# ADOPTION OF IMPROVED SOYABEAN VARIETIES: THE CASE OF BUNO BEDELE AND EAST WOLLEGA ZONES OF OROMIA REGION, ETHIOPIA

**MSc THESIS**

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# Adoption of Improved Soyabean Varieties: The Buno Bedele and East Wollega Zones of Oromia Region, Ethiopia

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*I dedicate this piece of work in memory of my late sister Hinsene Abebe for her kindness, devotion and endless support. Let God keep her soul in Heaven.*

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# ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| BARC | Bako Agricultural Research Center |
| BCR | Benefit Cost Ratio |
| CIMMYT | International Maize and Wheat Improvement Center |
| CSA | Central Statistical Agency |
| DARD | District Agriculture and Rural Development |
| DSA | Development Studies Associates |
| FAO | Food and Agriculture Organization |
| FDRE | Federal Democratic Republic of Ethiopia |
| GDP | Gross Domestic Product |
| MT | Metric Tone |
| MoARD | Ministry of Agriculture and Rural Development |
| MRR | Marginal Rate of Return |
| N2Africa | Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa |
| NFI | Net Farm Income |
| NGO | Non-Governmental Organization |
| NPV | Net Present Value |
| OARI | Oromia Agricultural Research Institute |
| TLU | Tropical Livestock Unit |

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**ADOPTION OF IMPROVED SOYA BEAN VARIETIES: THE CASE OF BUNO BEDELE AND EAST WOLLEGA ZONES OF OROMIA REGION, ETHIOPIA**

## *ABSTRACT*

*Achieving national food security and diversifying export earnings from agricultural products is one of the major challenges currently facing developing countries like Ethiopia. Pulse crops in general and soya bean in particular play great role in improving households' food security, increasing income for smallholder farmers. Despite the high production potential and the economic importance of the crop, adoption and dissemination of improved soya bean varieties is constrained by various factors. To this end, this study aimed at identifying determinants of adoption of improved soya bean varieties in Chewaka and Gobusayo districts, Buno Bedele and East Wollega zones of Oromia Region, Ethiopia with the specific objectives of identifying factors affecting adoption and intensity of adoption of improved soya bean varieties. The study was based on cross sectional data collected from 146 randomly selected soya bean producing farmers. Descriptive and econometric analyses were used to analyze data. The results show that about 32.88% and 67.12% were adopters and non-adopters of the crop respectively. Double hurdle model results showed that sex of household, age, education level, farm experience and training affected the probability of adoption of improved soya bean varieties positively and significantly while distance to nearest market affects it negatively and significantly. Age, farm experience, training and livestock holding affected the intensity adoption of improved soya bean varieties positively and significantly. This study suggests that the high importance of institutional and government support in the areas of education, extension service, training, infrastructural development (especially roads) and credit. Therefore, policy and development interventions should give emphasis to the improvement of such institutional support system and decrease gender disparities in access to such institutions so as to achieve the adoption practice which increases production and productivity of small scale farmers.*

**Keywords:** Adoption, intensity of adoption, soya bean, double hurdle

# 1. INTRODUCTION

## 1.1. Background of the study

Agriculture is a dominant sector of Ethiopian economy which makes a lion share contribution to the Gross Domestic Product, employment and foreign exchange earnings. Agriculture is still believed to remain a sector that plays an important role in stimulating the overall economic development of the country in the years to come. This would be realized if and only if strenuous efforts are made by the government and other concerned stakeholders including farmers to increase agricultural production and productivity (CSA, 2016).

Several factors can influence agricultural production and productivity improvement. Among other factors, the increased use of modern farm inputs, modernization of farming activities by using improved farm implements as well as introduction of modern farming technologies to the sector are the major ones. In order identify, plan, implement and monitor agricultural projects and programs, availability of reliable, comprehensive and timely statistical data on the overall performance of the sector is essential (CSA, 2016).

In many developing countries including Ethiopia, agriculture plays a vibrant role in promoting economic growth and development. The importance of agriculture in Ethiopia is evidenced by its share in GDP (43%), its employment generation (80%), share of export (70%) and providing about 70% raw material for the industries in the country in 2012/13(UNDP, 2013). Furthermore, 90% of the poor earn their livelihood from this sector (Yu *et al*,. 2011). Thus, it is not surprising that policy action in Ethiopia is largely based on influencing the dynamism of the agricultural sector.

Ethiopian agriculture is dominated by subsistence, low input, low output, rainfed farming system. The use of chemical fertilizer and improved seeds is quite limited despite government’s efforts to encourage the adoption of modern, intensive agricultural practices. Low agricultural productivity can be attributed to limited access by smallholder farmers to agricultural inputs, financial services, improved production technologies, irrigation and agricultural markets and more importantly poor land management practices that have led to severe land degradation (MoARD, 2010).

Following these facts, successive Ethiopian governments have focused on promoting technology-led initiatives to enhance productivity, particularly in smallholder agriculture (FDRE, 2010). Crop production is a subsector on which the country has unfailingly depended to bring about a livelihood transformation of the poor. Currently, the government is undertaking a strategy of improving agricultural productivity primarily through agricultural intensification, involving an increased use of inputs, including seeds of improved crop varieties.

Soya bean is a multipurpose crop, which can be used for a variety of purposes including preparation of different kinds of soya bean foods, animal feed, soy milk, raw material for the processing industry, and it counter effects depletion of plant nutrients in the soil resulting from continuous mono-cropping of cereals, especially maize and sorghum, thereby contributing to increasing soil fertility (Hailegiorgis, 2010). Producing and consuming more soya bean would improve food insecurity and malnutrition as soya bean provides a nutritious combination of both calorie and protein intake. It is the most nutritionally rich crop, as its dry seed contains the highest protein and oil content among grain legumes (40 to 42% protein) with a good balance of the essential amino acids and has 18-20% oil on a dry seed weight basis (FAO 2010).

Soya bean is a high value and profitable crop. The economic viability of soya bean production is determined by the commercial utilization of both its sub-products, meal and oil, which, respectively, account for about two thirds and one third of the crop's economic value. Soya bean oil and meal is consumed worldwide as food and animal feedstuff respectively (FAO, 2015).

Despite the significance of soya bean to address food security and malnutrition problems prevailing in the country, little emphasis has been given to production, supply and export of this important commodity. The major areas currently growing the soya bean are western and south-western part of the country, notably Benishangul-Gumuz, Gambela and parts of Oromia Region. Oromia and Benishangul-Gumuz regions account for the highest production of soya bean in the country, 51% and 40% respectively (Sopov, M. et al., 2015). From Oromia region Chewaka and Gobusayo are potential producers of soya bean and no study was conducted on adoption and intensity of adoption of improved soya bean varieties previously in this areas. This study therefore conducted to examine the determinants of adoption and intensity of adoption of improved soya bean varieties with a purpose of generating information that help understand and evaluate the key challenges to the adoption of improved soya bean in the study areas which will enhance informed decision making to improve adoption of soya bean, their production and by increasing productivity in the study areas.

## 1.2. Statement of the Problem

Though soya bean can be grown in different parts of Ethiopia, the major areas currently growing the crop are situated in the western and south-western part of the country, notably Benishangul-Gumuz, Gambela and parts of Oromia Region. Oromia and Benishangul-Gumuz regions account for the highest production of soya bean in the country, 51% and 40% respectively (Sopov, M. et al., 2015). Chewaka and Gobusayo districts of East Wollega and Buno Bedele zones of Oromia region are the potential area for production of soya bean. BARC and N2 Africa project promoted improved varieties of soya bean (Dedessa, Katta, jalale and Ethio-Yugoslavia) for the last four years.

The major challenges facing most of developing countries such as Ethiopia is improving rural livelihoods as well as food security and to stimulate underlying food system development. There is an ever-increasing concern that it is becoming more and more difficult to achieve and sustain the needed increase in agricultural production based on intensification, because there are limited opportunities for area expansion. Hence, the solution to food insecurity problem would depend on measures which help to increase yield through intensification. In Ethiopia, adoption of improved agricultural technologies has been a long term concern of agricultural experts, policy makers, and agricultural research and many others linked to the sector. However, evidence indicates that adoption rate of modern agricultural technologies in the country is very low (Kebede *et al*., 1990).

