ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

ANALYSIS OF FARMERS RESOURCE USE EFFICIENCY ON MALT BARLEY PRODUCTION AND ITS IMPACT ON FOOD SECURITY IN LEMUNA-BILBILO WEREDA, ETHIOPIA

BY

ENDALE GUDETA DUBE

A THESIS SUBMITED TO

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ADVISOR: Dr. SOLOMON TSEHAY

M.SC. THESIS SUBMITED TO

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JUNE, 2019

ADDIS ABABA, ETHIOPIA

Addis Ababa University

School of Graduate Studies

Declaration

I, Endale Gudeta Dube (Student ID GSR/2661/09) hereby declare that the contents of this Master's Thesis are original and true, and have not been submitted at any other university or educational institution for the award of degree or diploma.

All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

Endale Gudeta Dube ______________________________ __________________________

SIgnature Date

Addis Ababa University

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As Thesis research advisor, I hereby declare that I have read and evaluated this Thesis prepared, under my supervision, by Endale Gudeta Dube entitled "*Analysis of farmers resource use efficiency on malt barley production and its impact on food security in Lemuna-Bilbilo wereda, Ethiopia*". I recommend that this Thesis work can be submitted as fulfilling the requirements for the Degree of Masters of Science (M.Sc.) in Food Security and Development Studies.

Solomon Tsehay (Ph.D)	______________________	_____________________
(Advisor)	Signature	Date

Addis Ababa University

School of Graduate Studies

This is to certify that the Thesis prepared by Endale Gudeta Dube entitled: "*Analysis of farmers resource use efficiency on Malt barley production and its impact on food security in Lemuna-Bilbilo wereda, Ethiopia*" submitted in partial fulfillment of the requirements for the degree of Masters of Science in Development Studies Center for Food Security fulfills with the regulations of the University and meets the accepted standards with respect to originality and quality.

Approved by board of examiners

Dr. Solomon Tsehay		/ / 2019
Advisor	Signature	Date
		/ / 2019
Internal Examiner	Signature	Date
		/ / 2019
External Examiner	Signature	Date

Chair of Department / Graduate program Coordinator

DEDICATION

I dedicate this thesis manuscript to my mother Denbele Gelete who was born on the way to battle against the fascist Italy that invaded innocent Ethiopians in 1935G.C and who was used to speak five local languages fluently with no chance to formal education.

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Above all, sincere thanks go to the Almighty God who has blessed my work with His Mother for making this thesis success. This day what God have done for me is really beyond what I have dreamt.

BIOGRAPHICAL SKETCH

The author was born on May 05, 1972 in Adola/Kibremengist town of Jemjem Awraja of the then Sidamo region. He attended his elementary, junior and high schools in Negele Borena, grade 10 Ziway and Grade 11 to 12 in Bekoji Secondary Schools respectively.

Then he joined Jimma College of Agriculture and graduated with Diploma in Plant science in 1990. After his graduation he was employed in Ethiopian Agricultural Research Institute (EIAR), Holeta Research Center in Research Extension division, as a Technical Assistant. He joined summer course at Haramaya University in 2004 and graduated with B.Sc. degree in Rural Development and Agricultural Extension in September 2008. After his graduation, he was continued working in EIAR as a Farm Manager and Senior Technical Assistant until June 23, 2012. And then he was recruited in the Ministry of Agriculture from June 25, 2012 as a senior expert in agricultural inputs marketing in the directorate of Agricultural Inputs Marketing. He served as a senior expert and director in same directorate until he got the chance to join Addis Ababa University in 2018 regular program to peruse his M.Sc. study in Food Security. The author is married and has a son.

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ACRONYMS & ABBREVIATIONS

AE	Allocation Efficiency
AMF	Asela Malt Factory
ARDU	Arsi Rural Development Unit
CADU	Chilalo Agricultural Development Unit
CREATE	Community Revenue Enhancement through Agricultural Technology Extension
DFID	UK Department for International Development
EE	Economic Efficiency
ETB	Ethiopian Birr
FGD	Focus Group Discussion
GMF	Gonder Malt Factory
Gof	Goodness of Fit
m.a.s.l	Meter Above Sea Level
NGO	Non-Governmental Organization
NPS	Nitrogen, Phosphorus, & Sulfur
PSM	Propensity Score Matching
SFA	Stochastic Frontier Analysis
SFEA	Share of Food Expenditure Analysis
TE	Technical Efficiency
VIF	Variability Inflation Factor

ABSTRACT

The primary objective of this study was to analyse farmers' resource use efficiency of malt barley production and its impact on food security of the households in the study area. Primary data was gathered from field survey through a structured questionnaire. A total of 338 households were considered, of which 169 malt barley and the rest 169 food barley producers. In describing the independent variables t-test and chi square were executed. Stochastic frontier analysis (SFA), propensity score matching (PSM) technique, logit and tobit regressions were applied for data analysis. Results of stochastic frontier analysis showed that in malt barley production land size, oxen days, and amount of seed used contributed positively at a significance level of one, five, and ten percent respectively. Whereas total labour incurred more cost to the malt barley producing farmers significantly at 5 %, other inputs are homogenous. The t-test comparison on the efficiency result shows that malt barley producing farmers are efficient than food barley producing farmers. Malt barley producing households spend significantly more than food barley producing farmers for their food. All the results found show that malt barley producing farmers in the study area are more efficient in their decision for resource use than the food barley producers. This has positively impacted the food security status of the households. The research recommends that malt barley production should scale up to combat food insecurity and to prevail efficiency among farmers.

Key words*: Malt Barley, Stochastic Frontier, Efficiency, Impact, Food Security, Lemuna-Bilbilo*

CHAPTER ONE: INTRODUCTION

1.1 Background

Barley (*Hordeum vulgare* L.), a cereal crop in the world, ranking fourth important crop after wheat, maize and rice; European Union, Russian Federation, Ukraine, Turkey and Canada were the largest barley producers in the world while Ethiopia, Morocco, Algeria, Tunisia and South Africa are the top five largest barley producers in Africa (USAID, 2014) according to Samuel (2017).

It is a hardy crop which is grown throughout the temperate and tropical regions of the world (Singh *et al*., 1974). It is a cool-season crop that is adapted to high altitudes (Bayeh and Berhane, 2011). There are two types of barley varieties namely 2-row and 6-row (Singh *et al*., 1974). For malt purposes the grains of two row barley varieties are preferred over 6- row because of their plump, uniform in size, and possess other desirable characteristics like protein content, high diastatic power and a-amylase activity for malt purposes. (Singh *et al*.1974).

Barley grain is mostly used as feed for animals, malt, and food for human consumption where malt is the second largest use of barley (FAO, 2014). Smallholder barley production can achieve household food security by increasing cash income of households and enhancing the productivity of food crop production (PASDEP, 2005). Kassu *et al.* (2018), stated that malt barley is one of the most important crops for food, feed, malt and income generation for many smallholder farmers in the highlands of Ethiopia (FAO 2013; Mulatu and Lakew 2011).

It is a valuable input for industries in extracting malt, distillation, baby foods, cocoa malt drinks, ayurvedic medicines, (Sing *et al*. 2014). Traditionally it is used for making local recipes such as 'Enjera', 'Kita', 'dabo', 'kolo', 'genfo', 'kinche', 'beso', 'chuko', and drinks 'tela', 'bordie', and other types, (Bedada 2014; Tura 2015 and Adisu 2017). In the central and south east mid and high altitude areas of Ethiopia, Barley (both food and malt species) is one of the major cereal crops that are largely produced and its grain is mostly used for feed, malt and food (Bedada, 2014; Adisu 2017; Kassu *et al.* 2018).

Bayeh *et al.* (2011) stated that malt barley requires a favourable environment to produce a plump and mealy grain (Berhanu, Fekadu and Berhane, 2005). These scholars have also mentioned that at altitudes of about 3000 m.a.s.l or above, barley may be the only crop grown that provides food, beverages and other necessities to many millions of people.

As stated in Kassu *et al.*(2018), Ethiopia has favourable environment and considerable market opportunities for increased production of high quality malt barley; however, its production has not been expanded enough to benefit most barley growers, malt factories and breweries (Berhane *et al*. 2016).

There are numerous views on how to solve the global challenge, varying from the local food movement which aims for more self-reliant and resilient food networks, to biotechnological applications (Ederveen, 2016). In Ethiopia there are several barley varieties released from research and its production in the highland areas is highly expected to play a major role in the realization of food security and poverty alleviation strategy (MoA, 2016).

Malt barley accounts for about 90% of the raw materials cost in beer production in Ethiopia (USDA GAIN, 2014). According to Kasu (2018), 'malt barley has become a very important industrial crop in the country since the establishment of Saint George Brewery in 1974. The demand for malt has increased further since the establishment of Asela malt factory (AMF) in 1984.' The inauguration of Gonder malt factory in 2015 and the increasing of many more breweries created greater demands for malt barley (Berhane *et al*. 2016).

Traditionally, barley is cultivated with no or little external inputs (fertilizer, chemical), moreover, it is cultivated on eroded, low-moisture stressed hillsides, (Abraham *et al*. 2011). Also mal practices on harvesting, threshing and storage conditions negatively contribute for the quality of malt associated to fungal problems (Adisu, 2017).

Different scholars at different times have tried to study the malt barley related issues in Lemuna-Bilbilo *wereda.* But the studies do not show its impact on food security. In this study resource use efficiency of malt barley producing farmers were compared to non producers in order to see its impact on the food security of the households in the study area.

Farmers in the highlands of Ethiopia requires due attention in implementing household food security issue because of several reasons. Among the major targets set for the national nutrition strategy in GTP II, that aims at producing healthy and productive citizens, is fulfilling nutrition demand implemented with due consideration by the relevant stakeholders. The plan says special emphasis were given to ensuring household food security, maternal and child care, render health services accessible and create healthy environment (National Planning Commission, 2016).

1.2 Statement of the Problem

Bayeh *et al.* (2011), stated that food barley can be cultivated in stressed areas but malt barley requires a favourable environment to produce a plump and mealy grain (Berhanu, Fekadu and Berhane, 2005).

As cited in Abiro *et al. (2017*), 'the Ethiopian market is fast growing at 15-20% per year, driven by the corresponding market growth for beer', (Tadesse, 2011). But to malt barley farmers unattractive price is a challenge (FAO, 2013). Whereas, contract farming agreement for this crop indicates long term effects as the value chain is rather weak (Ederveen, 2016). This shows that farmer's production efficiency on the quality of their produce affects both open and contract malt barley marketing and their income generation. The situation is quite worse in Lemuna-Bilbilo *wereda* where crop diversification option is limited for income generation (Chilot *et al.* 2016).

Although barley is the most important cereal crop in Ethiopia, its productivity has remained low, at below 21.57 Qt/ha, (CSA, 2017). The potential yield goes up to 60 Qt/ha on experimental plots, (Berhane *et al.*, 1996). Its productivity is low due to several factors; of these, the major ones are poor soil fertility, use of low-yielding cultivars, poor agronomic practices, diseases and pests (Abraham Feyissa *et al*., 2011).

Farmers put in place their own mechanisms of balancing producing malt barley for market and for consumption confirming that producing malt barley for the industry does not affect their food security (Tarekegn, 2016). However mal practices on harvesting, threshing and storage conditions contribute negatively for the quality of malt associated to fungal problems that lead to market rejection, (Adisu, 2017). Moreover home consumption of market rejected malt barley, due to exposure to aflatoxin, associates with childhood stunting which is a chronic form of malnutrition (Addisu, 2017).

Overpopulation resulted in land resource scarcity, fragmentation of farm plots, and ecological degradation such as increasing emissions, soil erosion, deforestation, and the overuse of natural resources, (Wuletaw, 2018). As indicated by those scholars, although there is high malt barley demand by the breweries, overpopulation, poor soil fertility, low quality due to fungal diseases, and market problems influence farmer's income that is required to be efficient in malt barley production. Also farmers need to manage their pre and post harvest malt barley production activities in order to avoid market rejection by companies due to low quality induced by aflatoxin.

In total the production efficiency of malt barley producing farmers is challenged by both natural and managerial gaps. These combined problems influence income of the malt barley producing households to ensure their food security. In many of the references no data is found that show farmers resource use decisions to enhance their production efficiency in securing their food and dietary diversification. This study therefore will attempt to analyze the resource use efficiency of malt barley production and its impact on food security in Lemuna-Bilbilo *wereda*.

1.3 Objectives of the Study

The general objective of this study is to analyze farmers' resource use efficiency in malt barley production and its impact on food security in the study area, 2019.

The specific objectives of this study were to:

- estimate the level of efficiency in malt barley production,
- identify variables affecting the level of malt barley production efficiency, and
- assess impact of malt barley production on food security

1.4 Significance of the Study

Since this research paper is an academic exercise it will have both academic /methodological and policy significances. The research endeavour is first to generate relevant data on malt barley production efficiency and food security in the study area. The study results on the nexus between malt barley production efficiency and food security of the study area may be useful for policy makers, researchers and development actors in both the governmental and nongovernmental organizations working in the area as well as elsewhere in the country with similar agriculture based socio-economic, cultural and physical environment.

1.5 Scope and Limitations of the Research

If farmers are rationally efficient, addition of inputs shift production frontier upwards. Otherwise, if they are inefficient, the food security strategy should focuses on factors which are responsible on farmer’s inefficiency.

The study is limited to the analysis of technical efficiency in the production of malt barley crop and no information on other crops included in the estimation of efficiency scores. However, the result drawn from malt barley production could be used for other crops that have similar production processes. The data is based on cross-sectional data, in which time variability of efficiency is not considered.

1.6 Organization of the Study

This thesis is generally organized into six chapters. The first chapter demonstrated an introductory part which incorporated: background, statement of the problem, research questions, objectives, significance of the study, and scope & limitations of the study. The second chapter discuses review on the conceptual, theoretical and empirical literatures and describing a conceptual framework to this research. The third chapter deals with discussing the methodology; such as sampling design, method of data analysis, and defining variables. In the fourth chapter the geographical setting of the study area such as its location, demography, and climate conditions are discussed in brief. The fifth chapter elaborates the result and its discussion in terms of description of socio-economic variables of sample households, econometric estimation like *Efficiency, PSM (Propensity score matching), ATT (Average Treatment effect on the Treated)*, and food security analysis components. At last conclusion and recommendation were conveyed in chapter sixth.

CHAPTER TWO: REVIEW OF RELATED LITERATURE

2.1 Conceptual Literature Review

2.1.1. Concept of Food Security

Concept of food security has evolved significantly over time on a regular basis (Getu, 2011, Mesay, 2016). The definition of food security used in this proposal is the one adopted at the 1996 World Food Summit held in Rome. It says: food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.

The definition introduces four main dimensions of food security: Physical availability of food, Economic and physical access to food, Food utilization, and Stability of the other three dimensions over time.

One way to understand these four dimensions of the broad food security concept is to examine how the meaning and common understanding of food security has evolved over time. Access to food is influenced by market factors and the price of food as well as an individual's purchasing power, which is related to employment and livelihood opportunities.

A third dimension – food utilization – has become increasingly prominent in food security discussions since the 1990s. Utilization is commonly understood as the way the body makes the most of various nutrients in the food. This food security dimension is determined primarily by people's health status. General hygiene and sanitation, water quality, health care practices and food safety and quality are determinants of good food utilization by the body.

Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, and diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.

