56	
	Merchants	13	10.32	2	1.59	15	11.90	
	Credit and saving institution	22	17.46	3	2.38	25	19.84	
	Cooperatives	74	13.495 8.73	3	2.38	77	61.11	
	Total	116	92.06	10	7.94	126	100.00	
Purpose of credit	Purchase seed	17	13.49	1	0.79	18	14.29	2.3517
	Purchase fertilizer	20	15.87	1	0.79	21	16.67	
	Animal husbandry improvement	25	19.84	2	1.59	27	21.43	
	Consumption	19	15.08	2	1.59	21	16.67	
	Purchase pesticides	19	15.08	1	0.79	20	15.87	
	to hire oxen power and to hire human labor	16	12.70	3	2.38	19	15.08	
	Total	116	92.06	10	7.94	126	100.00	

Source:- Own survey, 2020

Further, as shown in table 15, only 21.43% of the respondents were took in cash credit, 16.67 and 4.76% were male and female respondents respectively, and 78.57% of the respondents were took in in kind (kg of other), 75.40 and 3.17% were male and female respondents respectively, The x2-value shows the existence of significant difference in getting in kind among members and nonmembers of cooperatives at 1% level of significance. This shows the importance of cooperatives in facilitating access to in cash and in kind credit services in the study.

Table 16: frequency of farmers who have borrowed credit in 2012

Group		Farmers' cooperative membership						X2- value
		Male		Female		Total		
		NO	%	NO	%	NO	%	
Cash (Amount in Birr	Yes	21	16.7	6	4.76	27	21.43	9.5981
	No							
In-kind (kg or other	Yes	95	75.4	4	3.17	99	78.57	
	No							

Note: *** shows significant at 1% level of significance.

Source: Own survey, 2020

4.2. Econometric Result

This section presents the econometrics model result of the study. The results of technical efficiency level and factors affecting technical efficiency are discussed successively. Before running the econometric analysis, the data was tested against different econometric problems. Accordingly the data was checked for Heteroskedasticity using Breusch Pagan test, and result showed absence of serious problem of Heteroskedasticity) appendix table 15). Multi Collin ear it y test for both continuous and dummy variables at the same time was done using variable inflation factor (VIF) to check multi collinear it y problem among all variables entered in the model.

In addition, multicollinearity test of continues and dummy Variables were checked by using variance inflation factor and contingency coefficient respectively. According to Gujarati (2004), value of VIF more that 10 is usually considered an indicator of serious multicollinearity and should be excluded from the model. On the other hand, variables having variance inflation factor of less than 10 are believed to have no serous multicollinearity problem and able to include as explanatory variables in the model. As a result, test for multicollinearity using both methods confirmed that there was no serious linear relation among explanatory variables (appendix Table 3 and 4)

4.2.1. Hypothesis Testing

The formulation and results of different hypotheses are presented in table 16. All the hypotheses were tested by using generalized likelihood – ratio (LR). The first hypothesis related to the appropriateness of the Cobb-Douglas functional form in preference to trans log model. The computed LR statistic was less than the critical value of chi-square at 10% probability level. The null hypothesis was accepted by indicating that the Cobb-Douglas functional form being a better representation of the data. These showed that the coefficients of the interaction terms and the square specifications of the input variables under the Trans log specifications were not different from zero. Hence, Cobb-Douglas production function was the best to fit the data for estimation of technical efficiency for lentil producing farm household in the study area.

The second hypothesis was tested for the existence of the inefficiency component of the total error term of the stochastic production function. In other words, it was concluded whether the average production function (without considering the non –negative random error term) best fits the data. Hence, the second hypothesis stated that y=0, was rejected 10% level of probability confirming that inefficiencies existed and were indeed stochastic (LR statistic 8.6> chi-square = 2.71). The coefficient for the parameter y could be interpreted in such a way that about 95.02 percent of the variability in lentil output in the study area was attributable to technical inefficiency effect, while the remaining about 4.08 percent variation in output was due to the effect of random noise. This implies that there was a scope for improving output of lentil by first identifying those institutional, socioeconomic and farm specific factors causing this variation.

The third hypothesis which stated the technical inefficiency effects were not related to the variables specified in the inefficiency effect model, as Accepted at 1% level of significance (LR statistic 4.6 critical chi-square = 26.2). Thus the observed inefficiency among the lentil farmers in the area could be attributed to the variables specified in the model and the variables exercised a significant role in explaining the observed inefficiency.

The forth test conducted was given such functional forms for the sample households; it was considered whether the technical efficiency levels were better estimated using a half normal or a truncated normal distribution of μ_i the results indicated that the half normal distribution was appropriate for the sample households in the study area as the calculated LR value of 6.2 was less than the critical x2 value of 9.24 at less than 10% probability.

Table 17: Generalized likelihood ratio testes of hypothesis for the parameters of the SPF

Null hypotheses	Degree of freedom	Calculated	Critical x2 – value	Decision
Production function is cobb-Douglas ($H0:B_{ij}=0$)	6	10.64	14.2	Accept
There is no inefficiency effects in model (HO: y =au2=0)	1	8.6	2.71	Reject
The coefficients of the explanatory variables associated with technical inefficiency effects model are all zero (Ho:Ui=δ0=Z1…Z12=0)	12	4.6	26.2	Accept
Half normal model is adequate (H0:--- =))	5	6.2	9.24	Accept

Source: Model result 2020

4.2.2. Maximum Likelihood estimation of parameters

The maximum-likelihood estimates of parameters of the stochastic production frontier and inefficiency effect models as described with equations (15) and (16) were obtained after treating the data set with STATA version 13. A stochastic production frontier model permits to consider production of lentil in the study are with Cobb-Douglas stochastic production was tested and found to be best to fit the data. It was used to estimate efficiency of farmers and to identify factors determining the inefficiencies in lentil producing farmer. Estimation of parameters was carried out with a one-stage procedure under the assumption of normal/half-normal distribution of the error terms. This approach leads us to the final estimates of parameters of the six explanatory variables of the frontier function; and twelve explanatory variables which influence the mean efficiency of lentil producing farmers.