Adoption of agricultural innovations in developing countries attracts considerable attention because it can provide the basis for increasing production and income. Small-scale farmers' decision to adopt or reject agricultural technologies depends on their objectives and constraints as well as costs and benefits accruing to it (Million and Belay, 2004). Hence, farmers will adopt only technologies that suit their needs. Several factors influence adoption of agricultural technologies. Among these, economic factors (farm size ,farm income ,livestock ownership and off /non-farm income), social factors **(**sex, education, age and labor availability), institutional factors ( distance to market, access to market, access to credit, extension contact, demonstration, training and participation on field day) are the main variables that affect adoption and intensity of adoption.

Chewaka and Gobusayo districts are mainly characterized by irregular rainfall condition, meagre resource endowment, and diverse, complex and risk prone farming systems. Agriculture in the area is mainly rainfed. The nature of the rainfall is also erratic, low in amount and uneven in distribution. As a result, crop production has become unpredictable and unsatisfactory which leads to food insecurity. Food security of the majority of rural farmers can be improved if the performance of the agricultural sector is enhanced.

Improvement and diffusion of soya bean varieties have an invaluable role in reversing the present situation of food insecurity in the study areas. To this end, improved soya bean varieties have been generated and promoted for five years in the study areas. Promotion and diffusion activities have been continued still now. N2Africa project being executed by BARC is one of the major efforts extended to the farmers which aimed at improving soya bean productivity in the study areas. The project mainly promoted improved soya bean varieties. Despite such an intervention the adoption of improved soya bean varieties is still very low and there is also variation among farmers in their intensity of adoption. Moreover, there is no empirical information on the various factors determining adoption, intensity of adoption of improved soya bean varieties in the study areas. Therefore, this study was proposed to identify the determinants of adoption and intensity of adoption of improved soya bean varieties to fill the existing knowledge gap

The study tries to answer the following research questions:

1. What are the determinants of adoption of improved soya bean varieties in the study areas?
2. What are the determinants of intensity adoption of improved soya bean varieties in the study areas?

## 1.3. Objectives of the Study

The general objective of the study was to analyze the determinants of adoption and intensity of adoption of improved soya bean varieties.

The specific objectives of the study were:

1. To identify factors affecting adoption of improved soya bean varieties in the study areas
2. To identify factors affecting intensity of adoption of improved soya bean varieties in the study areas

## 1.4. Scope and Limitations of the Study

The time and financial resource limitations have forced the researcher to limit the study to only two districts of the Oromia Region. Accordingly, the study was confined only to Chewakka and Gobusayo districts with specific crop category soya bean. The generalizations made based on the findings would be more applicable to the location of the study. In addition, the result of this study might be applicable to other areas of the region and the country where similar situations may prevail.

The study focused only on adoption and intensity of adoption of improved soya bean varieties. Therefore it was restricted to identifying the determinants of adoption and intensity of adoption of improved soya bean varieties in the study areas. In addition, this study was also limited in terms of finance, time, resource availability and being cross-sectional data. Nevertheless, the result of this study has practical validity mainly to areas having similar features and can be used as a reference for other similar areas.

## 1.5. Significance of the Study

Farmers are not always adopting the newly introduced technologies that come to them from any extension organization as it is. They try to evaluate according to its match with their social, environment and economic importance. So understanding these factors is important for the scientists to develop and generate agricultural technologies, which suits to the current conditions of farmers. There are several reasons to invest in studying the adoption of agricultural technologies. These include improving the efficiency of technology generation, assessing the effectiveness of technology transfer, understanding the role of policy in the adoption of new technology, and demonstrating the impact of investing in technology generation.

Soya bean is one of the crops which are produced in the study areas. It has a multi-purpose utilization type by the farmers. In the research areas various soya bean technologies have been promoted by BARC in collaboration with N2Africa project. However, the flow of research outputs has been uni-directional for long time. The participation of farmers in technology development through provision of their preference and incorporation of local idea was very limited otherwise non-existent. Now it is known that adoption and intensity of adoption of improved soya bean varieties is conditioned on socioeconomic, institutional and farmers' perceptions. Therefore, the study tried to identify important factors which hinder success in the adoption and intensity of use of improved soya bean varieties. All development partners like technology generators, technical assistants, extension agents, policy makers, NGOs (especially N2 Africa project) and development agents involved in agricultural development must be aware and understand the factors affecting the adoption of improved soya bean varieties and level of adoption of improved soya bean varieties. Policy makers will benefit from the research output since they require micro level information to formulate and revise policies and strategies. This could facilitate allocation of major resources for research, extension and development programs.

## 1.6. Organization of the Thesis

The thesis is organized in to seven chapters. The first chapter introduces the background, statement of the problem, the objective, research question as well as the scope and limitation of the study. The theoretical framework, analytical framework and relevant literature are reviewed in the second chapter. The third chapter discusses the research methodology used to undertake the study. Results are presented and discussed in the fourth chapter. Chapter five present summary, conclusion and recommendations. The last two chapters present the references and appendixes respectively.

# 2. LITERATURE REVIEW

In this chapter, key concepts, theoretical explanations and empirical evidences relating to technology adoption are explored. The chapter is divided into seven sections. The first section discusses the definition of basic terms of adoption followed by concepts of current demand and supply and the role of soya bean in food security in Ethiopia. The fourth section shows an overview of production and productivity gaps of soya bean in Ethiopia. The remaining three sections discuss a review of analytical studies on adoption for analyzing factors affecting adoption and intensity of adoption of improved soya bean varieties on the basis of the insights gained from literature review and the actual context of the study areas, empirical studies and conceptual framework on adoption of technologies.

## 2.1. Definition of Basic Terms

**Adoption:** Adoption of an innovation within a social system takes place through its adoption by individuals or groups. According to Feder *et al*. (1985), adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. Dasgupta (1989) noted that adoption, however, is not a permanent behavior. This implies that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional, and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs. Feder *et al*. (1985) classified adoption as an individual (farm level) adoption and aggregate adoption. Adoption at individual farmers' level is defined as the degree of use of new technology in long run equilibrium when the farmer has full information about the new technology and it's potential. In the context of aggregate adoption behavior they defined diffusion process as the spread of new technology within a region. This implies that aggregate adoption is measured by the aggregate level of specific new technology with a given geographical area or within the given population.

**Adoption Process:** Rogers (1983) defines the adoption process as the mental process through which individual passes from first hearing about an innovation or technology to final adoption. This indicates that adoption is not a sudden event but a process. Farmers do not accept innovations immediately; they need time to think over things before reaching a decision.

**Rate of adoption:** The rate of adoption is defined as the percentage of farmers who have adopted a given technology. The intensity of adoption is defined as the level of adoption of a given technology. The number of hectares planted with improved seed (also tested as the percentage of each farm planted to improved seed) or the amount of input applied per hectare will be referred to as the intensity of adoption of the respective technologies (Nkonya *et al*, 1997).

## 2.2. Demand and Supply of Soya bean in Ethiopia

According to Sopov, M. *et al.*, 2015, Ethiopia produced an estimated volume of 150,000 tons in 2014/15, the result of combined production by smallholders and commercial farmers. The growth in production is attributed mainly to the increase in area cultivated and productivity. The total area of land under soya bean production during the last 10 years has increased tenfold, while the total volume of production during the same period increased 21 times. Productivity level of soya bean is 2.1 tons per hectare and this level is very low compared to its potential, which could go up to 4 tons per hectare if improved varieties are used. Though soya bean can be grown in different parts of Ethiopia, the major areas currently growing the crop are situated in the western and south-western part of the country, notably Benishangul-Gumuz, Gambela and parts of Oromia Region. Oromia and Benishangul-Gumuz regions account for the highest production of soya bean in the country, 51% and 40% respectively.

Over the last several years, soya bean production has doubled from 35,000 metric tons in MY11/12 to 72,000 metric tons in MY14/15. Most of this growth in production was due to an increase in the area planted and to a lesser extent improved yields. Owing to the late rains and uneven rainfall distribution in some of the main soya bean-producing areas, production for MY 2015/16 is forecast downward to 66,000 metric tons, a drop of 6,000 metric tons from previous year. Going forward, production is expected to rebound and continue its upward climb in order to meet some of the increasing local demand for edible oil and soya bean meal for livestock feed, most notably soya bean meal for poultry production. These anticipated increases in production will come with improved yields and expanded acreage planted in soya beans, some of which will be done on commercial farms.

Soya beans contribute nearly 9 percent to the country's total oilseed production and account for only 4 percent of area planted to oilseeds (FAS/Addis Staff, 2016).