Food security was traditionally perceived as consuming sufficient protein and energy (food quantity). The importance of micro-nutrients for a balanced and nutritious diet (food quality) is now well appreciated.

For food security objectives to be realized, all four dimensions must be fulfilled simultaneously. Even if people have money, if there is no food available in the market, people are at risk of food insecurity. Similarly, the importance of food utilization has further enriched our understanding. Food security is not just about quantity of food consumed, but also about quality, and that your body must be healthy to enable the nutrients to be absorbed. Finally, these three dimensions should be stable over time and not be affected negatively by natural, social, economic or political factors.

2.1.2 Concept of Production Efficiency

Productive efficiency is a situation in which the economy could not produce any more of one good without sacrificing production of another good. In other words, productive efficiency occurs when a good or a service is produced at the lowest possible cost, (Wikipedia, 2018).

A firm is technically efficient (TE) when maximum level of output is attained for a given level of inputs and the range of technology available. Allocative efficiency (AE) is attained when the farmer adjusts output and input levels to reflect relative prices and the production technology. On the other hand, technical efficiency and allocative efficiency are then combined to give economic efficiency (EE). These concepts can be illustrated graphically using a simple example of a two- input (x_1, x_2) and two-output (y_1, y_2) production process (Figure 2.1).

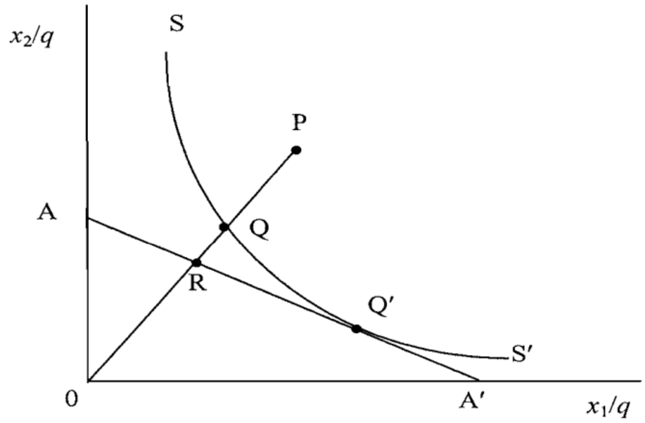


Figure 2.1 Technical and allocative efficiencies

From figure 2.1, SS' is an isoquant, representing technically efficient combinations of inputs, x_1 and x_2, used in producing output Q. AA' is an isocost line, which shows all combinations of inputs x_1 and x_2 such that input costs sum to the same total cost of production. However, any firm intending to maximize profits has to produce at Q', which is a point of tangency and representing a least cost combination of x_1 and x_2 in production of Q. At point Q' the producer is economically efficient.

Knowledge of the unit isoquant of fully efficient firms represented by SS', in Figure 2.1, permits the measurement of efficiency. If a given firm uses quantities of inputs defined by the point P to produce a unit of output, the technical efficiency of that firm could be represented by the distance QP, which is the amount by which all resources could be proportionally reduced without a reduction in output. This is usually expressed in percentage terms by the ratio of QP/OP, which represents the percentage by which all inputs need to be reduced to achieve technically efficient production. From figure 2.1, the technical efficiency is most commonly measured by the ratio OQ/OP = 1 - QP/OP.

The input price ratio AA', is also known as allocative efficiency (AE) of a firm operating at point P could be measured as the ratio: OR/OQ.

The total economic efficiency (EE) is defined to be the ratio EE=OR/OP. The product of the technical efficiency and allocative efficiency provides the measurement of overall economic efficiency. That is, *EE=TE * AE = (OQ/OP)*(OR/OQ) = OR/OP*. This reveals a farmer whose income is based on his economic efficiency has great impact on its household food security.

2.2 Theoretical Literature Review

Neoclassical economics assume that producers in an economy always operate efficiently, however in real terms producers are not always fully efficient (Kokkinou, 2010). Efficiency in production refers to scarce resources being used in an optimal fashion and efficiency estimation may not be consistent as farmers produce series of outputs, (Essa, 2011). In microeconomic theory of production, the producer uses different inputs to produce outputs and in the process desires to maximize revenues. Efficiency can be considered in terms of the optimal combination of inputs to achieve a given level of output, or the optimal output that could be produced given a set of inputs (Coelli *et al.*, 1998). Accordingly, efficiency in major crops production is attained when a farmer uses available farm resources for the purpose of profit or output maximization, given the best production function, level of fixed factors, major crops output and variable factors prices. In this regard, the concept of economic efficiency in the production theory can be used to assess the performance of smallholder crop producers.

Adequate information on resource use efficiency and agricultural productivity; information on production and farm income of smallholder farmers are necessary to make the right decisions in policy concerning agricultural development and food security (Essa, 2011).

2.3 Empirical Literature Review

Food security in the context of local communities included self-reliance on food, sufficient food and water for feeding family, dependence on natural resources, the security of occupation and income relating to buying food from markets, the production providing, food safety and nutritious diet, culture, and food sustainability. (Katesuda *et al*, 2018).

Barley was part of the staple diet of those living in ancient Egypt, Greece and China; it was introduced by Europeans to the New World in the sixteenth and seventeenth centuries, (Bayeh *et al*, 2011**)**. Barley is major staple grain which accounts for over 60% of the food of the people in the highlands of Ethiopia and cultivated by small holders in every region of the country Samuel (2016). According to this scholar even though barley is able to grow at all elevations, it performs best at the higher elevations in the northern and central regions of the country.

Traditionally, barley is cultivated with no or little external inputs (such as fertilizer, or chemical application to control major barley diseases, pests and weeds); moreover, it is cultivated on eroded, low-moisture stressed hillsides, (Abraham *et al*. 2011). The bulk of the barley currently supplied to the maltery is produced by farmers having fragmented and small plots of land, which use archaic methods of production and inadequate levels of agricultural inputs. (Getachew *et al*, 2011).

In Ethiopia the domestic market potential of malt barley is expected to grow from 58,000 MT in 2011 to 133,000 MT in 2016, showing that malt barley is an important cash crop for resource poor farmers in areas where crop diversification options are very limited and malt barley is often the only possible crop (Chilot *et al.* 2016).

Barley bridges the critical food shortage that it matures early before the harvest time of other crops around September (Samuel, 2016). According to Samuel 'barley also serves as a substitute for wheat when wheat prices are high'.

On experimental plots the potential yield of barley goes up to 60 Qt/ha (Berhane *et al*, 1996). Its productivity is low due to several factors. Of these, the major ones are poor soil fertility, use of low-yielding cultivars, poor agronomic practices, diseases (scald, net blotch, spot blotch, rusts and smuts) and pests (Russian wheat aphid and barley shoot fly) (Abraham *et al*, 2011). Although Barley is the most important cereal crop in Ethiopia, the national yield has remained low at below 21.57 Qt/ha, (CSA, 2017).

Abro *et al.* (2017) in their malt barley adoption study conducted in Oromia region, that includes Lemuna-Bilbilo *wereda*, have shown that the effects of changes in the explanatory variables (Social participation, Distance to market, Attitudes on technologies, Profit from malt barley, Operated plot size, and Farm size in hectare) on the probability of adoption and intensity of use of malt barley technologies for the significant variables.

Based on the study of these scholars reported a 100% Change in attitudes on malt barley technology of household head result in 60% increment in adoption and intensity of use of malt barley technologies of which 3% contributes for increments of in intensity of use of adopters. Where as a 100% increase in profit generated from malt barley results in relatively increased malt barley technology adoption and intensity of use by 0.4%. The operated plot size has also a positive estimate on the magnitude of 100% change in it increase an adoption and intensity of malt barley technology by 9.2%.

Kassu *et al.* (2018) in their agronomic study have recommended that farmers of Lemuna-Bilbilo area and other similar agro-ecologies are advised to apply 50% recommended compost (RC) + 50% recommended NP (RNP) or 50% recommended farm yard manure (RFYM) + 50% RNP or 33% RFYM + 33% RC + 33% RNP for optimum ecological and economic benefits.

As cited in Kasu *et al.* (2018) low soil fertility and poor agronomic practices are among the major constraints responsible for the low productivity of malt barley in Ethiopia, (Gete *et al*. 2010). And in their study they found combining organic and mineral fertilizers also gave 7–17 and 1–6% increase in available soil Potassium and total Nitrogen content of the soil.

In a research on the Characterization of barley based farming system conducted in the Arsi highlands of Ethiopia (Bedada *et al.* 2014), more farmers generated more income from malt barley production; i.e the mean income earned from malt barley sales by more than 64% respondent farmers was 7,156.7ETB which was the highest income in comparison with the mean income obtained from the sales of other commodities. Also the study reported that farmers could get minimum income of 200ETB and on contrary farmers could earn income up to 26,550ETB from malt barley sales. This indicates that the contribution of producing malt barley in building the financial capability of the households to ensure food security at household level.

Majority of farmers at Wegera *wereda* discontinued or did not produce malt-barley seed at all because there was no clear contractual modality to which they can sale their output (Wuletaw *et al*, 2017).

Ederveen (2016) studied on the impact of the CREATE project on the livelihood and food security of contracted smallholders in Arsi, Ethiopia. Her results showed that short term effects on livelihood and food security are positive.

In Ethiopia the total area of barley ranks 5th, about 951,993.15 hectare with total production of 20,529,963.72 quintals and its productivity 21.57 Qt/ha, from a total number of holders 3,505,609 (CSA 2017).

In Ethiopia, it is the fifth most important cereal crop after Maize, Tef, Sorghum, and Wheat, in total production. The total production of barley ranks fifth, (Figure 2.1) (CSA area and production data).

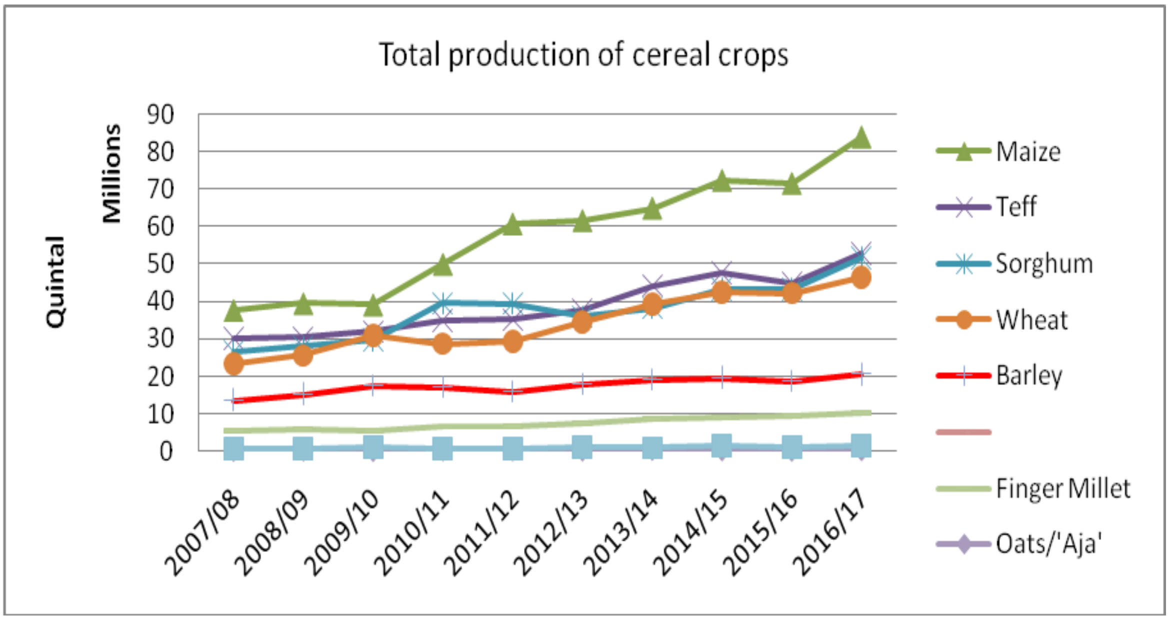


Figure 2.2 Cereal crop production trend in million quintals. (CSA area and production data - graph own processed).

The maltery at St. George Brewery formerly obtained its malt barley from farmers and state farms in Arsi; then small-scale research was also conducted at Deberezeit and Holetta Agricultural Research Centers to verify the suitability of imported malt barley varieties, such as ‘Beka’, ‘Holker’ and ‘Proctor’, (Tadesse, 2011).

The varieties, released by the research centers and those imported from abroad as basic seed, were distributed to the farmers and state farms by the then Chilalo Agricultural Development Unit-Arsi Rural Development Unit (CADU-ARDU) that was operating in Arsi. These units also provided support extension services to farmers. They distributed improved seed, fertilizer and other inputs. Following the establishment of Asela Malt Factory (AMF) in 1984, the state farms in Arsi and Bale were given the responsibility of supplying to the maltery, and the Ethiopian Seed Enterprise (ESE) was required to maintain continued supply of seed to the state farms. The factory was also obtaining 20% of its barley requirement from the farmers' cooperatives.

As shown in the assessment by Offspring Consulting Group (2018) in Ethiopia malt barley producing farmers receive agricultural extension services through governmental agricultural extension workers in their communities. There are more than 17,000 Farmers Training Centers (FTC) throughout the country, mandated to provide extension advisory services through demonstrations and training. On the other hand Diageo, Heineken, Dashen, AMF and GMF all use extension workers to advice and follow-up with their malt barley farmers. The gap is around smallholders outside contract farming schemes.

Around 80% of food barley is consumed by the households with the balance sold for income or retained for planting. In contrast, 70-80% of the malt barley produced is sold, with the balance for home consumption and for seed. Malt barley is predominantly grown as a cash crop, so market access is very important.

Demand for malt barley has been growing as a result of increased urbanization and rising incomes contributing to growth in beer consumption. The main use for malt barley is for commercial beer brewing, but malt barley is also a desirable food source, notably as injera (fermented thin bread), porridge or roasted. It is also used for making local alcoholic beverages and there is a growing demand for bread made from malt barley, mainly in Addis Ababa. While most malt barley ends up being used for commercial beer brewing, there are competing demands for it.

2.4 Knowledge/Research Gap

In many of the references no data was found that show malt barley producing farmers resource use decisions to enhance their production efficiency to secure their food and dietary diversification. This study therefore attempted to analyze the resource use efficiency of malt barley production and its impact on food security in Lemuna-Bilbilo *wereda*, Ethiopia.

2.5 Analytical Framework

Farmers are said rational on their decisions. As cited in Chernet (2016), in the theory of production, the main production decision is centered on what to produce, how much to produce and how to produce (Kenneth *et al*, 1999). But for technical or allocative efficiency conditions in malt barley production, some variables such as sex, age, land size, family size, level of education, experience, TLU, etc. influence farmer's decision on resource use.

The success in resource use reveals the ability of farmers' efficiency and income generation which ultimately contributes for food and non food expenditure. Both resource use efficiency and income obtained from malt barley production reflect on the household's dietary diversity through purchase.

Therefore, production efficiency level of the households and income generated from malt barley through decisions on the use of resources were analyzed with share of food expenditure analysis (SFEA) to tell us what the impact of malt barley production efficiency has on the household's food security.