The ML estimates of the parameters of the frontier production functions and inefficiency effects are presented in table 15. The coefficients of the input variables were estimated under frontier production function (MLE). During the estimation, a single estimation procedure applied using the Cobb-Douglas functional form. The computer program FRONTIER version 4.1 gave the value of the parameter estimations for the frontier model and the value of sigma 2 Moreover it gave the value of Log-likelihood function for the stochastic production function. The maximum likelihood estimates of the parameter of SPF functions together with inefficiency effects model are presented in Table 17 below. Out of the total six variables considered in the production function, one (oxen power) had a significant effect in explaining the variation in lentil production farmers. The coefficient o oxen power was negative significant at 5% level of significance. This inform as that they were significantly different from zero and hence these variables were important in explaining lentil production in the study area. The positive production elasticity with respect to fertilizer seed lend and labor imply that as each of these variables increase, lentil output will increase. On average, as the farmer increases area allocated to lentil amount of chemical fertilizer application, labor and fertilizer for the production of by 1% each, he/she can increase the level of output by .021 and .031 percent, respectively.

Table 18: Maximum likelihood estimate of stochastic production

Variables	Parameters	Coefficients	Std.err	Z-value
Constant	β0	24.62***	5.18	3.02
Ln(LAND)	β 1	.318	.499	0.64
LN (OXD)	β2	-036**	.015	-2.31
Ln (HLAB)	β3	.017	.014	1.20
Ln 9SEED)	β4	.091	.071	1.28
Ln (fertilizer)	β5	-005	.015	0.35
Ln(CHEM	β6	-008	.552	-0.01
Sigma 2		114.50***	41.32	
Gamma		.9540***	.028	
Sigma-u2		109.2***	41.12	
Sigma-v2		5.261***	2.92	
Log likelihood		-428.8		
Returns to scale		0.387		

Note: Represents significance at 5% and 10% probability levels, respectively

Source: Model result 2020

Returns to scale is the sum of elasticity of Cobb-Douglas frontier production respect to all inputs used, reflects the degree to which a proportional increase in all the inputs output the sum of elasticity $\sum\beta$ as presented in Table 17 is 0.387 which implies decreasing returns scale such that when all inputs specified in the model for the production of lentil are increased by 1 unit, output will in turn increase by 0.387 units. Even though non negative and less than value of the sum of elasticity imply that producers are operating in the stage two of the production process, they are note efficient in allocation of resource this implies production is inefficient moreover there is a room to increase production with a decreasing rate.

4.2.3 Variability of output due to Technical efficiency Differentials

The maximum likelihood estimation of the frontier model gave the value for parameter (y), which is the ratio of the variance of the inefficiency component to the total error term the y value indicated the relative variability of the one sided error term to the total error-term in other words, it measured the extent of variability between observed and frontier output that is caused by the technical inefficiency. As a result the total variation in output from the maximum may both have necessarily caused efficiency differentials among the sample households. Hence, the disturbance term had also contributed in varying the output level. In this case, it was crucial in determining the relative contribution of both usual random noises and the inefficiency component in total variability. The TE analysis revealed that technical efficiency score of sample farmers varied from 12.9% to 98%, with the mean efficiency level of %. This variation was also confirmed by the value of gamma (y) that was 0.9540. The gamma 0.9540 value of suggested that 95.4% variation in output was due to the differences in technical efficiencies of farm household in while the remaining 4.6% was due to the effect of the disturbance term.

4.2.4 Technical efficiency of farmers

One of the objectives of this study was to measure the technical efficiency levels of lentil producing farmers in MO retina Jiru Woreda. Given the chosen functional from used, estimation procedure implemented and the distributional assumptions made about the two error terms and ui, the technical efficiencies were estimated. The estimation result showed that the mean efficiency level of lentil farmers were 62.6% with the minimum and maximum efficiency level of about 12.9 and 98% respectively (appendix table 17). This shows that there is a wide disparity among lentil producer farmers in the level of technical efficiency which may in turn indicate that there exists a room for improving the existing level of lentil production through enhancing the level of farmers' technical efficiency.

The mean level of technical efficiency further tells us that the level of lentil output of the sample respondents can be increased on average by about 37.4% if appropriate measures are taken to improve the level of efficiency of lentil growing farmers. In other words, there is a possibility to increase yield of lentil by about 37.4% using the resources at their disposal in an efficient manner without introducing any other improved (external) inputs and practices. It also indicated that small farms in the study area, on average, can gain higher output growth at least by 64.1% (1-62.6/98) through the improvements in the technical efficiency. Moreover, from the total sample households, more than half scored above the mean TE score while almost half of sample respondent produces less than the mean TE score of farmers in their vicinity (table 19)

Table 19 Estimated technical efficiency scores

Item	TE scores (%)
Average	62.6
Minimum	12.9
Maximum	98
Std. Deviation	20.28

Source: Model result, 2020

4.2.7. Determinant of Technical efficiency

The focus of this analysis was to provide an empirical evidence of the determinant productivity variability /inefficiency gaps among small holder lentil farmers in the study area. Meryl having knowledge that farmers were technically inefficient might not be useful unless the sources of the inefficiency are identified. Thus, in the second stage of this analysis, the study investigated farm and farmer-specific attributes that had impact on smallholder's technical efficiency. The driving force behind measuring farmer's efficiency in lentil production is the identification of important variables/determinants with which to work for development in order to improve the existing level of efficiency. The parameters of the various hypothesized variables in the technical inefficiency effect model that are expected to determine efficiency differences among farmers were estimated though MLE method using one-stage estimation procedure.