Soya bean consumption, which continues to grow, is forecast to reach 41,000 metric tons in MY15/16. Consumption is expected to continue its upward climb as consumers demand more soy-based edible oil and as the poultry sector demands more soya bean meal. In addition to oil, soya beans are used to make a variety of local foods, such as bread, chappati, porridge, soy milk, yoghurt as well as the traditional Ethiopian stew, *shero wot*. Soya beans are also used to make corn-soy blend (CSB) for emergency food assistance programs run by international organizations and the Ethiopian government.

Table 1: Supply and demand of soya bean (Qt)

| Year | Supply | Demand |
|---|---|---|
| 2014/15 | 72,000 | 113,810 |
| 2015/16 | 81,241 | 119,500 |
| 2016/17 | 81,234 | 125,470 |

Source: CSA (2017)

## 2.3. The Role of Soya bean in Food Security

Despite the enormous progress over recent years, much of Ethiopia's rural population lives in a state of chronic food insecurity and malnutrition. Average daily energy intake is estimated at 16–20% below the accepted minimum, while diseases due to nutrient deficiencies are widespread. Malnutrition in children is high. One out of every two children under the age of five is stunted or too short for their age (chronically malnourished). Stunting is irreversible and affects the physical and mental development, which later on translates into reduced labor productivity. Furthermore, 33% of children and pregnant and lactating mothers are classified as underweight (below a weight considered normal for one's age) (Sopov, M. et al., 2015).

Soya bean provides a wide range of opportunities for improving household food and nutrition security, as well as an important source of cash. The majority of the population in

Ethiopia does not have access to expensive animal protein sources such as egg, milk and meat, while child and maternal malnutrition are among the highest in the world. This, added to the fact that more than 40 million people in Ethiopia avoid eating animal protein for nearly 200 days a year during the fasting season, means that domestic consumption of soya beans has great potential. When roasted and milled, soy flour as a product on its own, or blended with other cereals such as maize and wheat, has a multitude of uses in the production of bread, biscuits, cakes, porridge and sauces. A number of soy food products can be integrated into the Ethiopian diet. Therefore, supporting local or household milling and food processing is important. Besides the technology, practical coaching and training in home economics is important to get the soy food-chain off the ground. There is a difficult market situation for soy, as all processing is concentrated around the Addis Ababa market including animal feed, edible oils and emergency feed (Sopov, M. et al., 2015*)*.

How important is soya bean for human nutrition, in particular in developing countries? The contribution of oils and fats to human diets is best estimated by measuring their contribution to overall available dietary energy supplies (DES) expressed in calories (see table 3). While total oils/fats (from all sources) in the diet account for about 24% of DES globally, the percentage figure is 21 for developing countries and 33 for developed nations. Among developing nations, this percentage appears to be consistently below the group average in countries with a high prevalence of hunger. These figures refer to the total intake of oils/fats in whatever form and from whatever origin (FAO 2017).

How does the situation described here affect domestic food security in developing countries? The reliable supply of competitively priced soyoil and meals, together with the on-going liberalization of agricultural trade have allowed imports of many low-income, food insecure developing countries to grow at a steady and fast pace, contributing to stable and normally rising levels of per caput consumption. In general, the fact that this development tends to increase the dependence on imports is not in conflict with strategies aimed at improving national food security (FAO 2017).

Food and water security will be a major national security focus in the coming decades as both climate change and population increases affect food production worldwide. Countries lacking basic food resources to feed their growing urban populations may become hotbeds for conflict, unrest and terrorist activities. While many solutions for food insecurity should be addressed and considered by lawmakers, scientists and farmers alike, soya bean technology is a first step in addressing the needs of poverty stricken regions by providing a modified crop that can meet multiple goals. Re-engineered soya beans are an innovative (and healthy) way to help address local food security issues worldwide. Not only do they provide a good food source, but their wide use in products from oils to food to animal feed guarantee a lucrative market for local farmers. Reducing poverty through innovative changes in the way staple crops are traditionally grown is an economical and feasible way to bring food security, in light of climate and population challenges, to developing regions of the world *(*Andrea Blinkhorn, 2014*).*

## 2.4. Production and Productivity Gaps of Soya bean in Ethiopia

There are favorable climatic and soil conditions for soya bean production in South and Western Ethiopia which is essential both for commercial purposes as well as for subsistence farming. The problems of producing soya bean is not only limited to market access but also low productivity and production, lack of processing facilities, lack of capital to increase production and no market information system for effective agricultural marketing (Bezabih 2010).

Soya bean is a high value and profitable crop. The economic viability of soy production is determined by the commercial utilization of both its sub-products, meal and oil, which, respectively, account for about two thirds and one third of the crop’s economic value. Soy oil and meal are consumed worldwide as food and animal feedstuff respectively. Soy meal accounts for over 60% of world meal production (vegetable and animal meal) and occupies a prominent position among protein feedstuffs used for the production of feed concentrates. Soya bean oil is the second most important vegetable oil (after palm oil); it accounts for 25% of global vegetable/animal oils and fats consumption. The widespread use of soya bean oil in particular as edible oil is due to its plentiful and dependable supplies, its competitive price, and its neutral flavor and stability in both un hydrogenated and partially hydrogenated form. Moreover, the rapid rise in the demand for compound feed - und thus soya meal - has contributed considerably to the rise in soy oil production. Oil palm is a major competitor with soya bean oil. Although the palm produces far more oil per unit area than soya bean, soya bean’s role is expected to be secure because soya meal is in huge demand and oil is a very lucrative by-product. It is also true that oil palm is generally grown in different ecologies than soya bean, so there is a certain amount of geographical complementarities (P. P. Thoenes, 2014).

Soya bean varieties selected for drought tolerance have the potential of improving agricultural productivity and hence livelihoods if adopted by farmers. Soya bean grows in areas where maize and common beans are grown. It grows to a height of 60–120 cm, maturing in 3 to 6 months depending on variety, climate, and location. Soya bean is drought tolerant. Depending on the variety, the crop can be grown from 0-2200m altitude and under rainfall ranging from 300 to 1200mm. Altitude influences temperature that in turn affects the initiation of flowering and maturity. At very high altitudes, flowering may not occur and the crop remains vegetative. Soya bean is therefore a crop that requires warm climates and is suitable for low to medium altitudes. It grows best when planted in pure stands. The presence of Rhizobium japonicum in the roots of soya bean enables the crop to fix nitrogen in the soil contributing to improved soil fertility (Kasasa P. *et al*., 2000)

Table 2: Estimate of Area, Production and Yield of soya bean

| Crop | Area in Hectares | | | Production in Quintals | | | Yield(Quintals/Hectare) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2015/16 | 2016/17 | % change | 2015/16 | 2016/17 | % change | 2015/16 | 2016/17 | % change |
| soya bean | 38,166.04 | 36,635.79 | -4.01 | 812,418.33 | 812,346.59 | -0.01 | 21.29 | 22.17 | 4.13 |

Source: CSA, 2017

## 2.5. Analytical Framework of the Study

Most adoption studies used Tobit model (Tobin, 1958) to identify factors affecting the status and intensity of technology adoption. Tobit model is, however, very restrictive for both economic and statistical reasons, which makes this model unsuitable for certain empirical applications. It is also restrictive because it assumes that the same set of variables determine both the probability of adoption and level of adoption. This is not realistic in most situations.

Some farmers adopt and cultivate improved soya bean varieties and some do not. Also, there are differences in level of adoption among the adopters. We have two questions to answer: why are some adopting and some not and why does the level of adoption vary among the adopters? Cragg's double-hurdle model answers these two questions. Use of Cragg's model for analyzing adoption and level or intensity of adoption is common in agricultural economics literature (Cooper and Keim, 1996; Gebregziabher and Holden, 2011; Shiferaw *et al.*, 2008; Teklewold *et al*., 2006; Solomon *et al.*, 2011; Hassen *et al* 2012). Another alternative here might be the Heckman selection model. According to Jones (1989), one of the important differences between these two models concerns the sources of zeros. In the Heckman model, the non-adopters will never adopt under any circumstances. On the other hand, in a double-hurdle model, non-adopters are considered as a corner solution in a utility-maximizing model. In the case of soya bean, the assumption of Heckman's seems to be too restrictive. Changes in input price or extensive extension programs may encourage non-adopters to adopt. Hence, use of Double-hurdle model instead of Heckman's is appropriate. In this study Double-hurdle model was used to identify determinants of adoption and intensity of adoption of improved soya bean varieties.