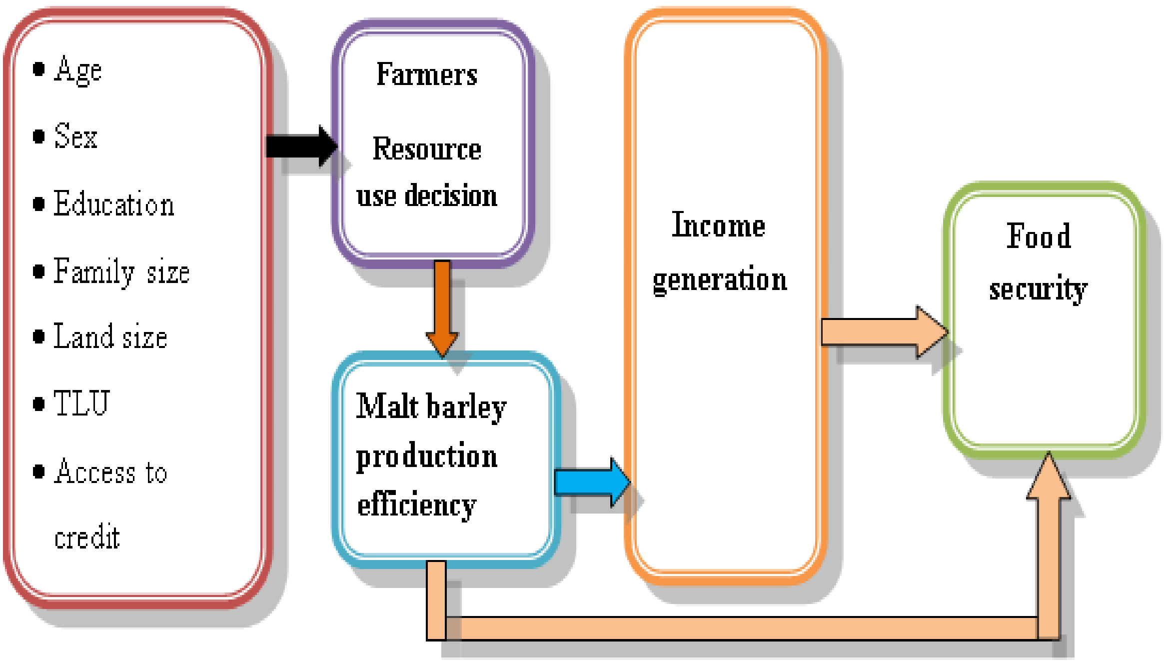


Figure 2.3 Conceptual framework: resource use decision and efficiency of malt barley producing farmers & its impact on food security (own construction).

CHAPTER THREE: RESEARCH METHODS

3.1 Description of the study area

Lemuna-Bilbilo *wereda* is located in the southeastern highlands of Ethiopia. It is one of the 25 *weredas* in Arsi zone. The wereda is found between 7°10'14″ to 7°40'20″N latitude and 39°4'59″ to 39°38'56″E longitude at altitudes ranging from 2,633m to 2,755m.a.s.l. in Oromia region (Figure 4.1). The wereda is bordered by Digaluna-Tijo & Munesa in the North, Shirka & Enkolo-wabe in the East, Kore in the West and Adaba & Gedeb-Asasa weredas in the South, where Kore, Gedeb-Asasa and Adaba are found in West Arsi zone.

The area cover percentage of the wereda from Arsi zone is 6.4%. It has 25 rural and 7 town *kebele* administrations. The dominant soil classified as Nitisol and vertisols. According to CSA population projection 2014- 2017 the total population of the *wereda* is 180,695. Out of which 87.1% is dwelling in rural kebeles. Farmers of the wereda practice mixed farming system. They grow cereals, pulses and oil crops & rear cattle, horse, sheep, poultry. The *wereda* has a high potential for both food and malt barley production. In 2018 cropping season from the cultivated cereals malt barley stands third in hectare coverage; which is 17.3% next to Bread wheat (52.8%) and Food barley (21.5%) respectively. The share of Tef production area is only 2%, (report from Limuna-Bilbilo office of agriculture), (Table 3.1).

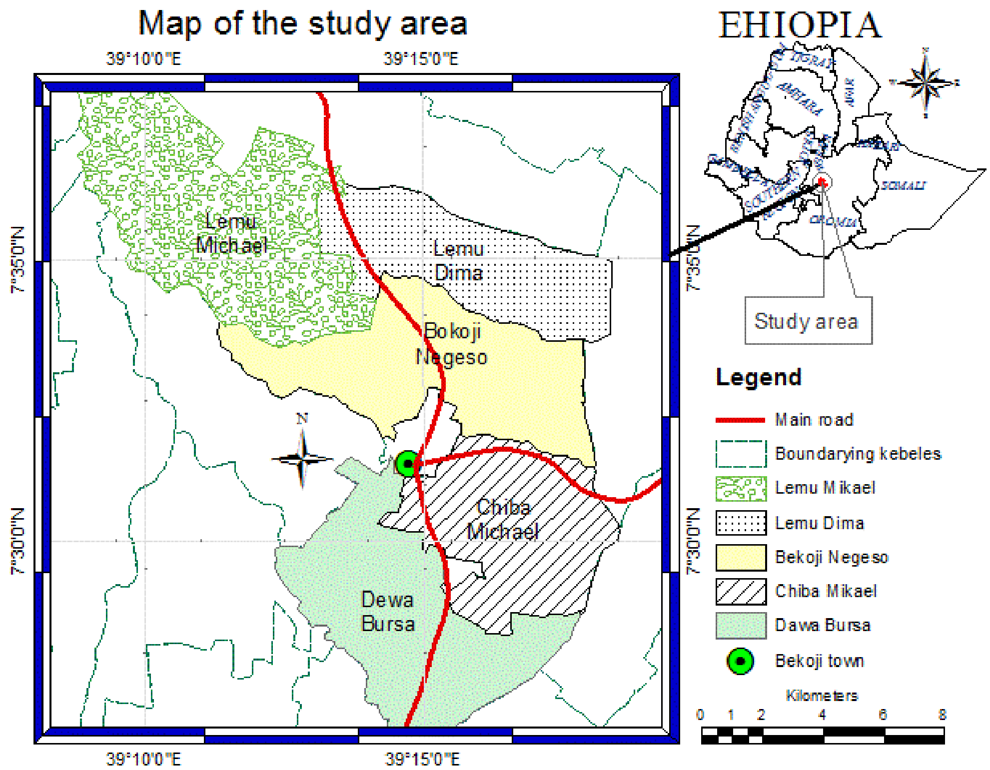
Table 3.1 Type of cereal crops production and their area coverage in Limuna-Bilbilo, 2018.

Cereal crop	Hectare	% Share	Rank
Bread wheat	24,759.0	52.77	1
Food Barley	10,064.5	21.45	2
Malt barley	8,134.0	17.34	3
Durem wheat	1,905.0	4.06	4
Maize/Corn	1,005.0	2.14	5
Tef	957.5	2.04	6
Emer wheat (Aja)	92.0	0.20	7

Source: Report from Lemuna-Bilbilo *Wereda* office of Agriculture.

As stated by Kassu *et al.* (2018) the *weredas* climate is characterized as warm temperate sub-humid to humid. The long term mean annual rainfall of the *wereda* is 1,053mm; and the rainy season starts in March and continues to October with the highest precipitation occurring in July and August. The mean annual minimum and maximum temperatures of the area are 7.07 and 19.42°C, respectively. November and March are the coldest and hottest months with temperatures of 6.09 and 21.34°C, respectively.

Figure 3.1. Map of the selected *kebeles* in the study *wereda*.



Source: Own construction based on data from CSA 2007.

3.2 Source of Data

The data source were a cross-sectional where individual (sampled household heads), key informants/KI (elders, kebele administration, *wereda* office of agriculture and cooperative office) and focus group discussion (FGD) were used for the crosscheck of individual households response.

3.3 Sampling Procedure

3.3.1 Sample Size

To determine the sample size, this study adopted Kothari's (2004) formula. This allows addressing more number of *kebeles* with limited resource to represent the *wereda*. Based on this, the required sample size (n) to a population size (N) that is greater than or equal to 10,000, is determined as:

$$n = (Z^2pq)/d^2$$

Whereas n = the sample size;

Z = Standard normal variable at the 95% level of confidence which is 1.96;

P = the proportion in the target population estimated to have characteristic 15%;

q = (1 - p), which is (1 - 0.15) = 85%, and

d = the level of tactical significance at 5%.

Since the total population size in the study area identified was 1930 which is less than 10,000. This study used a formula:

fn = n/(1+n/N) if N is less than 10,000.

$96/(1+\frac{196}{1930}) =$ 178 , N < 10,000.

The final sample size adjusted for response rate (r) = 95% is assumed 178 * 0.95 = 169

Table 3.2 Sample size of malt barley produced HHs in each kebele in 2018 meher.

Rural kebele	Number of malt barley produced HHs	Sample size in proportion to the malt barley produced HHs
Dawa Bursa	367	32
Lemu michael	143	13
Lemu Dima	471	41
Bekoji Negeso	433	38
Chibaa Michael	516	45
Total	**1930**	**169**

Therefore; 32, 13, 41, 38 and 45 (169 sample farmers in total) malt barley producing household farmers were selected from Dawa-Bursa, Lemu-Michael, Lemu-Dima, Bekoji-Negeso, and Chibaa-Michael kebeles, respectively. For comparison purpose equal number of food barley producing farmers were selected following similar procedure, see appendix I.

3.3.2 Sampling Procedure

A stratified simple random sampling was implemented to select households. A sampling method in which the population is divided into a number of groups from which samples were drawn; these were then divided into groups or secondary stages from which samples were drawn, and so on.

In the first stage, Lemuna-Bilbilo *wereda* was purposively selected on the following main reasons; first it has potential in malt barley production from Arsi zone; Lemuna-Bilbilo represent the major malt barley growing areas where improved varieties are beginning to be adopted by farmers (Abro *et al.*, 2017). In the second stage, five rural *kebeles* were purposively selected on the basis of share in total area of malt barley production and their proximity from Bekoji town, the administrative center (i.e. accessibility) with the consultation of Office of Agriculture in the *wereda*; in the final stage units of malt barley producers (universe) with malt barley production were identified with the help of development agents (DAs) at each *Kebele*.

Sample households were selected randomly by systematic random sampling technique. It was from these farmers that the necessary information was obtained and the list was used as a sampling frame.

3.3.3 Method of Data Collection

A structured questionnaire was employed to collect primary data. Questionnaire pretest was conducted for completeness, relevance, non-ambiguity, coherence of questions, and unexpected responses that could arise from loss of memory. Necessary modifications were made based on the feedbacks from the pretest.

Enumerators were recruited to interview the sampled farmers. All the enumerators were given a brief explanation and given one day training on how to gather information according to the questionnaire before they embarked on data collection. Data collection was conducted in close supervision and a day to day checkup of the researcher.

Relevant secondary data and data specific to the study area as a whole and having little difference among households was collected based on the group discussion made with key informants who were selected based on their age, agricultural experience and indigenous knowledge.

3.3.4 Instruments of Data Collection

This study used qualitative and quantitative data types. Which are variables such as sex, age, family size, education, training, experience, attitude, farm size, access to credit, livestock owned, inputs used, output obtained, income earned, food and non food expenditures of the study area in 2018.

3.3.5 Ethical Consideration

In collecting the data, ethical considerations were seriously taken into account to ensure the confidentiality, consents protection of concern and other human elements of the informants.

This was primarily taught for the enumerators to respect the respondent's values in their cultural and religious perspective. The ideas obtained and pictures taken shall not be disclosed to the public without the good will of the respondents. Unless there was consensus in group discussions and with no minutes taken, these ideas shall not be taken as a reference.

3.3.6 Method of Data Analysis

The focus of this study was to analyze farmers' resource use efficiency in malt barley production and show its impact on food security in the study area. Data collected were analyzed through descriptive and econometric analysis. The study utilized to make comparative analysis using different statistical model tests.

3.4 Variables in the Production Frontier

In the production frontier part of the model, the outcome variable is grain yield of barley in kg per hectare. Whereas, the input variables such as amount of applied seed (kg), NPS & Urea fertilizers (Kg), herbicides (Lit), fungicides (Lit), total labour (Man days), and Oxen (oxen days) were used.

3.5 Statistical methods used

The socio economic characteristics of the household respondents were analyzed using descriptive statistics that comprised of mean & standard deviation using t-tes, and frequency & percentage using chi square. To get similar characteristics of the respondents in both groups Propensity Score Matching (PSM) was run on their characteristics. In finding the common support estimations such as nearest neighbour, radius, kernel, and stratification were executed. Different statistical models (logit, probit, and tobit regressions) were tested and post estimation diagnosis using goodness of fit (GoF) and variance inflation factor (VIF) were computed. Econometric analysis was run through stochastic frontier analysis (SFA) to measure efficiency. The STATA-13 software was employed to calculate those statistics. Among the different food security metrics the food security component of this study preferred to use share of food expenditure analysis (SFEA) to identify share of food expenditure from the total income of household's from their barley crop.

In this study different analytical regressions were used. Average treatment effect on the treated (ATT) analysis was used after matching to check whether there is proper matching among the variables. The researcher selected the best model that fit with the observed data by considering the specific attributes of the study area. Therefore, logit, probit, and tobit models were employed in this research not arbitrarily but in order to estimate factors affecting resource use decision of farmers on malt barley production. The detailed descriptions of the models are presented next.

i) Estimating resource use decision of farm households

In identifying variables affecting level of malt barley production efficiency, this study used Cobb-Douglas production function frontier because it allows using cross-sectional data as:

$\ln(Q_i) = \beta_0 + \beta_1\ln(k_i) + \beta_2\ln(L_i) + ... + (v_i-u_i)$,

Where:

ln: represents natural logarithm,

Q_i, K_i, and L_i were assumed for output, capital, and labour, respectively.

v_i & u_i were assumed for normal and half normal distribution, respectively.

$i = 1, 2 \ldots n^{th}$ sample farmer

Based on the above model, a stochastic frontier model for malt barley farmer was given by:

$$\ln(output)_i = \beta_0 + \beta_1\ln(landsize) + \beta_2\ln(seed) + \beta_3\ln(fert) + v_i + u_i$$

Where:

output: represents total yield of malt barley of the i^{th} farm or household and it was a continuous variable measured in kg.

landsize: represents plot of malt barley for the i^{th} farm and it was a continuous variable measured in hectare.

Fert: represents the total amount of fertilizer (NPS + Urea) use per plot in kg.

Seed: represents the amount of malt barley seed used per plot and it was a continuous variable measured in kg.

ii) Estimating Technical Efficiency of resource use decision

Stochastic frontier analysis (SFA) was implemented to estimate level of efficiency in malt barley production, with farmer's technical and allocative efficiency analysis. This was undertaken using STATA-13. The Stochastic Frontier Analysis (SFA) builds on the microeconomic concept of production function which represents the maximum output attainable given a certain quantity of inputs. The inputs may include all variables affecting the production performance; also the stochastic frontier production function was estimated with the maximum likelihood method. The production of malt barley was likely to be affected by climate and resource use decision of farmers. In addition, surveying errors could also occur during the data collection. Therefore, to capture effects of these errors, this study used stochastic frontier production function. The general stochastic frontier production function for the cross-section data, which were considered in this study, defined as:

$Y_i = f(X_i; \beta)\exp(\varepsilon),$

Where; i = 1, 2, 3,....n

Here Y_i = denotes the output yield in kg for the i^{th} sample farmer producing malt barley; $f(X_i,\beta)$ was an appropriate production function (e.g. Cobb-Douglas); X_i represents the actual vector of input used by the i^{th} farmer, ß stands for the vector of unknown parameters; and n represents the number of sample farmers. ε_i was a composed disturbance term made up of two elements (v_i and u_i). v_i was a random error that accounts for the stochastic effects beyond the firm/farmer's control measurement errors as well as other statistical noise. The symmetric component (v_i) was assumed to be independently and identically distributed as $N(0, \delta_v^2)$.