The determinants of technical inefficiency/efficiency in a given period vary considerably depending on the socio-economic conditions of the study area particularly pertaining to managerial characteristics and other related factors. Before discussing the significant factors which influencing inefficiency in lentil production, it is important to see how efficiency and inefficiency are interpreted. The result can be presented in terms of efficiency or in terms of inefficiency.

The result in the table 19 is presented in terms of inefficiency and hence the negative sign shows the increase in the value of the variable attached to the coefficient means the variable negatively contribute to inefficiency level or conversely it contributes positively to efficiency levels. Thus, any negative coefficient happens to reduce inefficiency which implies its positive effect in increasing or improving the efficiency of the firm and vice versa. Accordingly, the negative and significant coefficients of age of the household head, off/non-farm activities, and Access to credit indicate that improving these factors contribute to reducing technical inefficiency. Whereas, the positive and not significant variable such as land size, Lentil farm experiences. Education, extension service, and Access training, effect the technical inefficiency positively that is increases in the magnitude of these factors aggravated the technical inefficiency level while the negative and not significant variable such as Household size Market and price condition output and cooperative membership.

Table 20 Maximum likelihood estimates of the factors determining technical inefficiency

Inefficiency Model	Coefficients	std. Err	Z-value
Constant	37.739***	.651	57.95
Age of the farmer	-.0880***	.0108	-8.10
Lentil farm experiences	.0821*	.035	2.31
Education	.0140	.0700	0.20
Extension service	5.322***	.109	48.46
Family size	-.1069***	.033	-3.23
Off/non-farm activities	-.448**	.138	-4.35
Access to credit	-1.824	.2147	-2.09
Sex of household head	-.940	1.594	-1.14
Access training	.082	1.156	-0.81
Land size	-.597	.120	0.69
Market and price condition output	-2.011***	.540	-1.11
Cooperative membership	1.69e-07	.288	-6.97
Sigma-v	10.680	.0000624	
Sigma u	114.07	.6728	
Sigma2	6.31e+07	14.37	
Lambda		6.31e+07	
Log likelihood		-389.87	

Note: *,**,***, significant at 10%, 5% and 1% level of significance Source: model output, 2015.

Source: Own Survey. 2020

Age of farm household heads: the age of the household is the proxy for the experience of the household head in farming. The result indicated that age of the household influenced inefficiency negatively at 1% level of significance. This suggested that older farmers were more efficient that their young counterparts. The reason for this might be that the farmers become more skill full as they grow older due to cumulative farming experiences (Liu and Zhung, 200). Moreover increase in farming experiences leads to a better assessment of the important and complexities of good farming decision-making including efficient use of input. This result was consistent with the arguments by Eva line et al. (2014. Mesay et al. (2013) and Ogada et al. (2014) they indicated that, since farming as any other professions needs accumulated Knowledge, skill and physical capability, it is decisive in determining efficiency. The knowledge, the skill as well as the physical capability of farmers in likely to enhances as age increases.

Education: education enhances the acquisition and utilization of information on technology by the farmers. In this study, education measured in years of formal schooling, as expected, the sign of education was negative effect on technical inefficiency at 1% level of significance. The result implies that less educated farmers are not technically efficient that those that have relatively more education. This could be because; educated farmers have the ability to use information from various sources and can apply the new information and technology such as fertilizers, pesticides and planting materials much faster than their counterparts. This result was in line with the findings of Tefera et al. (2014), Ali and Kahan (2014), Haile Mariam (2015), Fanta*et al.* (2015b), Ouedraogo (2015) and Michael and James (2017) who stated that an increase in human capital will augment the productivity of farmers.

Farm size: it is measured as total land cultivated by the farmer including those rented and shared in. in this study, it was hypothesized that farm size affects inefficiency positively. As the farm size of a farmer increases the managing ability of him/her will decrease given the level of technology, this lead to reduce the efficiency of the farmer. Accordingly, the estimated result coincides with the expectation and that coefficients of this inefficiency variable found positive and not statistically significant. That means total area cultivated by a household affected technical inefficiency level positively and not statistically significantly. This shows that a household operating on large area is less efficient than a household with small land holding size. This might be because an existence of increased in area cultivated might entail that the farmer might not be able to carry out important crop husbandry practice that need to be done on time, given his limited access to resources. As a result, with increase farm holding size the technical inefficiency of the farmer might increase. This finding was in line with results obtained by Getchew and Beamlike (2014), Sultan and Ahmed (2014), Mwajombe 1 and Mlozi (2015) and Kabir et al. (2015).

Training: Training is an important tool in building the managerial capacity of the household head. Household's head that get training related with crop production and marketing or any related agricultural training are hypothesized to be more efficient than those who did not receive training. Training of farmers on lentil crop was important because it could improve farmers' skill regarding production practices and related aspects. A number of farmers in the study areas received training on lentil for few days mainly on practices and importance of using improved package. The dummy coefficient of training was negative and not statically significant in the technical inefficiency model of lentil production. This implied that technical inefficiency effect decreases with farmers having training on lentil. It may also be concluded that farmers with training on lentil tended to have lower inefficiency effects than farmers without training. That is, farmers with training were technically more efficient than farmers without training. This result is in line with the arguments by Bayan et al. (2013), Getahun (2014), Birhan (2015) and Michael and James (2017) who indicated that training given outside locality relatively for longer period of time determined inefficiency negatively and significantly.