## 2.6. Empirical Studies on Technology Adoption

Different adoption studies were undertaken by different scholars in the smallholder agricultural sector of Ethiopia. Some of the studies are discussed as follows:

Samuel (2017) studied Factors affecting adoption and degree of adoption of soya bean in Ilu-Ababora Zone; Southwestern Ethiopia. The study was based on cross sectional data of 185 soya bean producing farmers. The study used the Logistic regression model to identify factors affecting probability of adoption and Tobit model to identify intensity of adoption. Training, use of soy food at home affected positively and significantly while age, farm size and distance to nearest market affected negatively and significantly adoption of Soya bean. Sex, Farm size and training positively and significantly while distance to cooperatives and use of soy food at home affected negatively and significantly intensity of adoption of Soya bean.

E. F. Fabiyi (2015) studied Adoption of Improved Soya bean Technologies in Bauchi Local Government Area, Bauchi State, Nigeria. The study was based on cross sectional data of 45 maize producing farmers. The study used the multiple regression analysis. House hold size, Labor source affected positively and significantly while processing experience affected a negatively and significant adoption of improved Soya bean Technologies varieties.

Yenealem *et al.* (2013) studied determinants of adoption of improved maize varieties for male headed and female headed households in West Harerghe zone. The study was based on cross sectional data of 148 maize producing farmers. The study used the logistic regression model applied to assist in estimating the probability of adoption of improved maize verities. Cultivated farm size, number of Livestock (TLU), Extension contact affected positively and significantly while Age and Distance to the nearest input market affected a negatively and significant the probability of adoption of improved maize varieties.

Afework and Lemma (2015) conducted a study on the determinants of improved rice varieties adoption in Fogera district of Ethiopia. The study was based on cross sectional data of 151rice producing farmers. The study used Univariate Probit model in order to address factors that influence the decision to participate in improved rice varieties adoption. Household size, education of the household head, land, rice farming experience, access to new cultivars of rice, off-farm income and institutions affected positively and significantly while distance to the nearest village market, access to main market, distance to access agricultural extension office affected negatively and significantly the probability of participation in improved rice cultivation.

Ermias (2013) conducted a study on adoption of improved sorghum varieties and farmers' varietal trait preference in Kobo district, north Wolo zone, Ethiopia. The study was based on cross sectional data of 150 sorghum producing farmers. The study used Tobit to trace determinants of adoption and intensity of use of improved sorghum varieties among the sample households. Tropical Livestock Unit, participation in off-farm, perception on taste quality of improved sorghum, irrigated farm size (ha), striga infested land (ha) and perception on yield capacity of improved sorghum affected positively and significantly while farm size (ha) proportion of sorghum area from total crop land, distance from farmers training center to home and active labor ratio affected a negatively and significantly adoption of improved maize varieties.

Mekuria (2013) identified factors influencing adoption of improved maize varieties in Gorogutu Woreda of Eastern Hararghe, Ethiopia. The study was based on cross sectional data of 130 improved maize producers. The study used Tobit model to analyze factors affecting probability and intensity of adoption of improved maize seed. Educational level of household head, size of own cultivated land, off-farm employment, access to credit, contact with extension agent, membership in cooperative, income from chat, land size and affects positively and significantly while cosmopolitan affect negatively and significantly adoption of improved maize varieties.

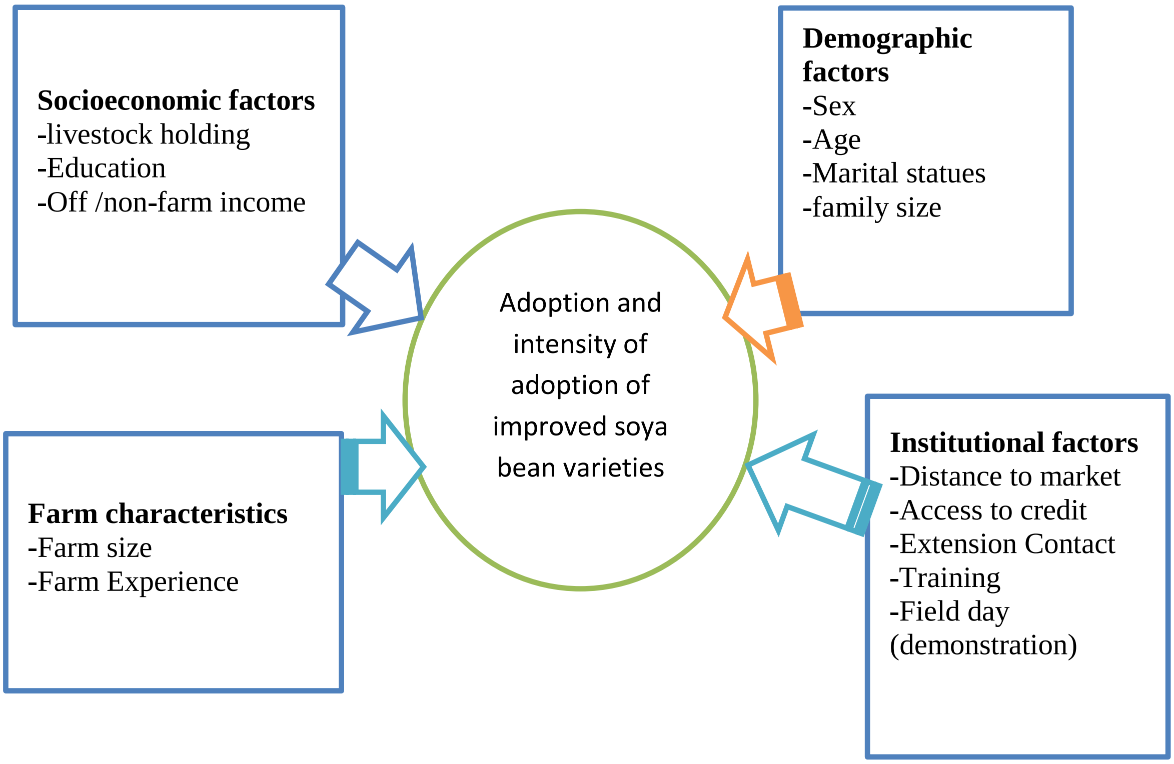
Sisay (2016) conducted a study on the agricultural technology adoption, crop diversification and efficiency of maize-dominated smallholder farming system in Jimma Zone, South-Western Ethiopia. This study used cross-sectional data collected in 2013/14 production season from a sample of 385 farm households selected through multi-stage sampling techniques. The study used Tobit, Count data and Multivariate probit models for identifying factors influencing status and intensity, speed of technology adoption and decision to adopt recommended agronomic practices in maize farming, respectively. The results showed that age, family size, level of education, family education, ownership of mobile phone, extension services, cooperative membership, livestock holding and farm size positively and significantly while distance to development negatively and significantly influence adoption of improved agricultural technologies. The results also showed that age, extension services, livestock holding, landholding, cooperative membership and ownership of mobile phone positively and significantly while sex, distance to development and market centers negatively and significantly influence the speed of improved maize variety adoption. The decision to adopt recommended agronomic practices was significantly influenced by, family education, and ownership of mobile phone, livestock holding and extension services positively and significantly while sex and distance to development centers negatively and significantly influence decision to adopt recommended agronomic practices.

Hassen *et al.* (2012) studied determinants of chemical fertilizer technology adoption in North Eastern highlands of Ethiopia. The study was based on cross sectional data of randomly selected 252 farmers. This study used a double hurdle model to identify factors affecting the probability of adoption and intensity of use of inorganic fertilizers. About 45 (3%) were adopters and 207 (97%) were non-adopters. Extension service access, Distance from Development Agent, credit service influence significantly and positively while distance to market, distance to input supply, credit distance influence significantly and negatively the probability adoption of chemical fertilizer technology. Sex, age, education, adult equivalent, total cultivated land, livestock owned, off/non-farm income, extension service access, influence significantly and positively while Active labor force, distance to market, distance to road, number of plots, distance to input supply, DA distance, credit service, credit distance influence significantly and negatively the intensity adoption of chemical fertilizer technology.

## 2.7. Conceptual Framework of the Study

Agricultural technology adoption and diffusion patterns often vary from location to location. The variations in adoption patterns were created due to the presence of disparity in agro ecology, institutional and social factors. Moreover, farmers' adoption behavior, especially in low-income countries is influenced by a complex set of socio-economic, demographic, technical, institutional and bio-physical factors (Feder *et al.*, 1985).