The basis of a frontier function illustrated with a farm using *n* inputs for malt barley ($X_1, X_2, \ldots, X_n$) to produce output Y (grain yield of malt barley). Efficient transformation of inputs into output was characterized by the production function $f(x_i)$, which shows the maximum output obtainable from various input vectors used.

iii) Propensity score matching method (PSM)

More recently developed methods pair program participants with more than one nonparticipant observation, using statistical methods to estimate the matched outcome. In this study implementing Propensity Score Matching Estimators were done using STATA 13 program. Kernel matching model was preferred because it uses a weighted average over multiple persons in the comparison group.

If un-confoundedness holds, the study retrieve the average treatment effect (ATE) and average treatment effect on the treated (ATET) by weighting as:

$$E(\Delta_i) = E(Y_i^1 - Y_i^0) = E\left(\frac{Y_i T_i}{P(x_i)}\right) - E\left(\frac{Y_i(1 - T_i)}{1 - P(x_i)}\right)$$

3.7 Variables Definition

Dependent variables

The first dependent variable used in this research was the grain yield obtained, moreover output food expenditure and efficiency were also taken as a dependent variable.

Explanatory variables

In this specific model, the selection of variables which tested the factors affecting farmer's resource use decision is based on:

i. Farmer's socio-economic variables: (sex, age, education, training, attitude of the household head, access to credit, experience in farming, and income from off-farm activities)

ii. Institution related variables: attend formal training on barley production, access to credit, timely supply of fertilizer and improved seeds of barley.

iii. Farmer's endowment variables: farm size allocation to barley production, family size, livestock ownership (adjusted to TLU), use mechanized services for farm operation.

iv. Farmer's psychological variables: prior knowledge/experience on barley crop production and marketing.

CHAPTER FOUR: RESULT AND DISCUSSIONS

In this chapter a detailed descriptive and econometric analysis results for variables used in the study are presented. The result of descriptive statistics for continuous variables on demographic characteristics of the household head, asset and production, pattern of agricultural inputs use, revenue obtained, and expenditure assessment are described using t-test. For dummy variables chi square was used. In addition, as per the general objective of this study farmers' resource use efficiency are analyzed using econometric analysis through stochastic frontier analysis (SFA). The impact of malt barley production has been made using propensity score matching consider efficiency and food expenditure as outcome variables.

4.1. Descriptive Statistics of Socio-Economic Variables

4.1.1 Demographic & Socioeconomic Characteristics of Farmers

The average age of sample households is 45.7 with a standard deviation of 11.6 years. Whereas, the average age for malt barley and food barley sample farmers were found to be 45.7 and 45.8 years with a standard deviation of 11.30862 and 11.95563, respectively. The p-value of age was found 0.9033, showing that there was no significant difference between the mean age of the malt and food barley producing household heads (Table 4.1). The levels of education patterns in terms of grade for the malt barley and food barley producing household heads have a mean value of 5.93491 and 5.54438 with a standard deviation of 3.672844 and 3.556177 grade levels respectively. Its p-value is 0.0433 indicating that households producing malt barley have better educational level than the food barley producing household heads, (Table 4.1). Experience in producing barley crop in the study area was examined. The t-test result shows a mean value of 20.98817 and 21.17751 with a standard deviation of 8.10716 and 8.336907 for the malt and food barley producing farmers respectively. The combined mean value is 21.08284 with a standard deviation of 8.211174 and p-value 0.8325 indicating that experience of the household heads in both treatments is homogenous, (Table 4.1). Family sizes of the control and treated groups have found to have a mean value of 6.65089 and 6.76331 with a standard deviation of 2.110634 and 2.340803 respectively. Whereas, in combined family size mean is 6.70710 per household with a standard deviation of 2.226095, (Table 4.1).

Table 4.1 Descriptive statistics (T-test result) of sample household's demographic variables

Variables	Malt barley (169)		Food barley (169)		Total (338)		T-value	Significance Level
	Mean value	SD	Mean value	SD	Mean value	SD		
Age	45.66864	11.95563	45.82249	11.30862	45.74556	11.6196	0.9033	
Education	5.934911	3.672844	5.153846	3.40168	5.544379	3.556177	0.0433	**
Family Size	6.763314	2.340803	6.650888	2.110634	6.707101	2.226095	0.6432	
Farm Experience	20.98817	8.10716	21.17751	8.336907	21.08284	8.211174	0.8325	

Note: ** shows it is significance at 5%

The sex distribution of sampled household heads was found 5.92 % female and 94.08% were male. And the female's distribution were 4.73% and 7.1% for the malt and food barley producing farmers respectively, revealing the number of female household heads producing malt barley is smaller than food barley growing female household heads, (Table 4.2). Training obtained by the household heads in producing barley crop in the study area was tested by chi square test.

Among the respondent household heads farmers who got and not get training were analysed by their frequency and percentage. The yes result for malt barley, food barley and total shows 139, 102, and 241 mean frequencies with its percent value of 82.25, 60.36, and 71.3 respectively. Whereas not get trained was 30, 67, and 97 frequencies with 17.75, 39.64, and 28.7% respectively. The probability of chi square is 0.000 indicating that there is a one percent significance difference on the frequency of training. Malt barley producing farmers get better trained than food barley growing farmers in the study area, (Table 4.2).

Farmers of the study area get credit from different sources. Among these, Oromia Saving and Credit Association (OSCA), Meta Beer Factory, Maru, Techno, Harbu, Nebo, and Unions were mentioned upon focus group discussions. Among the respondent household heads farmers who used credit were analysed by their frequency and percentage using chi square.

The yes result for malt barley, food barley and total shows 44, 13, and 57 frequencies with percent of 26.04, 7.69, and 16.86 respectively. Whereas not used result was 125, 156, and 281 frequencies with 73.96, 92.31, and 83.14% respectively. The probability or chi square is 0.000 indicating that there is significance difference in use of credit. Malt barley growing farmers use credit better than food barley growing farmers in the study area, (Table 4.2). The means of land preparation in the study area is carried out by both Oxen and tractor. Both malt and food barley producing farmers use to plow their plots using Oxen and tractor separately or combined. Based on the data obtained 90.53 and 92.31 % of them use oxen and 8.88 & 7.69% use tractor respectively. Farmers that use both means of plowing were found only 0.59 and 1.18% respectively. And the chi square test result shows a probability of 0.613 indicating that there is no significant difference of using means of land preparation between the treatments, (Table 4.2).

Table 4.2 Descriptive statistics (Frequency and percent) result of dummy variables

Variables	Category	Malt barley Mean value		Food barley Mean value		Total		X^2- value (probability)
		Frequency	%	Frequency	%	Frequency	%	
Sex	Female	8	4.73	12	7.1	20	5.92	0.356
	Male	161	95.27	157	92.9	318	94.08	
Training	Not trained	30	17.75	67	39.64	97	28.7	0.000 ***
	Trained	139	82.25	102	60.36	241	71.3	
Credit use	Yes	44	26.04	13	7.69	57	16.86	0.000 ***
	No	125	73.96	156	92.31	281	83.14	
Plough by	Oxen	153	90.53	156	92.31	309	91.42	0.613
	Tractor	15	8.88	11	6.51	26	7.69	
	Both	1	0.59	2	1.18	3	0.89	

Note: **, *** show significance at 5% & 1% level respectively.

4.1.2. Asset and Production Characteristics

Size of plot of land allocation for barley crop in the study area in 2018 was examined using t-test. And its mean value found was 0.811243 and 0.7106509 with a standard deviation of 0.56939 and 0.408709 for the malt and food barley producing farmers respectively. The combined mean value is 0.7558876 with a standard deviation of 0.496938 and p-value of 0.0943, which shows there is 10% significance difference. The result shows that households allotted more plot of land for the production of malt barley than food barley in the study area, (Table 4.3).

The mean TLU level of food barley producing households was 5.313373, whereas the malt barley producing households were found 5.711006 with a standard deviation of 2.342216 and 2.833818 respectively. In total the mean value of TLU was 5.512189 with a standard deviation of 2.603429. And the p-value is 0.1606 showing there was no difference in the households' livestock holdings in terms of TLU, (Table 4.3). The oxen days used were computed by converting the cost of ploughing into oxen days. This makes it easy to compare as the means of ploughing is converted into similar unit, oxen days used to prepare their barley plots. Accordingly the mean value of oxen days was 25.38272, 22.02604, and 23.70438 with a standard deviation of 16.39662, 16.52697, and 16.5232 for treated, control and combined respectively. The p-value was 0.0617 which shows there is a 10% significance difference in ploughing barley plots, malt barley producing farmers dedicate more oxen days to prepare their plots for planting, (Table 4.3).

Total amount of labour allocated on barley crop production right from land preparation to harvesting was computed for the malt and food barley producing households. The mean value of labour used for ploughing was found 12.69136, 11.01361, and 11.85249 with a standard deviation of 8.199312, 8.263596, and 8.261624 for the treated, control and combined respectively. The p-value is 0.0618 showing malt barley farmers dedicate more man-days on preparing their plots of land. The result match with the oxen dedicated for ploughing. Similarly the amount of labour on harvesting was computed in t-test. The mean value result 6.674438, 6.008343, and 6.34139 with a standard deviation of 4.366256, 4.156119 and 4.269203 for the malt barley, food barley and combined respectively. The p-value is 0.1518 showing there is no significance difference on harvesting labour between the treatments, (Table 4.3).

Table 4.3 Descriptive statistics (T-test) of household asset and the cost of farm activities

Variable	Malt barley (169)		Food barley (169)		Total (338)		T-value	Significance
	Mean value	SD	Mean value	SD	Mean value	SD		
Land size	0.8011243	0.56939	0.7106509	0.408709	0.7558876	0.496938	0.0943	**
TLU	5.711006	2.833818	5.313373	2.342216	5.512189	2.603429	0.1606	
Plough freq	3.893491	0.740346	3.970414	0.727242	3.931953	0.733746	0.3359	
Oxen days	25.38272	16.39662	22.02604	16.52697	23.70438	16.5232	0.0617	*
Labour for plough	12.69136	8.199312	11.01361	8.263596	11.85249	8.261624	0.0618	*
Labour for	6.674438	4.366256	6.008343	4.156119	6.34139	4.269203	0.1518	

harvest	

Note: *, **, *** show significance at 10%, 5%, and 1% level respectively.

4.1.3 Agricultural Inputs Use Pattern

In addition to using improved barley seeds the use of agricultural inputs from industrial products such as inorganic fertilizers and pesticides (herbicides and fungicides) is found common in the study area. The mean value of farmers' decision on the amount of seed used was examined using t-test. The result shows a mean value 123.4917 and 126.1627 with a standard deviation of 85.20255 and 72.97365 for the malt and food barley producing farmers respectively. The combined result also shows a mean value of 124.8272 with 79.21762. The p-value is 0.7571 indicating there is no difference on the amount of seed applied in both treatments, (Table 5.4).

The amount of NPS fertilizer applied on barley plots was tested. The mean value of its application was 123.574, 96.56065, and 110.0673 with a standard deviation of 256.4232, 77.05268, and 189.5299 for treated, control and combined respectively. The p-value is found 0.1906 showing that there is no significance difference in the amount of NPS fertilizer application on both types of barley crops, (Table 4.4).

The amount of urea fertilizer applied on barley plots was tested. The mean value of its application was 16.76036, 11.42899, and 14.09467 with a standard deviation of 30.34352, 17.47135, and 24.86557 for treated, control and combined respectively. The p-value is found 0.0486 showing that there is a 5% significance difference in the amount of urea fertilizer application, so malt barley producing farmers apply more urea as compared to food barley producing farmers, (Table 4.4).

The amount of litre of herbicides sprayed on barley plots was computed using t-test. Accordingly the mean value of its application was 0.9121893, 0.8131953, and 0.8626923 with a standard deviation of 0.5252703, 0.5050782, and 0.5168905 for treated, control and combined respectively. The p-value is found 0.0783 showing that there is a 10% significance difference in the amount of herbicide spraying. Malt barley producing farmers use more herbicides than food barley producing farmer, (Table 4.4).

The amount of litre of fungicides sprayed on barley plots was analysed using t-test. Accordingly the mean value of its application was found 0.6832468, 8.875241, and 4.655953 with a standard deviation of 0.5957495, 70.15143, and 48.93916 for treated, control and combined respectively. The p-value is found 0.1483 showing that there is no significance difference in the amount of fungicides sprayed on both types of barley crop, (Table 4.4).

Table 4.4 Descriptive statistics (T-test) of agricultural inputs used by the treatments

	Malt barley **(169)**		Food barley **(169)**		Total **(338)**			Level of
Variables	Mean value	SD	Mean value	SD	Mean value	SD	T-value	Signifi-cance
Seed sown	123.4917	85.20255	126.1627	72.97365	124.8272	79.21762	0.7571	
NPS applied	123.574	256.4232	96.56065	77.05268	110.0673	189.5299	0.1906	
Urea applied	16.76036	30.34352	11.42899	17.47135	14.09467	24.86557	0.0486	**
Herbicide sprayed	0.9121893	0.5252703	0.8131953	0.5050782	0.8626923	0.5168905	0.0783	*
Fungicide sprayed	0.6832468	0.5957495	8.875241	70.15143	4.655953	48.93916	0.1483	

Note: *, **shows it is significance at 10% & 5% level respectively.

4.1.4 Revenue Assessment

The amount of barley crop harvest in a unit of kilo grams was collected based on the information the respondents provided during surveying. With regard to accuracy in the measurement of weight of their harvest this study bases on farmers long term experience in converting local measurement units into SI units like kilogram. Traditionally one quintal barley weighs 90 kilograms in average. Therefore, by taking the first hand information obtained from the interviewed household heads the t-test analysis was done.

The obtained grain yields in kg/ha mean value of malt barley, food barley, and combined was 4,189.6, 4,034.8, and 4,112.2 respectively. The p-value was 0.6671 which shows that grain yield obtained is homogenous (Table 4.5). Similarly the income obtained from barley grain was computed by t-test. Its mean value for treated, control, and combined was 55,435.96; 33,711.12, and 44,573.54 respectively. The p-value was 0.0001 which shows that income obtained from malt barley was significantly more than food barley, (Table 4.5).

On the other hand income obtained from animals was computed in the same way by t-test. And it's mean value for treated, control, and combined was found 18,748.87; 10,267.57, and

14,536.68 with a standard deviation of 17,093.7, 7,721.207, and 13,933.4 respectively. The p-value was 0.0000 which shows that income obtained from animals was significantly more by malt barley producing farmers, (Table 4.5). Whereas income obtained from non-farm activities was also computed in the same way by t-test. And it's mean value for treated, control, and combined was found 10,439.83; 7,721.974, and 9,072.02 with a standard deviation of 13,607.41, 17,024.79, and 15,431.88 respectively. The p-value was 0.2775 which shows that income obtained from non-farm activities was homogenous, (Table 4.5).