Access to credit:- it is an important element in agricultural production systems, it allows producer to satisfy their cash needs induced by the production cycle. Amount of credit increases farmers' efficiency because it temporarily solves shortage of liquidity/working capital. In this study, amount of credit was hypothesized in such a way that farmers who get more amount of credit at the given production season from either formal or informal sources were expected to be more efficient than those who get less amount of credit. Amount of credit affected in efficiency of farmers negatively and significantly at 5 % level of significance. This implies that credit availability shifts the cash constraint outwards and thus enables farmers to make timely purchases of inputs that they cannot afford otherwise from their own resources and enhances the use of agricultural inputs that leads to more efficiency. The empirical studies conducted by Gebregziahber eta al. (2012), Musa et al, (2014) and Biam et al. (2016) found positive and significant relationship between credit and farmers' technical efficiency which was in line with this study.

Family size:- The coefficient of family size in the technical inefficiency models negative and significant al 1% significance level. The result is similar to the expectation that those households having large family size are less inefficient than households having small family size, because; family labor is the main input in crop production. As the household has large family size, he/she would manage crop plots on time and may be able to use appropriate input combinations).

Sex of the respondent: the finding of the study shows that it has negative and not significant influence on technical inefficiency at level of significance showing that male respondents were more technically efficient than female respondents. The finding is in agreement with the finding of Ale may.

Extension contact: extension services also showed a positive and significant influence on the inefficiency of Lentil producing farmers in the study area at 1% level of significance. The finding indicates that having lesser number of extension contacts improves the technical inefficiency of farmers which in turn improves the technical efficiency of farmers. This suggests that access to extension services enabled farmers to obtain information on new technologies and practices on time. The finding is in line with the findings of Abdullah et al. (2006), seidu (2008) and Wakili (2012) who observed that farmers who get adequate extension contacts are able to access modern agricultural technology for input mobilization, input use, and disease control, which enable them to reduce technical inefficiency.

Cooperative membership: the coefficient associated with the variable was negative and significant at 1% level of in sginficantimplies that being a member of cooperative have a positive contribution towards reducing the inefficiency of haricot been producing farmers and it is consistent with the findings of Idiong (2007) and Tchale (2009).

Off/non-farm activities: The coefficient associated with the variable was negative and significant at 1 level of significance. The possible explanation is that it would assist the households to supplement other costs associated with their living, perhaps, It may have affected technical inefficiency negatively of the reason that the income obtained from such off/non- activities could be used for the purchase of agricultural inputs, and augment financing of household expenditures which would otherwise, put pressure on farm activities are less technically inefficient relative to those who were not engaged in activities other than their farm operations the possible explanation is that it would assist the households to supplement other costs associated with their living, perhaps. It may have affected technical inefficiency negatively for the reason that the income obtained from such off/non-farm activities could be used for the purchase of agricultural inputs, and augment financing of household expenditures which would otherwise, put pressure on on-farm income.

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

Productivity can be improved in two ways either by introducing new agricultural production technologies or improving the technical efficiency levels of farmers which is the possible strategies to increase the productivity of the agricultural sector in the country. Technical efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of the farmers are resource poor. Alternatively, productivity growth may attribute to either technological progress or efficiency improvement. Improving technical efficiency of the farmer plays a great role in increasing productivity, growth may attribute to either technological progress or efficiency improvement. Improving technical efficiency of the farmer plays a great role in increasing productivity, given the current state of technology.

The main objective of this study was measuring efficiency level of lentil farmers and identifying those facers which affect technical efficiency of lentil production in Morten Jiru woreda of Amhara National Regional state. Data were collected for the 2011/12 Production season by interviewing a total of 126 sample lentil producing farmers using a structured questionnaire that encompasses question related to demographic characteristics, inputs and output institutional and farm specific characteristics. Three –stage sampling technique was employed for selecting the respondents. Data were analyzed using both descriptive statistics and econometric model. The stochastic frontier production function of the Cobb-Douglas functional form was found to be best fitted the data to estimate the level of individual technical efficiency.

Cobb-Douglas functional form constitutes six input variables in frontier function and Thewlved explanatory variables in an inefficiency model. Direct or one stage estimation procedure was used to incorporate exogenous factors directly in the production frontier model. The study has also conducted a test of hypothesis which states a hundred percent efficiency. The hypothesis that technical efficiency effects are absent, given the specification of Cobb-Douglas stochastic frontier production function, was rejected based on the results of the econometric model. This shows that the technical inefficiency exists in the sample farmers considered and hence, the average response function that all farmers are fully technically efficient is not supported by the result obtained from statistical analysis of the data.

The estimated stochastic production frontier model indicated that area of lentil chemical fertilizers labor and oxen power is significant determinants of lentil output. The positive coefficient of these parameters indicates that increased use of these inputs will increase the production level to a higher extent. Hence, given that these inputs are used to their maximum potential, introduction and dissemination of these inputs will increase the production level of lentil in the study area.