Adoption of technologies is the outcome of several interactions of farmers' internal and external contexts. Demographic factors(sex, marital status, age and family size), socioeconomic factors (livestock ownership, land holding, education and off/non-farm income), institutional factors (distance to nearest market, access to credit, frequency of extension contact, demonstration, training and participation on field day) and farm characteristics factors **(**size of farm and farm experience) are the main key variables that were expected to influence the adoption of improved soya bean varieties in the study areas were summarized in figure 1.




source: Adopted from Hadush, 2015

Figure 11: Conceptual framework of adoption of improved soya bean varieties

# 3. RESEARCH METHODOLOGY

In this chapter a brief description of the study areas, sampling methods and sample size, sources and types of data and data collection methods, methods of data analysis, measurement and definitions of variables and cost benefit analysis are presented.

## 3.1. Description of the Study Areas

### 3.1.1. Location and physical features

Chewaka is located in Buno Bedele zone, Oromia Regional state about 570 kilometers southwest of Addis Ababa. It covers a total area of 342.167 $km^2$. It is situated in lowland areas of Dhidhessa valley, which lies below 1500m above sea level. The area is found between Dabena and Dhidhessa rivers. Dhidhessa River bounds the district from east to north and at the same time it is the boundary between Illubabor and East Wollega zone. On the other hand Dabena River bounds the area from west to north which joins Dhidhessa and finally leads to Blue Nile.

GobuSayo district is located in East Wellega Zone of Oromia region 265 km west of Addis Ababa. Its altitude is in the range of 1556-1680 meter above sea level. The capital town of Gobu Seyo (Ano) is located 65 K.M to East from Nekemte, the capital town of East Wellega Zone. The district consists of 9 Kebele Administrations.

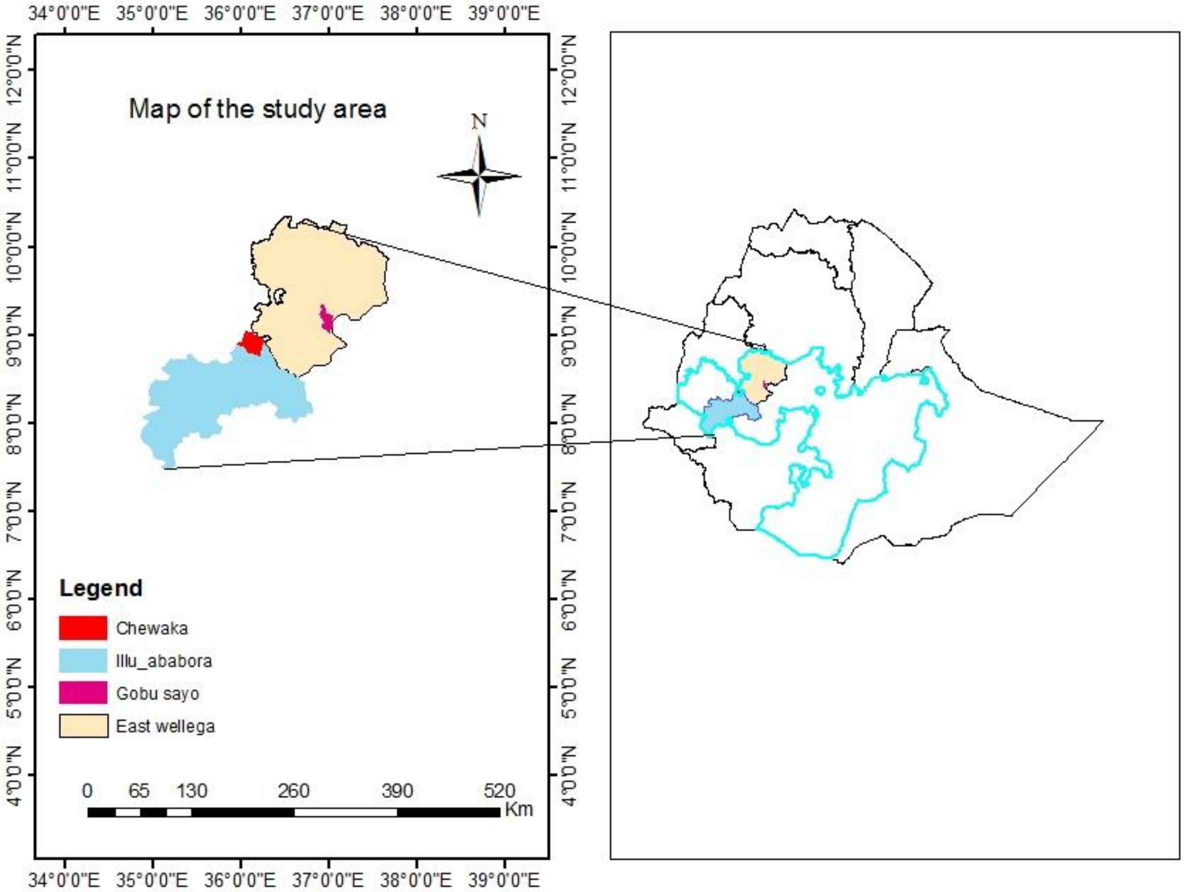



Figure 22: Map of the study areas, own sketch, 2017

### 3.1.2. Agriculture

Agriculture is the economic base of Chewaka district. Agriculture is mainly rain-fed and is characterized by low productivity. The majority of the residents depend on agriculture for their livelihood. The farmers are using traditional technologies and with limited accesses to agricultural inputs. Moreover, the sector in the zone is characterized by low-level use of farm inputs, traditional farm practice, and other related problems. Farmers of the study area produce agricultural crops for consumption and commercial purposes. The major crops produced in the area include maize and sorghum mainly for consumption while soya bean is produced for sale. Other crop types produced include rice, ground nut among others. It is one of the areas that produce cash crops mainly soya bean. The farmers slash and burn the area to prepare farmlands. The district is also potential for livestock production. Agriculture is also the main stay of the people in the Gobusayo district and the district is high potential for crop and livestock production. The major crops produced in the area include maize sorghum, and soya bean.

### 3.1.3. Population

The population of Chewaka district was 67,623 in 2015 and about 14,000 households while the total population of the Gobusayo district was 45,887 (49.44% males, 50.56% female) in which 7241 are male headed and 1055 are female headed households. The family members in both households are 14,772 males and 22,819 females.

## 3.2. Sampling Methods and Sample Size

A three stage sampling technique was employed to select sample respondents. In the first stage, Chewaka and Gobusayo districts were purposively selected for this study, due to the fact that improved soya bean varieties was widely popularized by Bakko Agricultural Research Center (BARC) and N2 Africa project in the study areas.  In the second stage, five Kebeles were randomly selected. Three Kebeles from Chewaka district and two Kebeles from Gobusayo district were selected for this study. Households in sample kebeles were stratified into producers and non-producers of soya bean and representative samples were selected from producers of soya bean.

The sample size was determined by using a formula developed by Cochran's (1977):

$$n = \frac{Z^2 pq}{e^2} \qquad (1)$$

Where n is the sample size for the study, Z is the selected critical value of desired confidence level (1.96), p is the estimated proportion of an attribute that is present in the population which is 0.32 in this study. q =1-p that is 0.68 and e is the desired level of precision which is 0.07.

Table 3: Sample size of soya bean producers by kebeles

| District | kebeles | Population | | Sample | | Total sample |
|---|---|---|---|---|---|---|
| | | Improved soya bean producers | Local soya bean producers | Adopters | Non-adopters | |
| Gobusayo | Jagan | 151 | 309 | 11 | 22 | 33 |
| | Burqa Anani | 118 | 242 | 9 | 18 | 27 |
| | Madda Jalala | 136 | 279 | 10 | 20 | 30 |
| Chewaka | Ongobo Bekenisa | 112 | 230 | 8 | 17 | 25 |
| | Gambela Tare | 140 | 285 | 10 | 21 | 31 |
| Total | | 657 | 1345 | 48 | 98 | 146 |

Source: Districts agricultural office, 2017

## 3.3. Sources and Types of Data and Data Collection Methods

Both primary and secondary data were used. For this study primary data were collected on one-to-one interview using a structured survey questionnaire (see Appendix II) pre-tested and administered by well trained and experienced enumerators who have knowledge of the farming system and the local language. During the personal interview information on soya bean varieties grown, socio-economic elements (age, gender, education level, family size, asset ownerships, distance of a residence from input and output markets and frequency of extension contact and institutional and other relevant) factors were collected. Secondary data source include books, journals and other published and unpublished documents from Bako agricultural research center, N2Africa (Putting nitrogen fixation to work for smallholder farmers in Africa), zonal and district agricultural offices, internet and other related sources to supplement primary data.

## 3.4. Methods of Data Analysis

In this study, both descriptive statistics and econometric model were used to analyze the data.