Table 4.5 Descriptive statistics (T-test) of revenue obtained by the household heads

Variables	Malt barley		Food barley		Total		T-value	Significance
	169		169		338			
	Mean	SD	Mean	SD	Mean	SD		
Yield kg/ha	4,190	4,474	4,035	1,356	4,112	3,301	0.6671	
Income from barley in Birr	55,436	53,674	33,711	47,957	44,574	51,972	0.0001	***
Income from animals in Birr	18,749	17,094	10,268	7,721	14,537	13,933	0.0000	***
Nonfarm income in Birr	10,440	13,607	7,722	17,025	9,072	15,432	0.2775	

Note: *** shows it is significance at 1% level.

4.1.5 Expenditure Assessment

Cost of plough was analyzed using t-test. The result shows a mean value of 3246.864 and 2789.053with a standard deviation of 2388.902 and 1712.606 for the malt and food barley producing farmers respectively. The combined mean value is 3017.959 with a standard deviation of 2087.982 and p-value 0.0437 which significant at 5% indicating that plough incurs significantly more cost to malt barley producing household heads than food barley producing farmers, (Table 4.6).

The expense for agricultural inputs was also examined using t-test. The result shows a mean value of 7197.531and 5427.324 with a standard deviation of 8255.985 and 3481.721 for the malt and food barley producing farmers respectively. The combined mean value is 6298.81 with a standard deviation of 6353.832 and p-value 0.0118 which significant at 1% indicating that malt barley producing household heads spend more to buy agricultural input than food barley producing farmers, (Table 4.6). Payment for grain harvesting was also computed using t-test. The result shows a mean value of 4178.6761and 3110.93 with a standard deviation of 6763.513 and 3235.978 for the malt and food barley producing farmers respectively. The combined mean value is 3690.239 with a standard deviation of 5454.495 and p-value 0.1819 which significant at 1% indicating that cost of harvesting incur significantly more to malt barley producing household heads than food barley producing farmers, (Table 4.6).

Food expenditure condition by the respondent household heads in the study area was analyzed using t-test. The result shows a mean value of 21,522.92 and 15,744.56 with a standard deviation of 13,204.86 and 7,645.697 for the malt and food barley producing farmers respectively. The combined mean value is 18,633.74 with a standard deviation of 11,155.23 and p-value 0.0000 indicating that malt barley producing household heads spend significantly more than food barley producing farmers for their food items, (Table 4.6). Similarly the non-food expenditure status of the respondent household heads in the study area was assessed using t-test. The result shows a mean value of 19,252.09 and 14,693.38 with a standard deviation of 14,823.06 and 8,125.547 for the malt and food barley producing farmers respectively. The combined mean value is 16,972.74 with a standard deviation of 12,151.57and the p-value is 0.0005 which is significant at one percent. This indicates that malt barley producing household heads spend significantly more than food barley producing farmers for non-food goods, (Table 4.6).

Table 4.6 A t-test examined for food expenditure by the treatments in Birr

	Malt barley **(169)**		Food barley **(169)**		Total **(338)**			
Variables	Mean value	SD	Mean value	SD	Mean value	SD	T-value	Level of Signifi-cance
Plough cost	3246.9	2388.9	2789.1	1712.6	3018.0	2088.0	0.0437	**
Inputs cost	7197.5	8256.0	5427.3	3481.7	6298.8	6353.8	0.0118	*
Harvest cost	4178.7	6763.5	3110.9	3236.0	3690.4	5454.5	0.1819	*
Food expenditure	21522.9	13204.9	15744.6	7645.7	18633.7	11155.2	0.0000	***

Variables	Malt barley (169) Mean value	SD	Food barley (169) Mean value	SD	Total (338) Mean value	SD	T-value	Level of Significance
Nonfood expenditure	19252.1	14823.1	14693.4	8125.6	16972.7	12151.6	0.0005	***

4.2 Econometric Analysis

4.2.1 Model diagnosis test

Logit model for the treatments was used to inspect the relative influence of different demographic and economic variables on malt barley producing household's resource use decision, their income from malt barley, and level of food security. The number of observations was 338 and the number of covariate patterns is 337. Pearson chi2 (338) is equal to 337.92. Whereas, the probability of chi square is 0.3412; which is greater than 5% significance level. Hence, the Pearson’s goodness-of-fit test indicates that the model fits the data well as (P value=0.3412). Therefore, the model fits well significantly, Table 4.7.

Table 4.7 Logistic model for t, goodness-of-fit test

number of observations	=	338
number of covariate patterns	=	337
Pearson chi2(328)	=	337.92
Prob > chi2	=	0.3412

In addition to goodness of fit multicollinearity was tested using variance inflation factor (VIF). The mean vif result revealed that p-value equal to2.06 and 1.94 for efficiency and food expenditure respectively, showing that there is no problem of multicollinearity observed as the p-value lies within range of 1 < vif < 5 /moderately correlated, Table 4.8. Therefore, the model fits well.

Table 4.8 Diagnosis result of VIF on efficiency and food expenditure

Test	Regression type	Test name	P-value Food expenditure	Efficiency
VIF	Linear	Mean vif	1.94	2.06

4.2.2 Logistic Regression

Logistic regression has been executed on the demographic variables of the households by treatments. The result for the variable training has a value of P is equal to 0.000, which is significant at one percent. Other variables are found homogenous. This reveals that training has positively affected malt barley production, Table 4.9.

Table (4.9) Logistic regression result of participant households in the study area

T	Coef.	Robust Std. Err.	z	P>z	
Sexhh	0.3651533	0.5252264	0.70	0.487	
Agehh	0.0209035	0.0207570	1.01	0.314	
Eduhh	0.0385855	0.0379096	1.02	0.309	
Trainhh	1.0517170	0.2710733	3.88	0.000	***
Exprience	-0.0264999	0.0287968	-0.92	0.357	
Tlu	0.0278495	0.0484670	0.57	0.566	
Famsize	0.0089990	0.0595619	0.15	0.880	
Landsize	0.3196805	0.2150611	1.49	0.137	
_cons	-2.169575	0.8896586	-2.44	0.015	

Total Sample size (N) = 338 Pseudo R2 = 0.0544 Wald chi2(8) = 21.58 Prob > chi2 = 0.0058 Log likelihood = -221.52859

Not: *** shows significance at $p < 0.01$ Source computation from own survey (2019).

4.2.3 Propensity score matching (PSM)

Matching was executed by propensity score to get similar characters of both malt and food barley producing household heads. Before matching the mean biasness of unmatched covariates' was 15.5% and reduces into 4.4% after matching. The mean bias value fulfils the percent absolute standardized bias < 5% procedure, while the percentage of biasness of malt and food barley producing group covariates before matching was 56.0% and it reduced into 13.8% biasness after matching. Therefore, as the percentage of biasness after matching is below 25%, the range of the covariates is within the required interval [0.5; 2.0], (table 4.10). The result shows matching was successful.

Table 4.10 Propensity score matching result on household heads demography by t.

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.054	25.35	0.001	15.5	12.7	56.0*	0.92	33
Matched	0.003	1.61	0.991	4.4	4.5	13.8	1.46	17

* if B>25%, R outside [0.5; 2]

4.2.3.1 Test result on the propensity score matching

After propensity score matching pstest was run and the distribution of common support was plotted in the histogram. The figure shows by plotting malt versus food barley producing households on their demographic characters, (figure 4.1). For that reason from the histogram there is overlap between malt and food barley producing households. The result implies there is a common support region between malt and food barley producing households. There is a common support means it is possible to undertake a comparison of the malt and food barley producing households.

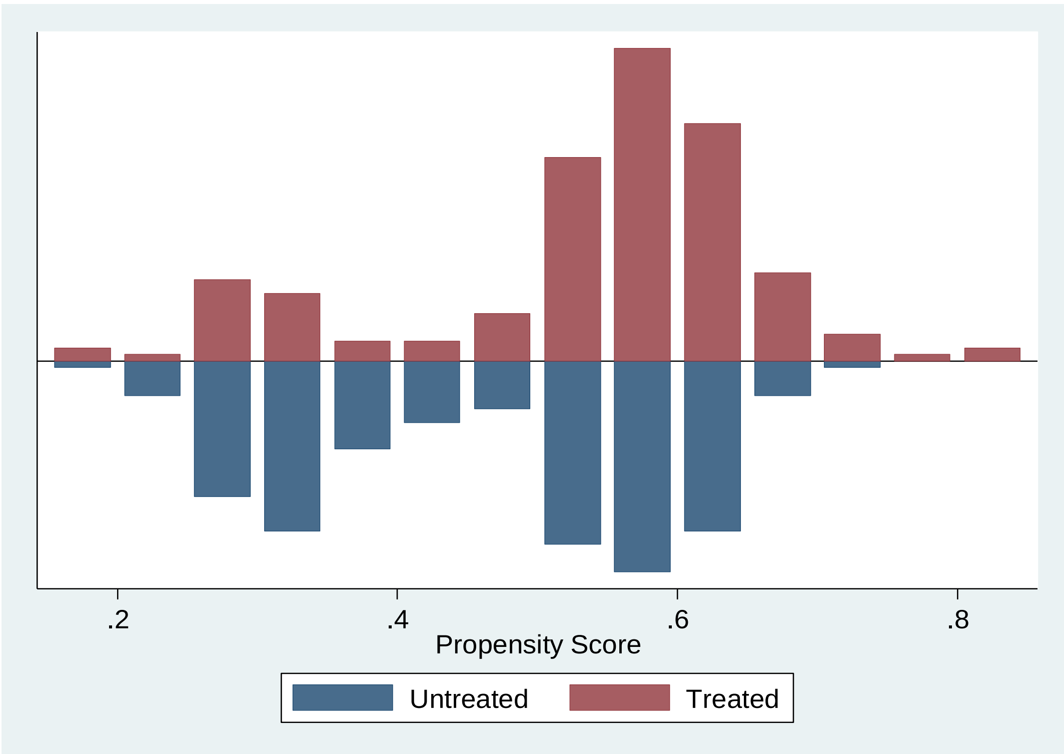


Figure 4.1 Region of common support between malt and food barley producing households respectively

4.2.4 Estimation of average treatment effect on treated (ATT)

Estimation of average treatment effect on the treated (ATT) was undertaken for the variable efficiency after tobit regression, the number of both groups were equal and values of all ATT estimations gave the same result (0.030). The matching with kernel, nearest neighbor, and radius has shown values of a probability of 3.128, 3.154 and 3.154 respectively which are found statistically significant, (Table 4.11). In nearest neighbor and radius the number of malt barley and food barley producing households refer to actual nearest neighbor matches, whereas analytical standard errors bootstrapped for kernel in 100 replications, (See appendix XVI - XVII).

Table (4.11) ATT effect on the matching for variable efficiency

Kind of matching	Number of malt barley group	Number of food barley group	ATT	Std.err.	T-value
ATT Kernel	169	169	0.030	0.010	3.128*
ATT Nearest	169	169	0.030	0.009	3.154*
ATT Radius	169	169	0.030	0.009	3.154*

* Statistically significant

4.2.5 The Impact of malt barley production on food security

Estimation of the levels of efficiency, income from barley and food expenditure was obtained from computations for matching using probit regression. Efficiency, income from barley & food expenditure were taken as an outcome variables. The common support on support for both malt and food barley producing households was 169 each. The estimation of propensity score shows T-statistics result of unmatched value 3.15, 1.57, and 4.79 to efficiency, income from barley, and food expenditure respectively. Whereas, ATT value is 1.70, 0.44, and 2.32 respectively, (Table 4.12). And the ATT results are found statistically significant, see appendix XIIIV-XIX.

Table 4.12 ATT result of efficiency, income/ha and food expenditure/adult equi.

Variable	**Sample**	**Malt B.**	**Food B.**	**Differenc e**	**S.E.**	**T-stat**
Efficiency	Unmatched	0.779850	0.749986	0.029864	0.009469	3.15
	ATT	0.779850	0.761550	0.018299	0.010751	1.70*
Income of	Unmatched	61,330.70	53,480.87	7,849.83	5,005.43	1.57

Variable	Sample	Malt B.	Food B.	Difference	S.E.	T-stat
barley per hectare	ATT	61,330.70	58,818.02	2,512.68	5,691.85	0.44*
Food expend per adult equivalent	Unmatched	6,816.69	4,783.44	2,033.25	424.14	4.79
	ATT	6816.69	5,542.76	1,273.93	548.69	2.32*

Note: S.E. does not take into account that the propensity score is estimated.
* Statistically significant

4.2.6 Stochastic frontier production function analysis

To generate the level of efficiency frontier analysis was used on the logarithmic variables that made unit of measurements unit less. In addressing the first specific objective of this study, which is to estimate level of efficiency in malt barley production, the frontier analysis was executed on variables transformed into logarithm to estimate the level of efficiency using STATA-13. The stochastic frontier model runs on 338 observations to generate the level of efficiency, out of which 169 are malt barley producing households. A Wald chi2 (9) = 654.52 and Prob 0.0000, shows that the model is robust enough. Log likelihood was equal to -161.57643. The p result for allocation of land size and plough frequency is significant at one percent. From this we can say that the level of efficiency in malt barley production by the respective households is significantly efficient due to allocation of more plot size and frequent plough, (Table 4.13).

Also the second specific objective, that is to identify variables affecting level of malt barley production efficiency, was evaluated in this result. The frontier analysis shows that grain yield increases as more size of land allocated, and by the use of optimum number of oxen days at 1%, and 5% significance level respectively. But the variables frequent plough and total labour used contributed negatively at 5% significance level showing that malt barley producing farmers dedicate more resource than food barley producing farmers expecting that they earn better from their produce.

Table 4.13 Stochastic frontier analysis result on logarithmic input & output variables

Lnyield	Coef.	Std. Err.	Z	P > z	Significance
Lnlandsize	0.9201981	0.0813730	11.31	0.000	***
Lnplowfrq	-0.2764309	0.1021884	-2.71	0.007	***
lnOxen	0.2283418	0.1298865	1.76	0.079	*
Lnlabortotal	-0.2530845	0.1461194	-1.73	0.083	*

Lnyield	Coef.	Std. Err.	Z	P > z	Significance
Lnseedsown	0.0070931	0.0766074	0.09	0.926	
lnNPS	0.0169932	0.0427935	0.40	0.691	
lnUrea	0.0084787	0.0133666	0.63	0.526	
Lnherbicide	0.0032789	0.0338937	0.10	0.923	
Lnfungicide	-0.0046400	0.0259627	-0.18	0.858	
_cons	8.7527710	0.4067220	21.52	0.000	
/lnsig2v	-2.2746710	0.1460850	-15.57	0.000	
/lnsig2u	-1.9820480	0.2926188	-6.77	0.000	
sigma_v	0.3206723	0.0234227			
sigma_u	0.3711964	0.0543095			
sigma2	0.2406175	0.0321568			
Lambda	1.1575570	0.0722117			

Likelihood-ratio test of sigma_u = 0: chibar2(01) = 6.42   Prob>= chibar2 = 0.006

4.2.7 Factors affecting efficiency of malt barley production

The "what makes malt barley producing farmers efficient in resource use decision" was assessed using a tobit regression on the efficiency of demographic factors. By taking the generated efficiency variable as an output tobit regression analysis was executed for the independent variables. The regressors include measures of the gender, age, level of education, training acquired, family size, experience of the households, amount of plot of land in hectare, and total livestock unit. This was undertaken on 338 observations. LR chi2(8) is 20.65. The value of probability greater than chi2 is equal to 0.0081, which is significant at 1%. Log likelihood = 351.97875. Psuedo R^2 value is -0.0302. Among the examined variables training has contributed positively at 1% significance level. And the p-value to the remaining independent variables was found homogenous, (Table 4.14).