The analysis also revealed that the sum of the partial output elasticity's with the respective inputs is 0.387. This result indicates that production structure was characterized by decreasing returns to scale. Which implied decreasing returns to scale such that when all inputs specified in the model for the production of lentil are increased by 1 unit, output will in turn increase by 0.387 units? Even though nonnegative and less that one value of the sum of elasticity imply that producers are operating in the stage two of the production process, they are not efficient in allocation of resource implies production is in efficient moreover there is a room to increase production with a decreasing rate. The value of the discrepancy ratio , y, calculated from the Maximum Likelihood estimation of the frontier was about 0.9540. The estimated result of the Cobb-Douglas production frontier indicated that proportion of the variation in the stochastic frontier production function being due to inefficiency. This implies that presence of chance for improvement of farmers' productivity through efficiency. The mean technical efficiency level of farmers in lentil production was 0.628 and its ranging from 0.129 to 0.98. The mean technical efficiency level of 62.6 percent indicates that production can be increased by 37.4 percent of the potential in those farmers who grow lentil through better use of the available resources, given the current state of technologies. Moreover, there is a wide variability in the technical efficiency level of farmers, and only few farmers attained efficiency levels of more than 90 percent for lentil production in the study area.

The socio –economic variables that are important in determining farmers' level of efficiency were also identified. Accordingly, the results of technical efficiency effects model showed; age education, farm size training and credit found to be the major determinants of efficiency level of the farmers in lentil production. The negative coefficients of age. Family size, credit, training off-non-farm activities, sex of household, and cooperative membership in inefficiency model means that these factors efficiency of the farmers in the area where they are significant. While, the positive coefficients of land size, education level, lentil farms and extensions service in inefficiency model indicated that these factors determine efficiency negatively.

In general, the SPF model showed that production can be improved by increasing the use of inputs. There is considerable room to improve the efficiency of farmers in lentil production. The implication is that, there will be considerable gain in production level if introduction and distribution of agricultural technologies tis joined with improving the technical efficiency of teff production in the study area.

5.2. Conclusions and Recommendations

The implication of this study is that, technical efficiency of the farmers can be increased through better allocation of the available resources especially: land oxen power, labor and fertilizer. Thus, local government or other concerned bodies in the developmental activities working with the view to boost production efficiency of the farmers in the study area should work on improving productivity of farmers by giving especial emphasis for significant factors of production.

Moreover, age should be considered in increasing resource use efficiency and productivity. This is because results showed that younger farmers are technically more inefficient than ones. It implies that there should be policies to improve resource use efficiency of younger farmers and encourage them to be in farming activities by providing them incentives. Continues trainings on the agricultural business environment and follow up during agricultural operation for younger farmers should be provided. However, this should not be at the e3xpense of older ones.

Training determined technical efficiency negatively and not significantly in producing farmers. Provision of training for farmers to improve their skills in use of improved seed, management post-harvest handling, and general farm management capabilities will increase their farm productivity. In addition to strengthening the practical training provided to farmers, efforts should be made to train farmers for relatively longer period of time using the already constructed farmers' training centers and agriculture research demonstration centers.

The amount of credit received was found to positively and significantly household technical efficiency level. But smallholder framers in the study area have financial constraints. This could imply that households needed external financial sources to solve their own financial constraints. Therefore, Amhara Credit and Saving institution (ACSI) have mandated to provide relatively high amount of credit from farmers should be encouraged and strengthen to deliver more than this and also harmonization loan delivery with the time input required and loan payment plans with harvesting seasons. In addition to this the regional government should intervene to strength the operation of rural saving and credit institutions at village level and crest awareness for those farmers to improve their saving habits so as to improve their formation.

Total farm size was negatively and statistical significantly related with technical efficiency in lentil production. This may be demanding clause supervision of the farm operator which share significant part of his/her time. Hence small holder farmers have a limitation of resources which are used for agriculture production on his/her available farm land in the given operation calendar. This in turn improves the production of the farmers due to using better technology which shifts the production frontier outward. Therefore, it would be better if the regional government or concerned such machinery services either on credit bases or cooperative rendering rental service.

Those farmers that are more educated are relatively more technically efficient than less educated ones, in the study area. This may be due to the fact that more educated farmers have access to information and better communication media that helps them to use modern lentil production technologies. Education is fundamental in improving the technical efficiency of farmers. The regional governments need to strengthen farmers'' access to education that could be implemented through expansion of farmers training center or expansion of formal and non-formal education in the area of sowing date.

Though several types of improved Lentil variety were released under the federal and regional research centers, the majority of farmers in the study area were used local seed. But the findings of the study shows that use of improved seed contribute towards improvement in Lentil productivity. Therefore, timely supply of available improved seed in terms of credit or cash at a reasonable price helps to improve Lentil output, similarly, the number of oxen day's shows that improvement in the use of this input among Lentil Producing farmers will improve Lentil output.

REFERENCES

Ahmad, Miner, Chaudhry, Ghulam M., Iqbal and Mohammed, 2002. Wheat productivity, efficiency, and Sustainability: A Stochastic Production Frontier Analysis. *The Pakistan Development Review*, 41(4): 643-663.

Ahearn, M., J. Yee, E. Ball, and R. Nehring, 1998. Agricultural Productivity in the United States, USDA-ERS, Agricultural information Bulletin, No. 740 Aigner, D.J., Chu, S.F., 1968. On estimating the industry production function. *American Economic Review*, 58: 826–839.

Aigner, D.J., C.A.K. Lovell and P.J. Schmidt, 1977. Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6: 21–37.

Akinwumi, A.A and K.D Kouakou, 1996. Relative efficiency of Women as farm managers: profit function analysis in Côte d'ivoizre. *Agricultural*, 16(1997): 47-53

Amaza, P.S. and D.C. Maurice, 2005.Identification of Factors that Influence Technical Efficiency in Rice-Based Production Systems in Nigeria. Paper presented at Workshop on Policies and Strategies for Promoting Rice Production and Food Security in Sub-Saharan Africa. Cotonou, Benin, 7-9 November 2005, International Institute of Tropical Agriculture.