### 3.4.1. Descriptive statistics

Descriptive statistics such as mean, standard deviation, frequencies distribution, and percentages were used to have a clear picture of the characteristics of sample units. Chi-square test and t-tests were also used to compare adopters and non-adopters in terms of explanatory variables.

### 3.4.2. Econometric model

According to Cragg's model, a farmer faces two hurdles while deciding on soya bean cultivation. The first is to decide whether to cultivate soya bean. The second hurdle is related to the level of adoption, or how much land or capital to allocate to soya bean production. The most important underlying assumption of the model is that these two decisions are made in two different stages. At the beginning of a cropping season a farmer may decide to cultivate soya bean without making exact plans about the quantity of land. Many factors can influence a farmer's decision afterwards, i.e., price and availability of inputs, potential to cultivate competing crops, information about production technology, etc.

The first stage of Cragg's model is a probit model to identify the determinants of adoption, and the second stage is a truncated model for identifying the determinants of the level of adoption (Cragg, 1971). Let $d_i^*$ is the latent variable describing a farm's decision to adopt, $y_i^*$ is the latent variable describing its decision on the level of adoption, and $d_i$ and $y_i$ are their observed counterparts, respectively. Based on the specification by Cragg (1971) and Moffatt (2005), the two hurdles for a farmer can be written as:

$$d_i^* = \alpha \mathbf{z}_i + v_i \quad (2)$$

$$y_i^* = \beta \mathbf{x}_i + \varepsilon_i , \quad (3)$$

Where

$$d_i = \begin{cases} 1, if \;\; d_i* > 0 \\ 0, if \;\; d_i* \leq 0 \end{cases} and \;\; y_i = \begin{cases} y_i*, if \;\; y_i^* > 0 \;\; and \;\; d_i* > 0 \\ 0, if \;\; otherwise \end{cases}$$

Where $\mathbf{z}_i$ is the vector of variables explaining whether a farmer adopts improved soya bean varieties, $\mathbf{x}_i$ is a vector of variables explaining level of adoption, and $v_i$ and $\varepsilon_i$ are the error terms.

The dependent variable in the first stage is the farmer's adoption decision. This variable is binary in nature, taking numeric value 1 for adopters, and 0 for non-adopters. In the second stage, the dependent variable is area of improved soya bean varieties cultivated in hectare. In the double-hurdle model, both hurdles have equations associated with them, incorporating the effects of farmer's characteristics and circumstances. Such explanatory variables may appear in both equations or in either of them (Teklewold *et al.*, 2006). According to Carroll *et al* (2005), equations 1 and 2 are assumed to be independent, and therefore the error terms are randomly and independently distributed, $v_i \sim N(0,1)$ and $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$.

The log-likelihood function for the double hurdle model is:

$$\log L = \sum \ln\left[1 - \Phi(\alpha Z_i'(\frac{\beta X_i}{\sigma})\right) + \sum \ln\left[\Phi(\alpha Z_i)\frac{1}{\sigma}\phi\left(\frac{Y_i - \beta X_i}{\sigma}\right)\right] \tag{4}$$

Where $\Phi$ and $\phi$ are the standard normal cumulative distribution function and density function, respectively. The log-likelihood function is estimated using the maximum likelihood estimation (MLE) technique.

The double-hurdle model is reduced to the Tobit model when the probit mechanism ($d_i^* > 0$) is absent in Equation 2. This can also be seen in the log-likelihood function presented in Equation 3, when $\Phi$ ($\boldsymbol{z}_i\, \alpha$) = 1. The Tobit model arises if $\alpha = \beta/\sigma$ and $x = z$ (Martinez-Espineira, 2006). Absence of the probit mechanism implies that the decision about adoption and level of adoption are made simultaneously. We also develop a Tobit model and do standard likelihood ratios test between the Tobit and double-hurdle model to know how these decisions are made. Following Gujarati (2003), the Tobit model for our specific case can be written as:

$$y_i = \begin{cases} y_i^* \ \text{if land allocated for soybean} > 0 \\ o \ \text{otherwise} \end{cases} \tag{5}$$

Where, $\beta_0 \ldots, \beta_k$ are the unknown parameters to be estimated and $\boldsymbol{x}_{1i} \ldots \boldsymbol{x}_{ki}$ are the same set of explanatory variables used in the second stage of the Cragg model. Using MLE, the Tobit model is estimated. According to Maddala (1992), the likelihood function for the Tobit model can be written as

$$L = \prod_{V_i > 0} \tfrac{1}{\sigma} f \left(\tfrac{yi - \beta x_i}{\sigma}\right) \prod_{V_i < 0} F \left(-\tfrac{\beta X_I}{\sigma}\right) \tag{6}$$

Through maximizing the function with respect to $\beta$ and $\sigma$, we get the MLE estimates of these parameters.

As the Tobit model is nested in the Cragg model, it is possible to compare these two models through a standard likelihood ratio test when the determinants in both hurdles are the same (Buraimo *et al*, 2010). The test statistics can be computed as in Greene (2000):

$$\Gamma = -2[\ln L_T - (\ln L_P + \ln L_{TR})] \sim \chi_k^2 , \quad (7)$$

Where $L_T$, $L_P$, and $L_{TR}$ are log-likelihoods of the Tobit, probit, and truncated regression models, respectively. Rejection of the null hypothesis ($\Gamma > \chi_k^2$) argues for superiority of the double-hurdle model over the Tobit model and establishes that the decisions about adoption and level adoption are made in two different stages.

## 3.5. Definitions of Variables and Hypothesis

### 3.5.1. Dependent variables

**Adoption decision:** The dependent variable for probit model takes a dichotomous value depending on the farmers' decision either to adopt (at least one) or not to adopt any of the improved soya bean varieties.

**Intensity of adoption:** The dependent variable for truncated regression model would have a continuous value which is the intensity of use of the technology. In this case, it indicates the proportion of area cultivated under improved soya bean varieties in hectare. Adopters are farmers who produce either of Dedessa, Katta, Jalale and Ethio-Yugoslavia varieties. Non-adopters are farmers who did not produce those improved varieties during the production year.

### 3.5.2. Independent variables

Adoption literature provides a long list of factors that may influence the adoption of agricultural technologies. Generally, farmers' decision to use improved agricultural technologies and the intensity of the use in a given period of time are hypothesized to be influenced by a combined effect of various factors such as household characteristics, socioeconomic and physical environments in which farmers operate. Based on the previous studies conducted on the adoption of improved crop technologies and the experience of the farming system of the study areas, the following listed explanatory variables in the table were selected for this study.

**Sex of the household head:** This is a dummy independent variable indicating sex of the household head. It was represented by 1 for males and 0, otherwise. The gender difference is found to be one of the factors influencing adoption of new technologies. Female headed households are not efficient and able to adopt new technology as compared to their male counterpart (Yemane, 2014, Samuel *et al* 2017*)*. Therefore, it is hypothesized that male farmers are more likely to adopt new technologies.

**Age of the household head:** Age is a continuous variable and is one of the factors that affect adoption, intensity of adoption and speed of adoption in one of the several ways. The direction of influence is not, however, very clear and there are always mixed results from empirical analysis. Older farmers may have more experience, resource, or authority that would allow them more possibilities for trying new technologies. On the other hand, it may be that young farmers are more likely to adopt new technologies, because they may have more schooling than older farmers and have been exposed to new ideas and hence more risk takers (Assefa and Gezahegn, 2010). Hence, age of the household head may have positive or negative effect on the adoption and intensity of adoption of improved soya bean varieties.

**Education level of the household head:** It is a continuous variable measured in terms of the level of education a farmer attended. It is expected that the more years an individual is exposed to education, the more open he/she would be to new ideas. Educated farmers may also be more aware of the benefits of modern technologies and may have a greater ability to learn new information hence easily adopt new technologies. Hence, educational level of the household head has a positive effect on the status, intensity and speed of technology adoption (Sisay, 2016, Hassen *et al.*, 2012, Afework and Lemma, 2015). Education thus was expected to have a positive effect on the decision to adopt and intensity of adoption of improved soya bean varieties.

**Contact with extension agents:** It is a continuous variable measured in terms of the frequency of contact between the extension agent and the farmers is hypothesized to be the potential force, which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt new crop technologies. According to Yemane (2014) contact with extension agents has positively influenced the adoption of improved upland rice varieties. A similar study of Hassen *et al.*, (2012) indicated that, more contacts with extension agents will increase farmers' adoption of technologies. It was hypothesized that contact with extension workers will increase a farmer's likelihood of adoption and intensity of adoption of improved soya bean varieties.