Table (4.14) Factor affecting efficiency using tobit

Eff	Coef.	Std. Err.	T	P > t	Significance
Sexhh	0.007512	0.0203709	0.37	0.713	
Agehh	0.000197	0.0008391	0.24	0.814	
Eduhh	0.000649	0.0015671	0.41	0.679	
Trainhh	0.034118	0.0106552	3.20	0.001	***

Eff	Coef.	Std. Err.	T	P > t	Significance
Famsize	0.003537	0.0023819	1.48	0.139	
Exprience	-0.00133	0.0011319	-1.17	0.241	
Landsize	-0.01328	0.0096898	-1.37	0.171	
Tlu	0.001861	0.0019178	0.97	0.333	
_cons	0.724971	0.0337362	21.49	0.000	
/sigma	0.08541	0.0032846			

4.3 Food Security Analysis Component

Among the proposed food security component methods of analysis for this study Share of Food Expenditure Analysis (SFEA) was implemented to compute household's expenditure for food. Accordingly from the total expenditure of the households the ratio of expenditure for food revealed that in 2018 the food and malt barley producing households spent 49.55 and 50.45 percent of their income for food respectively per adult equivalent. The malt barley producing households spent a bit more by 1.05% than food barley producing households indicating that they have better income to spend on purchasing their foods, (Table 4.15).

The data on the type of foods that the respondents answered during surveying were similar in that they did not used sea foods like fish in their diet among the twelve types of food categorized.

Table 4.15 Total expenditures of food and non food items per adult equivalent, 2018.

Treatment	Food expenditure Per adult equivalent	Non food expenditure Per adult equivalent	% expenditure on food items	% expenditure on non food items
Food barley	5,750.81	5,238.52	49.57	49.55
Malt barley	5,849.35	5,332.69	50.42	50.45

CHAPTER FIVE: CONCLUSION AND RECOMMNDATION

5.1 Conclusion

This study was conducted to analyze farmer's resource use efficiency on malt barley production and its impact on food security in Lemuna-Bilbilo *wereda* on 338 sampled households. From the total 169 household heads were malt barley producing farmers. To analyze the resource use efficiency of the households Stochastic frontier analysis and propensity score matching analysis were employed in this study. To evaluate the impact of malt barley production, food expenditure analysis was performed using share of food expenditure analysis (SFEA). In addition, for analyzing the factors affecting decision making on use of farm resources demographic factors were conceptualized in this study.

Level of education was observed in t-test and have found positively significantly contributing, indicating that households producing malt barley have better education in terms of grade level. This concretely indicates that schooling rural areas implied on farmers proximity to agricultural technology to undertake their routine agricultural activities based on the recommendations provided by the respective agricultural research and development agents that ultimately trigger food security in the study area.

An asset and production characteristic of the households in both treatments was also assessed. The t-test result shows malt barley producing farmers in this area allocate more land size for their malt barley than food barley producing farmers, significantly at 5%. On the other hand, the cost of land preparation and use of inputs incurred on malt barley producing farmers is more than food barley producing farmers significantly at 5%. However the amount of grain yield they harvested is found more than food barley producing farmers being significant at 1%. This means the cost benefit ratio of malt barley producing farmers is better than food barley producing farmers.

The investigation on efficiency by comparing the two groups was undertaken based on the amount of grain yield obtained by the households using stochastic frontier. So, a t-test result after the stochastic frontier analysis revealed a probability of 0.0592 that shows malt barley producing farmers are efficient than food barley producing farmers in their resource use decision in the study area. This has its own contribution on the output in terms of grain harvested and income generated compared to food barley production. This shows that farmer's resource use decision has positive contribution on the production efficiency in malt barley.

The descriptive statistics carried out on use of farm inputs such as Urea and herbicides are applied more significantly at 5 and 10% respectively on malt barley than food barley. A t-test result for revenues in terms of grain yield and income generation show p-value of 0.0001 for both grain yield and income obtained from barley grains. On the other hand income obtained from TLU was also resulted into a p-value of 0.0000 showing that malt barley producing households get significantly better income than food barley producing farmers.

In the same way, when we compare the two groups based on food expenditure the expenditure for food by malt and food barley producing farmers was significant at 1%, revealing the revenue obtained by malt barley producing farmers made them capable to spend more Birr for food than food barley producing farmers. Based on these results obtained I conclude that malt barley producing households are efficient in their resource use decision and this has positively impacted their food security compared to food barley producing households in the study area.

5.2. Recommendations

As the cool temperature limits crop diversification in the study area a close follow up and support in technical and material issues are critical to the farmers. This support helps them maintain and scale up the production of malt barley both for themselves and the malting industry. Timely delivery of improved seeds, soil fertilizers and pesticides are important for the system because they are rain dependent and no irrigation scheme is in place in the study area. Preparing periodical trainings to the farmers on matters related to agronomic and marketing issues is vital. To achieve this both government and public partners should work together by strengthening the link between farmers and other stakeholders such as agricultural research, extension services, input supplies, financial services, cooperatives, malt factories, and marketing is vital to ensure households food security through better resource use decision of farmers and ultimately raise the production efficiency of malt barley crop in the study area. The research recommends that malt barley production should scaled up to combat food insecurity of the prevailing efficiency among farmers.

References

Abiro Tigabie, Chilot Yirga, and Jema Haji. (2017). *Determinants of technology adoption.* (Master's Thesis). The case of Oromia, Ethiopia).

AbrahamFeyissa (2011). Research achievements in barley cropping systems in Ethiopia. In Mulatu, B. and Grando, S. (eds). 2011. *Barley Research and Development in Ethiopia* (pp 127-134). Proceedings of the 2nd National Barley Research and Development Review Workshop.28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, Aleppo, Syria.pp xiv + 391.

Aikaterini Kokkinou (2010). A Note on Theory of Productive Efficiency and Stochastic Frontier Models. *European Research Studies,* Volume XIII, Issue (4)

Avtar Singh, Harmeet Singh, J. S. Kang and Jasvinder Singh ADVANCEMENT OF AGRONOMIC PRACTICES IN MALT BARLEY-A REVIEW (2014). *International Journal of Current Research Vol. 6, Issue, 02: 4921-4935*.

Bedada Begna, Mesay Yami, and Eshetu Lema (2014). Characterization of barley based farming system in the Arsi highlands, Ethiopia. *Journal of Agricultural Extension and Rural Development*, 8(10): 309-320.

Berhanu Kuma, Shenkut Ayele, Tilaye Teklewolde and Yalembirhan Molla, (2011). Achievements in barley technology transfer and extension in Ethiopia (pp377-391). In: Mulatu, B. and Grando, S. (eds). 2011. *Barley Research and Development in Ethiopia*. Proceedings of the 2nd National Barley Research and Development Review Workshop.28-30 November 2006, HARC, Holetta, Ethiopia.ICARDA, PO Box 5466, Aleppo, Syria.pp xiv + 391.

Chernet Asefa (2016). *Technical efficiency of smallholder faba bean farmers: the case of Kersa Malima district, Oromia regional state, Ethiopia* (Master's Thesis). St. Mary's University Addis Ababa, Ethiopia.

Danilo Mejía ed. (2014). *BARLEY: Post-Harvest Operations.* The Central Research Institute for Field Crops, Ulus, Ankara,Turkey FAO (Technical) p:2

E.G. Smith, T.K. Turkington, J.T.O'Donovan, M.J. Edney, P.E. Juskiw, R.H. McKenzie, K.N. Harker, G.W. Clayton, K. Xi, W.E. May, R.B. Irvine, S. Brandt, E.N. Johnson, and S. Perkovic (2016). Influence of production systems on return and risk from malt barley production in western Canada. *Can. J. Plant Sci. 96: 339–346.*

Eshetu Bekele.(2000). *The Undelying Causes of Household Food Insecurity and Coping strategies* (Master's Thesis). The Case of Ligambo *Wereda*, South Wollo Zone, Amhara Region, Northern Ethiopia.

Essa Chanie Mussa (2011). Economic efficiency of smallholder major crops production in the central highlands of Ethiopia (Master's thesis). Egerton University, Kenya.

GTP II (2016). National Plan Commission. Addis Abeba, Ethiopia.

Hearn, S. and Buffardi, A.L. (2016). '*What is impact?*' A Methods Lab publication. London: Overseas Development Institute.

INDDEX Project (2018), Data4Diets: Building Blocks for Diet-related Food Security Analysis. Tufts University, Boston, MA. https://inddex.nutrition.tufts.edu/data4diets. Accessed on 23 April 2019.

J.T. O'Donovan, M.S. Izydorczyk, B. Tidemann, M.J. Edney, T.K. Turkington, C.A. Grant, K.N. Harker, and Y. Gan (2017). Effect of preceding crop and nitrogen application on malt barley quality. *Can. J. Plant Sci. 97: 1014–1023.*

Karlsson, M., Sochor, J., Aapaoja, A., Eckhardt., J., Konig, D.(2017). Deliverable 4: *Impact Assessment* MAASiFiE project funded by CEDR.

Kassu Tadesse, Asrat Mekonnen, Almaz Admasu,Wubengda Admasu, Dawit Habte and Bahiru Tilahun (2018). Malt barley response to integrated organic and mineral nutrient sources in Nitisol. *International Journal of Recycling of Organic Waste in Agriculture* 7:125–134.

Katesuda Sitthisuntikul, Pradtana Yossuck, and Budsara Limnirankul (2018). How does organic agriculture contribute to food security of small land holders?: A case study in the North of Thailand. *Cogent Food & Agriculture*, 4: 1429698.

Kene Ezemenari, Anders Rudqvist, K. Subbarao (1999). Impact Evaluation: *A Note on Concepts and Methods*. PRMPO, Poverty Reduction and Economic Management Network The World Bank.

Messay M.(2016). Food security and livelihoods. Compiled note. Addis Abeba University.

Musa Hasen Ahmed, Kassahun Mamo Geleta, Aemro Tazeze & Eden Andualem (2017). The Impact of improved maize varieties on farm productivity and wellbeing: *evidence from the East Hararghe Zone of Ethiopia, Development Studies Research,* 4:1, 9-21.

OECD, (2014).*Assessing the impact of impact of state interventions in Research Techniques,* Issues and Solutions", unpublished.

Offspring Consulting Group and Kadale (2018).*Assessment of the Malt Barley Market System in Ethiopia*.Consultants (UK) Ltd. Business Innovation Facility (BIF). http://www.ifpri.org/publication/barley-value-chain-Ethiopia.

Samuel (2017). Value Chain Analysis of Malt Barley (Hordium): A way out for Agricultural Commercialization? The case of Lemu Bilbilo District, Oromia Region, Ethiopia. *Journal of Economics and Sustainable Development.* Vol.8, No.13, 2017.

Samuel Weldeyohanis Kifle (2016). Review on Barley Production and Marketing in Ethiopia. *Journal of Economics and Sustainable Development* 7, (9).

Sandra Ederveen (2016). Malt barley: a short-term cash crop or a sustainable investment? A study on the impact of CREATE project on the livelihood and food security of contracted smallholder farmers in Ethiopia. *International Development Studies, University of Utrecht. Word count: 26.2017.*

Tadesse Kasshun (2011). Malt barley marketing and malt production from barley in Ethiopia. In: Mulatu, B. and Grando, S. (eds). 2011. *Barley Research and Development in Ethiopia* (pp327-338). Proceedings of the 2nd National Barley Research and Development Review Workshop.28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, Aleppo, Syria. pp xiv + 391.

Tewodros Tefera, Girmay Tesfay, Eyasu Elias, Mulugeta, Diro and Irene Koomen (2016). Drivers for adoption of agricultural technologies and practices in Ethiopia - A study report from 30 *woredas* in four regions. *CASCAPE project report no. NS_DfA_2016_1,* Addis Ababa/Wageningen.

Tura Kaso (2015). Review of Barley Value Chain Management in Ethiopia. *Journal of Biology, Agriculture and Healthcare. Vol.5, No.10*

Wuletaw M. Kebede, Abebe D. Koye, Essa C. Mussa, Daniel T. Kebede (2017). The Roles of Institutions for Malt-Barley Production in Smallholder Farming System: The Case of Wegera District, Northwest Ethiopia. *International Journal of Agriculture and Forestry*, 7(1): 7-12.

Wuletaw Mekuria (2018). The link between agricultural production and population dynamics in Ethiopia: a review *Adv Plants Agric Res.* 8(2):349–353.

Appendix:

Appendix I: List of selected *kebeles* and number of sample households in proportion.

Rural kebele	Number of malt barley producer HHs	Sample household malt barley	sample household non malt barley
Dawa Bursa	367	32	32
Lemu michael	143	13	13
Lemu Dima	471	41	41
Bekoji Negeso	433	38	38
Chibaa Michael	516	45	45
Total	**1930**	**169**	**169**

Source: Field survey 2019.

Appendix II: Type of variables and their definitions

Variables	Definition
Yield	Obtained grain, measured as an output in kg
Sex	Gender of the household head
Age	Age of the farmer, measured in years.
Education level	Level of farmers education, measured in grades
Family size	Size of family members in the household, measured in numbers
Experience	Years of experience in malt barley farming, measured in years.
Plot size	Farm size, measured in hectares.
Plowing frequency	Repetition in ploughing, measured in numbers.
Oxen for ploughing	Oxen used during ploughing, measured in numbers.
Labour for ploughing	Man days used on land preparation, measured in numbers.
Labour for harvesting	Man days used on harvesting measured in numbers.
TLU	total livestock units, adjusted using conversion factors.
Seed used	Amount of seed sown, measured in kg
NPS used	NPS soil fertilizer used, measured in Kg.
Urea used	Urea soil fertilizer used, measured in Kg.
Herbicide used	Weed control chemicals used, measured in litres.
Fungicide used	Disease control chemicals used, measured in litres.
Income of barley	Amount of income obtained from barley grain, measured in Birr
Income of animal	Amount of income obtained from sales of animals and their products, measured in Birr
Nonfarm income	Amount of income obtained from off farm activities & remittance, measured in Birr
Food expenditure	Amount of birr spent for food items purchase, measured in Birr
Non food expenditure.	Amount of birr spent for non food items purchase, measured in Birr

Appendix III: Conversion factors used to compute the values of the livestock in to TLU (Tropical Livestock Unit)

Livestock type	TLU value
Sheep	0.090
Goat	0.090
Plough ox	1.100
Cow	0.800
Heifer	0.500
Bull	1.100
Calf	0.200
Donkey	0.360
Horse	0.800
Mule	0.800
Hen	0.013

Source: Sharp, (2003) and Strock *et al*., (1991) as cited in (Chernet, 2014).