Asnake Fikre and Geletu Bejiga, 2004. Breeding Lentil for Wider Adaptation. pp. 80-84.Proceedings of the workshop on food and forage legumes. Addis Ababa, Ethiopia, 22-26 September 2006, International Center for Agricultural Research in the Dry Areas (ICARDA).

Awulachew, S.B., D.J. Merry, A.B. Kamara, B. Van Koppen, F. Penning de Vries, E.Boelee, G. Makombe, 2005. Experiences and opportunities for promoting small-scale/micro irrigation and rainwater harvesting for food security in Ethiopia. Working paper 98. Colombo, Sri Lanka, International water management institute.

Battese, G. E., S. J. Malik, M. A.Gill, 1996.An Investigation of Technical Inefficiencies of Production of Wheat Farmers in Four Districts of Pakistan. Journal of Agricultural Economics, 47: 37-49.

Coelli T.J., D.S.P. Rao and G.E. Battese, 1998. An Introduction to Efficiency & Productivity Analysis. Kluwer Academic Publishers, Boston, Dordrecht/London, pp. 134 – 249.

Coelli, T.J., D.S.P. Rao and G.E. Battese, 2006.An Introduction to Efficiency and Productivity Analysis. Kluwer academic Publishers, Boston, Dordrecht/London. pp. 134 – 249.

Coelli, T.J. and G.E. Battese, 1996.Identification of factors which influence the technical Inefficiency of Indian farmers. American Journal of Agricultural Economics, 40: 103 – 128.

Cooper, W.W., L.M. Sieofrd and K. Tone, 2000. Data Envelopment Analysis: A Comprehensive Text with models, applications, references and DEA-solver software. Kluwer Academic Publishers, Boston. 646p.

CSA, 2002. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2003. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2003.Central Statistical Authority statistical Abstract, Addis Ababa, Ethiopia

CSA, 2004. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2005. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2006. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2007. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2008. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2008. Summary and Statistical Report of the 2007 Population and Housing Census. Federal Democratic Republic of Ethiopia Population Census Commission, Addis Ababa, Ethiopia.

CSA, 2009. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

CSA, 2010. Agricultural Sample Survey, Report on Area and production of Crops. Addis Ababa, Ethiopia.

Fasil Kelemework, Kiflu Bedanae, 2004. Agricultural Technology Transfer of Highland Food Legumes in Ethiopia. pp. 316-319. Proceedings of the workshop on food and forage legumes. Addis Ababa, Ethiopia, 22-26 September 2006, International Center for Agricultural Research in the Dry Areas (ICARDA).

Fekadu Gelaw and Bezabih Emana, 2009. Analysis of Technical Efficiency of Wheat Production: A Study in Machakel Woreda. Journal of Agricultural Economics 7(2): 1-34.

Getachew Abate, 1995. Production Efficiency Analysis: The case of smallholder farming in coffee sector of Ethiopia and Kenya, Farming Systems and Resource Economics in the Tropics, Vol. 23.

Getu Hailu, 1997. Analysis of Performance Variation: The Case of Smallholder Farms in Eastern Hararghe Region. An MSc Thesis Presented to the School of Graduate Studies of Haramaya University. 130p.

Gezahegn Ayele and Dawit Alemu, 2004.Marketing of Pulses in Ethiopia. pp. 346-348. Proceedings of the workshop on food and forage legumes. Addis Ababa, Ethiopia, 22-26 September 2006, International Center for Agricultural Research in the Dry Areas (ICARDA).

Gimbichu District Agricultural and Rural Development Office (GDARDO), 2009.Gimbichu District Profile.

Hussein S., 1989. Analysis of Economic Efficiency in Northern Pakistan: Estimation, Causes and Policy Implications. Ph.D. Dissertation, University of Illions, USA.

Jema Haji, 2008. Economic Efficiency and Marketing Performance of Vegetable production in The Eastern and Central Parts of Ethiopia. Doctorial Thesis, Swedish University of Agricultural sciences, Uppsala.

Jondrow, J., C. A. Knox Lovell, I. S. Materov, and P. Schmidt, 1982. Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model, Journal of Econometrics, 19: 233-238.

Kinde Teshome, 2005.Technical Efficiency of Maize Production: A Case of smallholder farmers in Assosa Woreda. An MSc Thesis presented to The School of Graduate Studies of Haramaya University. 124p.

Kopp, R.J., and V. Smith, 1980. Frontier Production Function Estimates from Steam Electric Generation: A comparative Analysis. South Economic Journal, 47: 1049-1059.

Krishna, K.L. and G.S Sahota, 1991. Technical Efficiency in Bangladesh Manufacturing Industries, Bangladesh Development Studies, 19 (1 &2): 89-105.

Kumbhakar, S. C. and C.A. Knox Lovell, 2000.Stochastic Frontier Analysis. Cambridge University Press.

Lovell, C.A.K., 1993. Production frontiers and productive efficiency. In the measurement of productive efficiency: Techniques and applications. Harold O. Fried, Lovell y, C.A.K., Schmidt, S.S. (Eds.), Oxford: Oxford University Press: 3-67.

Lovell, C.A.K., 1994. Linear Programming Approaches to the Measurement and Analysis of Productive Efficiency. Top, 2: 175-248.

Meeusen, W. and J. van den Broeck, 1977. Efficiency Estimation from Cobb-Douglas production functions with composed error. International Economic Review, 18: 435–444.

Mkhabela T, 2005. Technical efficiency in vegetable based mixed-cropping sector in TugelaFerry, Missinga District, Kuazulu-Natal. Agrekon, 44(2): 187-204

Mohammed Hassena, H. Farah, W. Mwangi and Belay Kassa, 2000. Factors Influencing Technical Efficiency of Barely Production in Assassa District of Southern Ethiopia, Ethiopian Journal of Agricultural Economics 4(2): 1-22.