**Farm size:** It is a continuous variable measured in hectares. Farm size is an indicator of wealth and social status and influence within a community. This means that farmers who have relatively large farm size will be more initiated to adopt new technologies and the reverse is true for small size farmers. The land holding size returned a positive and significant relationship with adoption of new technology (Yenealem *et al., 2013*; Solomon and Bekele, 2010). Therefore, it is expected to be positively associated with the decision to adopt and intensity of adoption improved soya bean varieties.

**Area allocated under improved soya bean:** It is a continuous variable measured in hectares. Therefore, it is expected to be positively associated with the intensity of adoption improved soya bean varieties.

**Participation in training:** Training is one of the means by which farmers acquire new knowledge and skill. It is a dummy variable which have a value of 1 if the famer had been participated in training at least once in the last three years and 0, otherwise. Farmers who participated on training, their probability of adoption and intensity of adoption of new technologies increase (Wuletaw and Daniel, 2015; Hadush, 2015). Hence, participation in training is expected to positively influence adoption and intensity of adoption of improved soya bean varieties.

**Participation in demonstration:** It is a dummy variable which have a value of 1 if the famer had been participated in demonstration at least once in the last three years and 0, otherwise. Participation in field days is expected to positively influence farmers' adoption of improved technology (Alemitu, 2011; Hadush, 2015). Hence, participation in demonstration is expected to positively influence adoption and intensity of adoption of improved soya bean varieties.

**Access to credit:** It is a dummy variable that takes a value of 1 if households have access to credit and 0, otherwise. Farmers who have access to credit may overcome their financial constraints and therefore buy inputs. The credit availability positively affects the adoption of improved technologies (Tiamiyu *et al*., 2014; Leake and Adam, 2015). Therefore, it is expected that access to credit will increase the probability of adoption and intensity of adoption of improved soya bean varieties.

**Livestock holding**: It is a continuous variable measured in TLU. A household with large livestock holding can obtain more cash income from the sales of animal products. This income in turn helps smallholder farmers to purchase farm inputs. Leake and Adam (2015) reported that being owner of more livestock increases the level of adoption of improved agricultural technology. Therefore, livestock ownership is hypothesized to be positively related to the adoption and intensity of adoption of improved soya bean varieties.

**Family size:** It is a continuous variable measured in terms of adult equivalent of persons living together in the household. Adoption of soya bean requires adequate labor supply to carry out the production processes. It is obvious that large families may have adequate labor that would enhance the adoption of technologies. The labor availability is positively related with the adoption of improved new technologies (Hassen *et al.,* 2012; Debelo 2015). Hence, it is hypothesized that availability of labor has positively influenced the adoption and intensity of adoption of improved soya bean varieties.

**Market distance:** It is a continuous variable measured in kilometers. Market distance is one of the determining factors in the adoption of technology. Better access to the market can influence the use of output and input markets, and the availability of information. It is expected that farmers living near the market would easily access market for their farm produce hence readily adopt and intensively use new technology (Afework and Lemma 2015; Hassen *et al.,* 2012). Therefore, it is hypothesized that market distance is inversely related to adoption and intensity adoption of soya bean improved soya bean varieties.

**Non/off-farm activity:** It is treated as a dummy variable taking the value of 1 if a household head participated in non/off-farm income generating activities and 0, otherwise. The households engaged in non/off-farm activities are better endowed with additional income to purchase inputs. The study by Olalekan and Simeon (2015) indicated that participation in non/off farm income activities has a positive influence on the adoption new technology. Therefore, it is expected that the participation in non/off-farm income is positively related to adoption and intensity of adoption of improved soya bean varieties.

**Farm experience**: It is a continuous variable measured in years of soya bean production. It is expected that farmers who have adequate farm experience more likely to adopt new technologies than less experienced farmers. Aman and Tewodros (2016) indicated that farm experience affect adoption and intensity adoption of improved varieties positively. Therefore, it is expected that the farm experience is positively related to adoption and intensity of adoption of improved soya bean varieties.

Table 4: Summary of independent variables, their definitions and expected effect

| Dependent variables | | | |
|---|---|---|---|
| 1. Adoption of improved soya bean varieties | | Dummy (1.Yes 0.No) | |
| 2. Proportion of area under improved soya bean varieties (hectare) | | Continuous | |
| Independent Variables | Definitions of variables | Unit of measurement | Expected sign |
| District | District of study areas | Dummy 1.Chewaka 0.Gobusayo | +/- |
| Age | Age of household head | Years | +/- |
| Sex | Sex of the household head | 1.Male 0.Female | + |
| Family size | Number of persons per household | No | + |
| Marital statues | Marital status of household heads | 0. Married 1.Divorced 2.Widowed 3.Single | +/- |
| Education | Formal education level of household head | Grade attended | + |
| non/off farm | participation on off/ non-farm activities | 1.Yes 2.No | + |
| Farming experience | Soya bean farming experience of the household head | Years | + |
| Training | Participation on training of soya bean production | 1. Yes 0. No | + |
| Livestock | Number of livestock owned | TLU | + |
| Distance to market center | Distance of farmers house from nearby market | Hour | - |
| Credit | Use of cash credit in maize framing | 1= Yes 0=No | + |
| Farm size | Total land holding size of the household head | Hectares | + |
| Extension | Contact with extension agents | No | + |

# 4. RESULTS AND DISCUSSION

This chapter presents the major findings of the study and discusses it in comparison with the results of other studies. Both descriptive and econometric methods were used to analyze the primary data. Descriptive statistics were employed to describe the general demographic, socio-economic and institutional characteristics of sample soya bean producing farmers. Econometric analysis was also used to identify factors affecting adoption and intensity of adoption of improved soya bean varieties in the study areas. Cost-benefit analysis was used to assess the profitability of improved soya bean varieties adopted in the study areas.

## 4.1. Descriptive Results

### 4.1.1. Demographic characteristics households

The sample size handled during the survey was 146. Out of the total interviewed soya bean producers 94 (64.38%) were from Chewaka district and the remaining 52 (35.62%) were from Gobusayo district. Among the sample respondents from chewaka district, 74 (78.72%) were male headed and the remaining 20 (21.28%) were female headed while in Gobusayo 47 (90.38%) and 5 (9.62%) were male and female headed producers, respectively. The chi-square test of sex distribution between the adopters and non-adopters was found to be insignificant. Out of the total respondents, 97.26%, 1.37% and 1.37% were married, single and widowed respectively. The chi-square test of marital status between the adopters and non-adopters was found to be insignificant (table 5).

Table 5: Sex and marital status of sample households

| Variable | | Adopters (N=48) | | Non- adopters (N=98) | | | Total (N=146) | |
|---|---|---|---|---|---|---|---|---|
| | | No | % | No | % | $x^2$-test | No | (%) |
| Sex | Male | 41 | 85.4 | 80 | 81.6 | 0.33 | 121 | 78.7 |
| | Female | 7 | 14.6 | 18 | 18.4 | | 25 | 21.3 |
| Marital status | Married | 47 | 97.9 | 95 | 96.9 | | 142 | 97.3 |
| | Single | 1 | 2.1 | 1 | 1 | 1.25 | 2 | 1.4 |
| | Widowed | 0 | 0 | 2 | 2 | | 2 | 1.4 |

Source: Survey result, 2017

The average age of the adopters was 40.17 years and while it is about 38.55 years for non-adopters. The t-test of age between adopters and non-adopters was found to be insignificant. That means there is no statistical mean difference between adopters and non-adopters in terms of age (Table 6).

Table 6: Age of sample households

| Variables | Adopter (N=48) | | Non-adopters (N=98) | | |
|---|---|---|---|---|---|
| | mean | Std | Mean | Std | t-test |
| Age | 40.17 | 1.91 | 38.55 | 1.22 | -0.73 |

Source: Survey result, 2017

#### 4.1.2. Socio economic characteristics

Family size is one of the variables that characterize farm households. The average family size of the adopters was 2.83 people and while it is about 2.66 persons for non-adopters. The t-test of family size between adopters and non-adopters was found to be insignificant (Table 7).

Experience in soya bean production is taken to be the number of years that an individual was continuously engaged in soya bean production. The average years of soya bean production experience for the adopters was about 10.44 years and 8.58 years for non-adopters with standard deviation of 1.77 and 1.2 respectively. A producer with better experience in soya bean production is expected to adopt new technologies than less experienced. The t-test of farm experience between adopters and non-adopters was insignificant (Table 7).