Appendix IV: Logistic model test (model goodness of fit)

```
. logit  t  sexhh agehh eduhh trainhh exprience tlu famsize landsize, r

Iteration 0:   log pseudolikelihood = -234.28375
Iteration 1:   log pseudolikelihood = -221.57396
Iteration 2:   log pseudolikelihood = -221.52859
Iteration 3:   log pseudolikelihood = -221.52859

Logistic regression                               Number of obs   =        338
                                                  Wald chi2(8)    =      21.58
                                                  Prob > chi2     =     0.0058
Log pseudolikelihood = -221.52859                 Pseudo R2       =     0.0544
```

t	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.3651533	.5252264	0.70	0.487	-.6642716	1.394578
agehh	.0209035	.020757	1.01	0.314	-.0197796	.0615865
eduhh	.0385855	.0379096	1.02	0.309	-.0357159	.112887
trainhh	1.051717	.2710733	3.88	0.000	.5204231	1.583011
exprience	-.0264999	.0287968	-0.92	0.357	-.0829406	.0299409
tlu	.0278495	.048467	0.57	0.566	-.0671441	.1228431
famsize	.008999	.0595619	0.15	0.880	-.1077401	.1257381
landsize	.3196805	.2150611	1.49	0.137	-.1018314	.7411925
_cons	-2.169575	.8896586	-2.44	0.015	-3.913274	-.4258765

```
.
. estat gof
```

Logistic model for t, goodness-of-fit test

```
       number of observations =       338
 number of covariate patterns =       337
            Pearson chi2(328) =       337.92
                  Prob > chi2 =         0.3412

.
```

Appendix V: Result of PSM using probit regression

```
. psmatch2 t sexhh agehh eduhh trainhh famsize exprience landsize tlu
```

```
Probit regression                               Number of obs   =        338
                                                LR chi2(8)      =      25.35
                                                Prob > chi2     =     0.0014
Log likelihood = -221.60923                     Pseudo R2       =     0.0541
```

t	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.2050055	.3051628	0.67	0.502	-.3931027	.8031136
agehh	.0123796	.0126001	0.98	0.326	-.0123162	.0370754
eduhh	.0235499	.0235186	1.00	0.317	-.0225457	.0696456
trainhh	.6453577	.1611841	4.00	0.000	.3294426	.9612728
famsize	.0056335	.0357075	0.16	0.875	-.064352	.0756189
exprience	-.0154416	.017049	-0.91	0.365	-.048857	.0179739
landsize	.1983456	.1535697	1.29	0.197	-.1026455	.4993367
tlu	.0170794	.0287041	0.60	0.552	-.0391796	.0733384
_cons	-1.307869	.5072462	-2.58	0.010	-2.302053	-.3136847

Appendix VI: Result of propensity score matching test and its graph

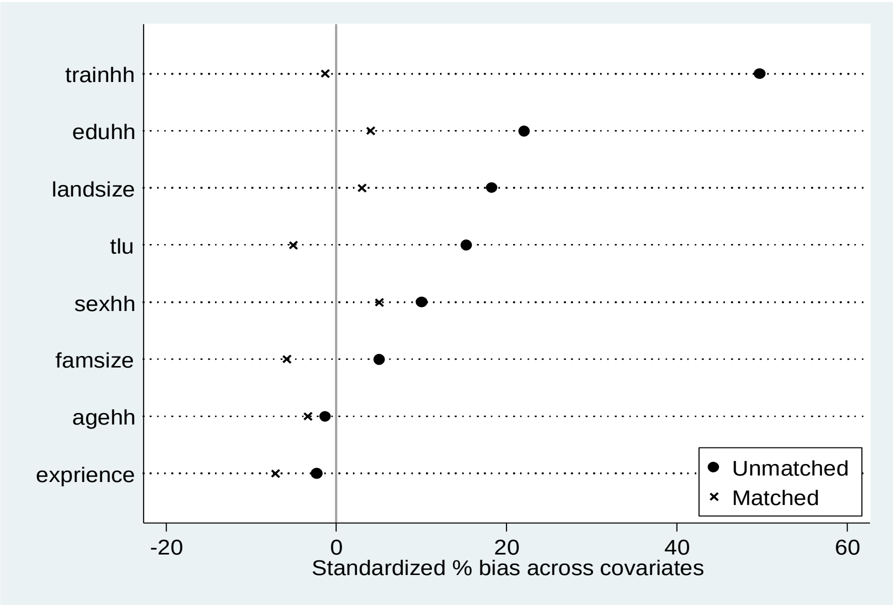
```
. pstest, graph both
```

Variable	Unmatched Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
sexhh	U	.95266	.92899	10.0		0.92	0.358	.
	M	.95266	.94083	5.0	50.0	0.48	0.629	.
agehh	U	45.669	45.822	-1.3		-0.12	0.903	1.12
	M	45.669	46.059	-3.4	-153.8	-0.31	0.760	1.07
eduhh	U	5.9349	5.1538	22.1		2.03	0.043	1.17
	M	5.9349	5.7929	4.0	81.8	0.37	0.712	1.18
trainhh	U	.82249	.60355	49.7		4.57	0.000	.
	M	.82249	.8284	-1.3	97.3	-0.14	0.886	.
exprience	U	20.988	21.178	-2.3		-0.21	0.832	0.95
	M	20.988	21.58	-7.2	-212.5	-0.64	0.522	0.84
famsize	U	6.7633	6.6509	5.0		0.46	0.643	1.23
	M	6.7633	6.8935	-5.8	-15.8	-0.53	0.594	1.19
landsize	U	.80112	.71065	18.3		1.68	0.094	1.94*
	M	.80112	.78633	3.0	83.6	0.28	0.783	2.02*
tlu	U	5.711	5.3134	15.3		1.41	0.161	1.46*
	M	5.711	5.8434	-5.1	66.7	-0.43	0.667	1.01

* if variance ratio outside [0.74; 1.35] for U and [0.74; 1.35] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.054	25.35	0.001	15.5	12.7	56.0*	0.92	33
Matched	0.003	1.61	0.991	4.4	4.5	13.8	1.46	17

* if B>25%, R outside [0.5; 2]



Appendix VII: Selection of common support using Pscore

. pscore t sexhh agehh eduhh trainhh exprience tlu famsize landsize, pscore(propensity) blockid(problock) comsup

```
****************************************************
Algorithm to estimate the propensity score
****************************************************
The treatment is t
```

Treatment	Freq.	Percent	Cum.
Food barley	169	50.00	50.00
Malt barley	169	50.00	100.00
Total	338	100.00	

Estimation of the propensity score

```
Iteration 0:   log likelihood = -234.28375
Iteration 1:   log likelihood = -221.63179
Iteration 2:   log likelihood = -221.60923
Iteration 3:   log likelihood = -221.60923

Probit regression                              Number of obs   =        338
                                               LR chi2(8)      =      25.35
                                               Prob > chi2     =     0.0014
Log likelihood = -221.60923                    Pseudo R2       =     0.0541
```

t	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.2050055	.3051628	0.67	0.502	-.3931027	.8031136
agehh	.0123796	.0126001	0.98	0.326	-.0123162	.0370754
eduhh	.0235499	.0235186	1.00	0.317	-.0225457	.0696456
trainhh	.6453577	.1611841	4.00	0.000	.3294426	.9612728
exprience	-.0154416	.017049	-0.91	0.365	-.048857	.0179739
tlu	.0170794	.0287041	0.60	0.552	-.0391796	.0733384
famsize	.0056335	.0357075	0.16	0.875	-.064352	.0756189
landsize	.1983456	.1535697	1.29	0.197	-.1026455	.4993367
_cons	-1.307869	.5072462	-2.58	0.010	-2.302053	-.3136847

```
Note: the common support option has been selected
The region of common support is [.16634342, .80888403]
```

Description of the estimated propensity score
in region of common support

Estimated propensity score

	Percentiles	Smallest		
1%	.215807	.1663434		
5%	.27136	.17129		
10%	.2912145	.179145	Obs	338
25%	.3747879	.215807	Sum of Wgt.	338
50%	.5459439		Mean	.5009924
		Largest	Std. Dev.	.1343428
75%	.6006975	.7413712		
90%	.6342652	.77478	Variance	.018048
95%	.6580645	.8069229	Skewness	-.5764288
99%	.7413712	.808884	Kurtosis	2.267872

****
Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
****
The final number of blocks is 5

This number of blocks ensures that the mean propensity score
is not different for treated and controls in each blocks
****
Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output
****
The balancing property is satisfied
This table shows the inferior bound, the number of treated
and the number of controls for each block

Inferior of block of pscore	Treatment Food barl	Malt barl	Total
.1663434	1	2	3
.2	63	26	89
.4	74	86	160
.6	31	53	84
.8	0	2	2
Total	169	169	338

Note: the common support option has been selected

****
End of the algorithm to estimate the pscore
****

Appendix VIII: Probit regression result on the demographic variables by treatment

```
. psmatch2 t sexhh agehh eduhh trainhh famsize exprience landsize tlu, outcome ( fdexadequ )

Probit regression                               Number of obs     =        338
                                                LR chi2(8)        =      25.35
                                                Prob > chi2       =     0.0014
Log likelihood = -221.60923                     Pseudo R2         =     0.0541
```

t	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.2050055	.3051628	0.67	0.502	-.3931027	.8031136
agehh	.0123796	.0126001	0.98	0.326	-.0123162	.0370754
eduhh	.0235499	.0235186	1.00	0.317	-.0225457	.0696456
trainhh	.6453577	.1611841	4.00	0.000	.3294426	.9612728
famsize	.0056335	.0357075	0.16	0.875	-.064352	.0756189
exprience	-.0154416	.017049	-0.91	0.365	-.048857	.0179739
landsize	.1983456	.1535697	1.29	0.197	-.1026455	.4993367
tlu	.0170794	.0287041	0.60	0.552	-.0391796	.0733384
_cons	-1.307869	.5072462	-2.58	0.010	-2.302053	-.3136847

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
fdexadequ	Unmatched	6816.69231	4783.44379	2033.24852	424.138467	4.79
	ATT	6816.69231	5542.76331	1273.92899	548.687033	2.32

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	169	169
Treated	169	169
Total	338	338

Appendix IX: Probit regression result taking income from barley as an output

```
. psmatch2 t sexhh agehh eduhh trainhh famsize exprience landsize tlu, outcome ( incomeperhectare )

Probit regression                                 Number of obs   =        338
                                                  LR chi2(8)      =      25.35
                                                  Prob > chi2     =     0.0014
Log likelihood = -221.60923                       Pseudo R2       =     0.0541
```

t	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.2050055	.3051628	0.67	0.502	-.3931027	.8031136
agehh	.0123796	.0126001	0.98	0.326	-.0123162	.0370754
eduhh	.0235499	.0235186	1.00	0.317	-.0225457	.0696456
trainhh	.6453577	.1611841	4.00	0.000	.3294426	.9612728
famsize	.0056335	.0357075	0.16	0.875	-.064352	.0756189
exprience	-.0154416	.017049	-0.91	0.365	-.048857	.0179739
landsize	.1983456	.1535697	1.29	0.197	-.1026455	.4993367
tlu	.0170794	.0287041	0.60	0.552	-.0391796	.0733384
_cons	-1.307869	.5072462	-2.58	0.010	-2.302053	-.3136847

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
incomeperhectare	Unmatched	61330.6983	53480.8711	7849.82722	5005.42908	1.57
	ATT	61330.6983	58818.0157	2512.68254	5691.85447	0.44

Note: S.E. does not take into account that the propensity score is estimated.

psmatch2: Treatment assignment	psmatch2: Common support On suppor	Total
Untreated	169	169
Treated	169	169
Total	338	338

Appendix X: Propensity Score Matching (PSM) and Average Effect with Matching Effect

. pscore t sexhh agehh eduhh trainhh exprience tlu famsize landsize, pscore(propensity) blockid(problock) comsup

```
****************************************************
Algorithm to estimate the propensity score
****************************************************
The treatment is t
```

Treatment	Freq.	Percent	Cum.
Food barley	169	50.00	50.00
Malt barley	169	50.00	100.00
Total	338	100.00	

```
Estimation of the propensity score

Iteration 0:   log likelihood = -234.28375
Iteration 1:   log likelihood = -221.63179
Iteration 2:   log likelihood = -221.60923
Iteration 3:   log likelihood = -221.60923

Probit regression                               Number of obs   =        338
                                                LR chi2(8)      =      25.35
                                                Prob > chi2     =     0.0014
Log likelihood = -221.60923                     Pseudo R2       =     0.0541
```

t	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
sexhh	.2050055	.3051628	0.67	0.502	-.3931027	.8031136
agehh	.0123796	.0126001	0.98	0.326	-.0123162	.0370754
eduhh	.0235499	.0235186	1.00	0.317	-.0225457	.0696456
trainhh	.6453577	.1611841	4.00	0.000	.3294426	.9612728
exprience	-.0154416	.017049	-0.91	0.365	-.048857	.0179739
tlu	.0170794	.0287041	0.60	0.552	-.0391796	.0733384
famsize	.0056335	.0357075	0.16	0.875	-.064352	.0756189
landsize	.1983456	.1535697	1.29	0.197	-.1026455	.4993367
_cons	-1.307869	.5072462	-2.58	0.010	-2.302053	-.3136847

```
Note: the common support option has been selected
The region of common support is [.16634342, .80888403]
```

Appendix XI: Estimation on propensity score matching

Description of the estimated propensity score
in region of common support

Estimated propensity score

	Percentiles	Smallest		
1%	.215807	.1663434		
5%	.27136	.17129		
10%	.2912145	.179145	Obs	338
25%	.3747879	.215807	Sum of Wgt.	338
50%	.5459439		Mean	.5009924
		Largest	Std. Dev.	.1343428
75%	.6006975	.7413712		
90%	.6342652	.77478	Variance	.018048
95%	.6580645	.8069229	Skewness	-.5764288
99%	.7413712	.808884	Kurtosis	2.267872

****
Step 1: Identification of the optimal number of blocks
Use option detail if you want more detailed output
****
The final number of blocks is 5

This number of blocks ensures that the mean propensity score
is not different for treated and controls in each blocks
****
Step 2: Test of balancing property of the propensity score
Use option detail if you want more detailed output
****
The balancing property is satisfied

This table shows the inferior bound, the number of treated
and the number of controls for each block

Inferior of block of pscore	Treatment Food barl	Treatment Malt barl	Total
.1663434	1	2	3
.2	63	26	89
.4	74	86	160
.6	31	53	84
.8	0	2	2
Total	169	169	338

Note: the common support option has been selected

****
End of the algorithm to estimate the pscore
****

Appendix XII: Frontier analysis on income of barley (malt, and food) crop

```
. frontier incombarley totplwcost seedcost NPSfertcost Ureacost Weedcost Fungicost harvestcost

Iteration 0:   log likelihood = -3948.9286
Iteration 1:   log likelihood = -3948.9286

Stoc. frontier normal/half-normal model          Number of obs    =        338
                                                 Wald chi2(7)     =     379.06
Log likelihood = -3948.9286                      Prob > chi2      =     0.0000
```

incombarley	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
totplwcost	13.36081	.7820655	17.08	0.000	11.82799	14.89363
seedcost	.3020766	2.502674	0.12	0.904	-4.603075	5.207228
NPSfertcost	-1.290384	2.876943	-0.45	0.654	-6.929088	4.348321
Ureacost	-1.353419	5.16884	-0.26	0.793	-11.48416	8.777322
Weedcost	2.075952	4.05585	0.51	0.609	-5.873367	10.02527
Fungicost	1.19314	3.114387	0.38	0.702	-4.910948	7.297227
harvestcost	1.472677	.3656514	4.03	0.000	.756013	2.18934
_cons	-468.0003	13352.69	-0.04	0.972	-26638.79	25702.79
/lnsig2v	20.52856	.0769231	266.87	0.000	20.3778	20.67933
/lnsig2u	-5.485979	498460.3	-0.00	1.000	-976969.8	976958.8
sigma_v	28689.37	1103.437			26606.18	30935.67
sigma_u	.0643776	16044.84			0	.
sigma2	8.23e+08	6.33e+07			6.99e+08	9.47e+08
lambda	2.24e-06	16082.75			-31521.61	31521.61

```
Likelihood-ratio test of sigma_u=0: chibar2(01) = 0.00   Prob>=chibar2 = 1.000
```