MoRAD, 2008.Ministry of Agriculture and Rural Development. Report on export of major agricultural products.

Murillo-Zamorano, L.R., 2004.Economic Efficiency and Frontier Techniques. Journal of Economic Surveys, 18(1): 33-45.

Mulat Demeke, 1989. The production Efficiency of Food Grain Producers in Ethiopia: The Case of Small Farmers in Arsi Province, Ph.D. Dissertation, Department of Economics, University of Strathclde.

Oromia Finance and Economic Development Bureau, 2009/2010.Socio economic profile, East showa Zone.

Parikh A. and M.K. Shan, 1996.Various Approaches to Measurement of Technical Efficiency in North-West Frontier Province of Pakistan. Pakistan Journal of Applied Econometrics, 11(1): 31-

Sarafraz H, 2004. Analysis of Technical Efficiency of Wheat Farmers in the Mixed Farming System of the Punjab, Pakistan. Doctoral Thesis submitted to University of Agriculture, Department of Agricultural Economics, and Faisalabad, Pakistan.

Senait Regassa, Legesse Dadi, Demissie Mitiku, Asnake Fikre and Aden.A.H, 2006. Impact of Research and Technologies in Selected Lentil Growing Areas of Ethiopia. EIAR: Research report No. 67.

Seyoum E.T., G. E. Battese and E. M. Fleming, 1998. Technical Efficiency and Productivity of Maize Producers in Eastern Ethiopia: A Study of Farmers within and Outside The Sasakawa – Global 2000 Project. J. Agricultural Economics, 19: 341–348.

Steven M.H. and Edward S.L., 2004.Farm size and the determinants of productive efficiency in the Brazilian Center-West. Agricultural Economics, 31: 241-249

Strock H., Bezabih Emana, Berhanu Adenew, A. Borowiecki and Shimelis W/Hawariate, 1991. Farming Systems and Farm Management Practices of Smallholders in the Hararghe Highlands. Farming Systems in Practices of Resource Economics in the Tropics, Vol. 11, Wissenschaftsverlag, Vauk, Keil KG, Germany.

Taylor, T.G., H.E. Drummond, and A.T. Gomes. (1986). Agricultural Credit Programs and Production Efficiency: An Analysis of Traditional Farming in South Eastern Minas Gerais, Brazil, American Journal of Agricultural Economics, 68(1):110-119.

Thiam A., B.E. Bravo-Ureta and T.E. Rivas, 2001. Technical Efficiency in Developing Country Agriculture: A Meta-Analysis. J. Agricultural Economics, 25: 235 - 243.

Werfring A., 2004.Typology of Irrigation in Ethiopia. An MSc Thesis Presented to University of Natural Resources and Applied Life Sciences, Vienna.

WHO (2007).World Health Organization Report. Health action in crises.

Zenebe Gebereegziabher, O. Arie and Tassew Woldehanna, 2004. Technical Efficiency of Peasant Farmers in Northern Ethiopia: A stochastic frontier approach. Draft, April, 2004

7.APPENDICS

7.1 Appendix Tables

Appendix Table1: individual technical efficiency scores

QN	TE	QN	TE	QN	TE	QN	TE	QN	TE	QN	TE
1	64.1	23	51.67	45	74.9	68	31	90	74.9	112	31
2	80.1	24	77.5	46	77.5	69	77.5	91	67.2	113	82.7
3	28.4	25	95.6	47	46.5	70	18.1	92	77.5	114	65
4	87.9	26	33.59	48	59.4	71	56.8	93	46.5	115	70
5	33.6	27	82.7	49	41.4	72	67.2	94	36.2	116	80.1
6	51.7	28	77.5	50	90.4	73	72.4	95	74.9	117	77.5
7	77.5	29	78	51	87.9	74	67.2	96	93.02	118	90.4
8	64.6	30	46.5	52	87.9	75	46.5	97	34	119	85.3
9	80.1	31	65	53	46.5	76	56.8	98	95.6	120	38.8
10	77.5	32	51.7	54	64.6	77	65	99	87.9	121	28.42
11	64.6	33	77.5	56	51.7	78	51.7	100	51.7	122	31
12	31	34	82.7	57	78	79	49.1	101	51.67	123	93.02
13	49.09	35	59.4	58	23.3	80	78	102	93.02	124	51.7
14	64.6	36	85.3	59	46.5	81	59.4	103	77.5	125	98
15	51.7	37	78	60	38.8	82	38.8	104	82.7	126	23.3
16	49.09	38	80.1	61	46.5	83	43.9	105	80.1	MeanTE	62.59
17	87.9	39	46.5	62	43.92	84	46.5	106	77.5		
18	20.7	40	77.5	63	47	85	64.6	107	69.8		
19	54.3	41	41.3	64	65	86	51.7	108	93.02		
20	74.9	42	77.5	65	51.7	87	77.5	109	64.6		
21	31	43	95.6	66	12.9	88	69.8	110	38.8		
22	65	44	78	67	47	89	77.5	111	69.76		

Appendix Table 3: Result of multicollinearity test of variance inflation factor

Variable	Tol	**VIF**	**1/VIF**
Z1	.74	1.35	.74
Z2	.003	333.3	.003
Z3	.0027	370.37	.0027
Z4	.0026	384.6	.0026
Z5	.0029	344.8	.0029
Z6	.0025	400	.0025
Z7	.003	333.3	.003
Z8	.0037	270.3	.0037
Z9	.0027	370.37	.0027
Z10	.0024	416.6	.0024
Z11	.0024	416	.0024
Z12	.0048	208.33	.0048

QUESTIONNAIRE PREPAREDFOR DATA COLLCATION

QUESTIONNAIRE DEVELOPED FOR Analysis of Technical efficiency of lentil in Ethiopia the case of more Tina -Jiru woreda north Shaw zone Amhara regional state .

1. Data of interview (dd/mm/yyy)________________________

2. Enumerators name--

1. FARMER AND SITEIDENTIFICATION

1. Sex of the household head 1.male 2 .Female

2.) Age of the farmer -----years

3. Maritalstatusof the respondent. 1. Married 2.single 3.Divorced 4.Widowed

4. Educational level

1. Never been to school 4.vocational school

2. Elementary 5 College/university

3. High school 6.Adult education (Read and write only)

5. Eduction is years of attendance ---------------years

6. please specify your household size using the following Table

S.NO	Household size category			
1.	Children 10years age and below			
2	Amalec children between 10-13 years of age			
3.	A female children between 10-13 years of age			
4	A male family member(b/n14 and65years)			
5	A male family member(b/n14 and65years			
6	Family member above65years of age			

7. Do you grow lentil crop? 1. yes 2.No

8. How Mach quintal in lentil cultivated during the cropping season--------------hectares

9. Estimates land used for lentil cropping

No	The types of land used	yes	No	How many hectares used for lentil filed
1	Land from government			
2	Share Land			
3	Leased land from others			
4	Land obtained by other means			

10. Labor participation of household head on -farm

1. Full time 2.part time

11. the type of labor used for the production of lentil during the current farming season (Multiple answers possible)

1. Hired labor 2.Family labor 3.Exchange labor

12. Estimate the number of labor force used for lentil cropping for each activity?

NO	Types of labor	The types of farm activity		
		Land preparation and planting	Weeding and cultivation	Harvesting
1	Hired labor			
2	Family labor			
3	Exchange labor			

13. please estimate the lentil seed utilization during the current farming seasons

13. please estimate the lentil seed utilization during the current farming seasons

NO		Types of lentil seed used	
		Improved variety	Local variety
1	How much kilogram of lentil seed sown?	----------------kg	-----------kg
2	Can you estimate the land covered by lentil seed?	-----------------ha	-----------ha
3	Can you estimate the land covered by lentil seed?	---------------Birr	-------------Birr

14. please estimate your fer utilizer lentil utilization during the current farming seasons

NO		Types of lentil seed used	
		Improved variety	Local variety
1	How much kilogram of fertilizer used for lentil cropping?	----------------kg	-----------kg
2	estimate the land covered by with fertilizer	-----------------ha	-----------ha
3	How much money spent to purchase fertilizer for lentil filed	---------------Birr	-------------Birr

15. What is the major constraint faced related to fertilizer utilization?

1. High price of fertilizer
4.Hightransportation cost
2. Lack of credit
5. Other specify
3 In appropriate loan repayment time

16. Please estimate your chemical utilization

NO		Types of chemical	
		Pesticide	Herbicide
1	How much litter used for lentil cropping	------------Litter	-----Litter
2	How much Birr purchased the chemicals	----------Birr	------Birr

17. What is your occupation (multiple choices possible)

1. Farming 2.state employs 3.peety trade 4. other specify

18. yearsof farming experience--------------------years

19. when did you sow lentil for the production time

1. Early(mid-end of June) 2.Latly beginning September)

3. August one up to August one up to August twenty

4. Endof August

20.Doyou have any income source other than farming

1. yes 2.No

21. HOWmuchis your average monthly income you gain from non/off-farm activity-------in Birr

22. what type of non/off-farm activity?

1. Tailor 3.Stateof employment

3. Trade. 4. carpenter 5 .other. Specify

22. where did you purchase agricultural in put

1. purchased from local market 2.purchased from traders

3.purchased others 4.purchased from cooperative

5. Purchased from government source like agricultural

6.Recycled from previous year

23. How many hectares your land size----------------hectares

24.Type of your land soil 1. Heavy black soils (Vertis oil) 2.Blacksoils

3. soilbund 4.stonebund

25. Agro-forestry practices

27. Whatis you're the fertility status of your lentil plot 1.Highfertility 2 low fertility

28. what is your lentil land slope 1.Gentle(flat slope) 2.sloppy 3.Relativlyfat
4.otherspecify

29. Frequency of plowing with lentil Landis--------times

Extension and Training

30 Did you have access to extension services about lentil farming?

1. Yes 2.NO

31.frquency of extension contact with development workers---------

32. Doyouhave Accesstotraining programmed employedinthestudy area

1. Yes 2.No

33. Haveyou participatein any training program employed in the local area

1.yes 2.No

34. Have you accessto credit sources? 1.Yes 2No

35. If yes. The sources of credit

1. Banks 2.relatives 3.Merchants 4.credit andsavinginstitution 5.cooperatives

36. Thetypeof this credit 1.cash (AmountinBirr) 2.inkind (kgor other)

37. what are the major lentil diseases in the study area

1. Rust,root rots andfusarium 2.weedinfestation 3.onlyrust andfusarium 4other specify

38.what is the most important problem regarding to lentil production(Rankaccordingtoprevalance)

1.Rust .2Water logging 3.Lowfertility of the land 4.poorlandpreparation,dueto shortage of oxen or other 5.weed in fesation 6.wetherconduction

39.Have you organized yourself in cooperatives with other farmers

1. yes 2.No

40. what is thepurpose0f this credit

1. Purchased seed 2.purchased fertilizer 3.animal husbandry improvement

4. consumption 5.purchasedpesticides 6.Tohier oxen power and Tohier human labor

Tank you cooperatives.