Appendix XIII: Tobit regression result for efficiency

```
. tobit eff sexhh agehh eduhh trainhh famsize exprience landsize tlu, ll(0) ul(1)

Tobit regression                                  Number of obs   =        338
                                                  LR chi2(8)      =      20.65
                                                  Prob > chi2     =     0.0081
Log likelihood =  351.97875                       Pseudo R2       =    -0.0302
```

eff	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
sexhh	.0075124	.0203709	0.37	0.713	-.0325607	.0475855
agehh	.0001973	.0008391	0.24	0.814	-.0014533	.0018479
eduhh	.0006488	.0015671	0.41	0.679	-.002434	.0037315
trainhh	.0341179	.0106552	3.20	0.001	.0131573	.0550786
famsize	.0035368	.0023819	1.48	0.139	-.0011487	.0082224
exprience	-.0013287	.0011319	-1.17	0.241	-.0035553	.0008979
landsize	-.0132799	.0096898	-1.37	0.171	-.0323414	.0057816
tlu	.0018608	.0019178	0.97	0.333	-.0019118	.0056333
_cons	.7249714	.0337362	21.49	0.000	.6586063	.7913364
/sigma	.0854097	.0032846			.0789482	.0918712

```
  Obs. summary:          0  left-censored observations
                       338     uncensored observations
                         0 right-censored observations
```

Appendix XIV: Variance inflation factor assessment result for food expenditure

```
. reg  fdexp  sexhh agehh eduhh trainhh exprience tlu famsize landsize, r

Linear regression                                   Number of obs =     338
                                                    F(  8,   329) =    9.31
                                                    Prob > F      =  0.0000
                                                    R-squared     =  0.3188
                                                    Root MSE      =  9318.3
```

fdexp	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sexhh	1950.049	2025.983	0.96	0.336	-2035.466	5935.564
agehh	-153.3079	75.01955	-2.04	0.042	-300.8864	-5.729414
eduhh	-281.2513	182.1678	-1.54	0.124	-639.6119	77.10927
trainhh	1713.729	1055.567	1.62	0.105	-362.7843	3790.242
exprience	261.0492	120.2654	2.17	0.031	24.46297	497.6355
tlu	534.4796	208.8783	2.56	0.011	123.5741	945.3852
famsize	894.4473	247.7848	3.61	0.000	407.0048	1381.89
landsize	9803.758	1535.812	6.38	0.000	6782.507	12825.01
_cons	2290.181	3678.363	0.62	0.534	-4945.897	9526.259

```
. estat vif
```

Variable	VIF	1/VIF
agehh	4.39	0.227708
exprience	3.99	0.250575
eduhh	1.43	0.696940
famsize	1.30	0.769879
tlu	1.15	0.868302
trainhh	1.08	0.928930
landsize	1.07	0.933503
sexhh	1.07	0.934154
Mean VIF	1.94	

.

Appendix XV: Linear regression result of demographic variables by treatment.

```
. reg t sexhh agehh eduhh trainhh exprience tlu famsize landsize , r

Linear regression                                      Number of obs =     338
                                                       F(  8,   329) =    3.38
                                                       Prob > F      =  0.0010
                                                       R-squared     =  0.0731
                                                       Root MSE      =  .48791
```

t	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
sexhh	.0816194	.121015	0.67	0.500	-.1564415	.3196803
agehh	.0047812	.0048116	0.99	0.321	-.0046842	.0142465
eduhh	.0090274	.0089159	1.01	0.312	-.0085119	.0265667
trainhh	.2489875	.0606722	4.10	0.000	.1296331	.3683419
exprience	-.0059395	.0065206	-0.91	0.363	-.0187668	.0068879
tlu	.0063853	.0112047	0.57	0.569	-.0156565	.0284272
famsize	.0020853	.0138015	0.15	0.880	-.0250651	.0292356
landsize	.0717382	.0461577	1.55	0.121	-.0190633	.1625396
_cons	-.0012793	.1995543	-0.01	0.995	-.3938426	.3912841

```
. estat vif
```

Variable	VIF	1/VIF
agehh	4.39	0.227708
exprience	3.99	0.250575
eduhh	1.43	0.696940
famsize	1.30	0.769879
tlu	1.15	0.868302
trainhh	1.08	0.928930
landsize	1.07	0.933503
sexhh	1.07	0.934154
Mean VIF	1.94	

.

Appendix XVI: Matching by radius for efficiency.

```
. attr eff t

 The program is searching for matches of treated units within radius.
 This operation may take a while.
```

ATT estimation with the Radius Matching method
Analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
169	169	0.030	0.009	3.154

Note: the numbers of treated and controls refer to actual matches within radius

Appendix XVII: Matching by nearest neighbor for efficiency.

```
. attnd eff t

 The program is searching the nearest neighbor of each treated unit.
 This operation may take a while.
```

ATT estimation with Nearest Neighbor Matching method
(random draw version)
Analytical standard errors

n. treat.	n. contr.	ATT	Std. Err.	t
169	169	0.030	0.009	3.154

Note: the numbers of treated and controls refer to actual nearest neighbour matches

Appendix XVIII: Do file used to undertake analysis in STATA-13.

```
ttest agehh, by(t)
ttest eduhh, by(t)
ttest exprience, by(t)
ttest famsizehh, by(t)
ttest landsize, by(t)
ttest tlu, by(t)
ttest yield, by(t)
ttest fdexp, by(t)
ttest nonfdexp, by(t)

tab sexhh t, cchi row
tab trainhh t, cchi row
tab attitude t, cchi row
tab credithh t, cchi row
tab plowby t, cchi row

gen lnyield= ln(yield)
gen lnlandsize= ln(landsize)
gen lnplowfrq= ln(plowfrq)
gen lnOxen= ln(Oxen)
gen lnlabortotal= ln(labortotal)
gen lnseedsown= ln(seedsown)
gen lnNPS= ln(NPS)
gen lnUrea= ln(Urea)
gen lnherbicide= ln(herbicide)
gen lnfungicide= ln(fungicide)

replace lnUrea=0 if (lnUrea>=.)
replace lnfungicide =0 if ( lnfungicide >=.)
frontier lnyield lnlandsize lnplowfrq lnOxen lnlabortotal lnseedsown lnNPS lnUrea lnherbicide l
> nfungicide
predict eff, te
sum eff
ttest eff, by(t)
ttest fdexp, by ( t )

psmatch2 t sexhh agehh eduhh trainhh famsize exprience landsize tlu, outcome (eff)
tobit eff sexhh agehh eduhh trainhh famsize exprience landsize tlu, ll(0) ul(1)
attnd eff t
attr eff t
attk eff t
attk eff t, comsup boot reps(100)
logit  t  sexhh agehh eduhh trainhh exprience tlu famsize landsize, r
attnd fdexp t
attr fdexp t
attk fdexp t, comsup boot reps(100)
psmatch2 t sexhh agehh eduhh  trainhh exprience famsize landsize tlu
pstest, graph both
psgraph
logit  t  sexhh agehh eduhh trainhh exprience tlu famsize landsize, r
estat gof
reg sexhh agehh eduhh trainhh exprience tlu famsize landsize, r
estat vif
```

Appendix XIX: Questionnaires

Adis Abeba University, College of Development Studies

Center for Food Security Studies

Analysis of farmer's resource use efficiency on malt barley production and its impact on food security in Lemuna-Bilbilo *wereda*, Ethiopia.

Farm Household Survey Questionnaire (2018/19 cropping season)

This questionnaire is designed to collect farm household data on malt barley production activities to use it as an input for the aforementioned study in Partial Fulfillment of the Requirements for Degree of Master of Science (M.Sc.) in Food Security. Therefore, the answers you give will be used for this (research) purpose only and will at all times remain completely confidential, and please be assured that you cannot be identified, nor can your views directed back at you. We are only interested in 'what was said', not 'who said it'.

Reminder for the enumerator:

1. Introduce yourself before the interview
2. Briefly tell the respondent about the purpose of this interview
3. Create conducive environment (place &seat)
4. Make sure that the respondent is able to understand the question
5. At the end of your interview, acknowledge the respondent

I. Interview Background

Name of the enumerator: ______________________

Date of interview: ______________________

Wereda: *Lemuna-Bilbilo*

Kebele: ______________________

Sub-*kebele* ______________________

II. Questions for the household head that produce malt barley ***in 2010/11E.C***

A	1. Name of respondent Mr/Mss. ....
	2. Sex a) Male b) Female
	3. Family size Male.......... Female.......... Sum........
	4. Educational level a) No b) Elementary c) High-school d) College
	5. Have you got training on malt barley a) Yes b) No
	6. Age of family members (0-2) ...., (3-5) ...., (6-10) ...., (11-18) ...., > 18 ....
	7. Experience in m/b production ....year
	8. Purpose of malt barley production a) Consumption b) income. c) profit d) diversification
	9. Attitude in malt barley production a) positive b) negative)
	10. Merits of produce malt barley? a) high yield b) good quality c) high income d) other ....

B	11. Access to credit a) Yes ....b) No ....
	12. If yes, from where do you get it? ....

C	13. Farm size allocated for malt barley...............hectare
	14. Yield obtained from..........................(Qt)
	15. Malt-barley for home consumption.................. (Qt)
	16. Amount of malt barley sold.............. (Qt)
	17. Mode of sale a) Contract b) Open market
	18. Rejected due to poor quality............. (Qt)

	19. Money earned from sales of malt-barley .... Birr
	20. Type of meals used: *Cereals*☐, *Fish and seafood*☐, *Root and tubers*☐, *Pulses/legumes/nuts*☐, *Vegetables,*☐, *Milk and milk products*☐, *Fruits*☐, *Oil/fat*☐ *Meat*☐, *poultry*☐, *offal*☐, *Sugar/honey, Eggs, and Miscellaneous.*

D	21. Yield obtained from other crops Potato........./ food barley............../ other...................... (Qt)
	22. Amount planed for home consumption Potato....../ food barley......./other ....(Qt)
	23. Income from Casual employment................... Birr 24. other (Remittance) .... Birr
	25. Income from sales of **other** crops grain Potato/food barley/other etc........................... Birr
	26. Income from sales of **other** commodities Firewood/charcoal etc................................ Birr

E	27. Livestock holding (in number) Cattle............./ Sheep ..../ Horse........... other ....
	28. Income from livestock sales (in Birr)..........Cattle...../ Sheep ..../ Horse.... other..................
	29. Income from sales of products (Birr) Milk...........Butter..........Cheese............Eggs..... Honey........
	30. Income from remittance …... Birr

F	31. Expense for (*Salt, Edible oil, Sugar, Coffee* .... Birr
	32. Purchasing vegetables................................ Birr
	33. Purchasing meat ....Birr
	34. Medical care expenditures........................... Birr

	35. Purchasing spices........................... Birr
	36. Cost for light energy (Candle/fuel/battery/electricity)........................ Birr
	37. School fee...................................... Birr
	38. Tax payment.............. ....Birr
	39. Expense for soap/detergent purchasing.................... Birr
	40. Ceremonials expenditures (Wedding/holidays/religious festivals)............. Birr
	41. Expense for cloth purchasing........... Birr
	42. Transport cost.................................Birr
	43. Social commitment payments (Edir/ Mahiber) Per month.............................. Birr

G	44. Malt barley Seed purchasing...........................Birr
	45. Fertilizer purchase for malt barley.....Birr
	46. Herbicides purchasing.................................... Birr
	47. Fungicides purchasing for malt barley .... Birr
	48. Machinery rent (Tractor/Combiner) .... Birr

III. Questions for the household head that do not produce *malt barley in 2010/11E.C*

A	1. Name of respondent Mr/Mss. .
	2. Sex a) Male b) Female
	3. Family size Male ....Female...... Sum....
	4. Educational level a) No..... b) Elementary..... c) High-school..... d) College......
	5. Have you got training on food barley a) Yes.......b) No...........
	6. Age of family members (0-2) ...., (3-5) ...., (6-10) ...., (11-18) ...., > 18 ....
	7. Experience in food barley production........
	8. Purpose of food barley production a) consumption b) income. c) profit d) diversification
	9. Attitude in malt barley production a) positive b) Negative
	10. Why not you produce malt barley? a) low yield b) poor quality c) low income d) Other ......

B	11. Access to credit a) Yes .... b) No.......
	12. If yes, from where do you get it? ....

C	13. Farm size allocated for crop production...............ha
	14. Grain yield obtained................ (Qt)
	15. Grain allocated for home consumption............. (Qt)
	16. Amount of grain sold.............. (Qt)
	17. Mode of sale a) Contract b) Open market
	18. Rejected due to poor quality.............. (Qt)
	19. Money earned from sales of food-barley .... Birr

	20. Type of meals used: *Cereals*☐, *Fish and seafood*☐, *Root and tubers*☐, *Pulses/legumes/nuts*☐, *Vegetables*☐, *Milk and milk products*☐, *Fruits*☐, *Oil/fat*☐ *Meat*☐, *poultry*☐, *offal* ☐, *Sugar/honey, Eggs, and Miscellaneous.*

D	21. Yield obtained from food barley & other crop Food barley..........Potato........./ other crop........(Qt)
	22. Amount planed for home consumption Potato........./ food barley................/other................(Qt)
	23. Income from Casual employment.................... Birr 24. Other (Remittance) .... Birr
	25. Income from sales of grain of **other** crops Potato/ other etc.................................... Birr
	26. Income from sales of **other** commodities, firewood/charcoal etc.............................. Birr

E	27. Livestock holding (in number) Cattle................/ Sheep ..../ Horse .... other................
	28. Income from livestock sales (in Birr)Cattle.............../ Sheep ..../ Horse........... other.............
	29. Income from sales of products (Birr) Milk.........Butter.........Cheese........ Eggs........Honey........
	30. Income from remittance…........................ Birr

F	31. Expense for (*Salt, Edible oil, Sugar, Coffee* .... Birr
	32 Purchasing vegetables................................ Birr

	33. Purchasing meat ....Birr
	34. Medical care expenditures........................... Birr
	35. Purchasing spices.............................. Birr
	36. Monthly cost for light energy (Candle/fuel/battery/electricity)........... Birr
	37. School fee... Birr
	38. Tax payment.................................... Birr
	39. Expense for soap/detergent purchasing .... Birr
	40. Ceremonials expenditures (Wedding/holidays/religious festivals)............. Birr
	41. Expense for cloth purchasing........... Birr
	42. Transport cost...................... Birr
	43. Social commitment payments (Edir/ Mahiber) Per month................... Birr

G	44. Food barley Seed purchasing............................ Birr
	45. Fertilizer purchase for food barley................... Birr
	46. Herbicide purchase for food barley.................. Birr
	47. Fungicides purchasing for food barley .... Birr
	48. Machinery rent (Tractor/Combiner) .... Birr