Education can influence productivity of producers and adoption of newly introduced technologies and innovations. Hence, literate producers are expected to be in a better position to get and use information which contributes to improve their soya bean production practices. According to the survey results, on average adopters have about 6 grades of formal educations while non-adopters have 3. The t-test result indicates that education level of household was found to be significant between adopters and non-adopters at 1% level of significance. That means adopters have higher level of education compared to non-adopters (Table 7).

Farm animals have an important role in rural economy. They are source of draught power, food, such as, milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport. The districts where known by livestock production as major occupation. Livestock holding size is also one of the indicators of wealth status of the households in the study areas. Livestock is kept both for generating income and traction power. As it confirmed in many studies, farmers who have better livestock ownership status are likely to adopt improved agricultural technologies because livestock can provide cash through sales of products which enables farmers to purchase different agricultural inputs like seeds and used as traction power.

The livestock species found in the study areas are cows, oxen, bulls, heifers, calves, sheep, goat, donkey, mule and poultry. To help the standardization of the analysis, the livestock number was converted to tropical livestock unit (TLU).The conversion factors used were based on Storck *et al.,* (1991) and it is shown in Appendix I- Table 4. The average livestock ownership of adopters was 5.17 and 4.13 TLU for the non-adopters. The t-test of livestock holding between adopters and non-adopters was found to be insignificant. That means there is no statistical mean difference between adopters and non-adopters in terms of livestock holding (Table 7).

The average total land holding, total cultivable land and land allocated for improved soya bean for adopters is 2.00, 1.84 and 0.25 hectares respectively while it is 2.2, 1.97, and 0 hectares for non-adopters. The t-test of total land holding and total cultivable land between adopters and non-adopters was found to be insignificant. That means there is no statistical mean difference between adopters and non-adopters in terms of total land holding and total cultivable land but the t-test of land allocated for improved soya bean between adopters and non-adopters was found to be significant at 1% level of significance indicating that there is statistical mean difference between adopters and non-adopters in terms of land allocated for improved soya bean varieties (Table 7).

Frequency of extension contact refers to the number of contacts per year that the respondent made with extension agents. The effort to disseminate new agricultural technologies is within the field of communication between the change agent (extension agent) and the farmers at the grass root level. Here, the frequency of contact between the extension agent and the farmers is hypothesized to be the potential force which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt new technologies. The mean extension contact for adopters and non-adopters was 10.56 and 1.7 respectively. The t-test of extension contact between adopters and non-adopters is significant at 1% level of significance indicating that there is statistical mean difference between adopters and non-adopters in terms of frequency of extension contact (Table 7).

Table 7: Socio-economic characteristics of sample households

| Variable | Adopter (N=48) | | Non-adopters (N=98) | | |
|---|---|---|---|---|---|
| | mean | Std | Mean | Std | t-test |
| Family size | 2.83 | 0.24 | 2.66 | 0.13 | -0.70 |
| Farm experience | 10.44 | 1.77 | 8.58 | 1.20 | -0.40 |
| Education level | 6.29 | 0.43 | 3.20 | 0.33 | -5.46*** |
| Livestock holding(TLU) | 5.17 | 0.97 | 4.13 | 0.47 | -1.0937 |
| Total land holding | 2 | 0.14 | 2.20 | 0.16 | 0.88 |
| Total cultivated land | 1.84 | 0.12 | 1.97 | 0.13 | 0.62 |
| Land allocated for improved soya bean | 0.25 | 0.02 | 0 | 0 | -14.8*** |
| Extension contact | 10.56 | 2.87 | 1.7 | 0.56 | -4.11*** |

Source: Survey result, 2017 *** significance level at 1 %

### 4.1.3. Participation in off/nonfarm activities and Access to credit

Participation on off /non-farm can affect the decision to adopt new technologies. This is particularly true if the adoption of the new technology would require a minimum investment in purchased inputs. Most of the farmers interviewed reported that they didn't participate on off/non-farm because of poor infrastructure development in the area. About 18.75% of adopters and 13.27% of non-adopters participate on off farm while about 81.25% of adopters and 86.73% of non-adopters did not participate on off farm activities. 25% of adopters and 19.39% of non-adopters participate on non- farm while 75% of adopters and 80.61% of non-adopters did not participate on non- farm activities. The $x^2$ test of off farm and off farm participation between adopters and non-adopters was found to be insignificant. That means there is no difference between adopters and non-adopter in off farm and non-farm participation (Table 8).

Credit is an important institutional service to finance poor farmers who cannot purchase input from own savings especially at early stage of adoption. As presented in table 11, about 81.25% and 40.43% adopters and non-adapters access credit respectively while about 18.75% and 59.57% does not access credit. The result of $x^2$ test revealed that there is difference in access to credit between adopters and non-adopters farmers at 1% level of significance (Table 8).

Table 8: Participation in off/nonfarm activities and Access to credit of households

| Variables | | Adopters (N=48) | | Non-adopters (N=98) | | | Total (N=146) | |
|---|---|---|---|---|---|---|---|---|
| | | No | % | No | % | $x^2$ test | No | % |
| Off farm | Yes | 9 | 18.75 | 13 | 13.27 | 0.76 | 22 | 15.07 |
| | No | 39 | 81.25 | 83 | 86.73 | | 124 | 84.93 |
| Non-farm | Yes | 12 | 25 | 19 | 19.39 | 0.61 | 31 | 21.23 |
| | No | 36 | 75 | 79 | 80.61 | | 115 | 78.77 |
| credit | Yes | 39 | 81.25 | 38 | 40.43 | 23.32*** | 77 | 52.74 |
| | No | 9 | 18.75 | 60 | 59.57 | | 69 | 47.26 |

Source: Survey result, 2017 *** significance level at 1 %

### 4.1.4. Distance to nearest market

The time taken to travel from home to the nearest soya bean market place where farmers sell their product (soya bean), are presented in table 12. Adopters and non-adopters travel on average 0.24 and 0.97 hour respectively to reach nearest market. The t-test of distance to nearest market between adopters and non-adopters is significant at 1% level of significance indicating that non-adopters travel more hours to reach nearest market than adopters.

Table 9: Distance to nearest market of households

| Variable | Adopter (N=48) | | Non-adopter (N=98) | | |
|---|---|---|---|---|---|
| | mean | Std | Mean | Std | t-test |
| Distance to nearest market | 0.24 | 0.02 | 0.97 | 0.08 | 5.81*** |

Source: Own survey result, 2017 *** significance level at 1 %

#### 4.1.5. Major crops produced

As presented in table 13, in the study areas, maize is the dominant crop produced with mean 20.77 quintals for adopters and 20.36 for non-adopters and it is the basis of livelihood in the study areas. The second dominant crop produced is sorghum with mean of 8.9 and 5.6 quintals for adopters and non-adopters respectively. Rice is the third dominant crop produced with mean of 5.41 and 4.07 quintals for adopters and non-adopters respectively. Soya bean is also the major crop produced in the study areas with mean of 5.12 and 1.65 quintals for adopters and non-adopters respectively. This low productivity of soya bean is due to disease (rust) which occurs in the study areas for the last two years. The result of t- test revealed that there is significant mean difference between adopters and non-adopters farmers in terms of amount of soya bean produced and amount of sorghum produced at 1% and 5% significance level respectively.

Table 10: Major crops produced by sampled households (Qt)

| Variables | Adopters (N=48) | | Non-adopters (N=98) | | |
|---|---|---|---|---|---|
| | Mean | Std | Mean | Std | t-test |
| Amount of soya bean produced | 5.12 | 1.30 | 1.65 | 0.63 | -4.37*** |
| Amount of maize produced | 20.77 | 3.56 | 20.36 | 2.19 | -0.10 |
| Amount of sorghum produced | 8.90 | 1.21 | 5.60 | 0.68 | -2.56** |
| Amount of rice produced | 5.41 | 1.47 | 4.07 | 0.98 | -0.77 |

Source: survey result, 2017 **and*** significance level at 5% & 1 % respectively

#### 4.1.6. Perceptions about soya bean varieties attributes

In order to get insight on farmers' decisions of new technology use, looking at their perceptions about each attributes of a given technology is of paramount important. Hence, knowledge of respondent farmers' evaluative criteria as regard to technology attributes is needed. These include: yield, drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging. Three descriptions, i.e., superior, the same and inferior were used to facilitate the comparison by farmers of the recommended improved soya bean varieties against their local seed.

About 2.63%, 2.63%, 7.89%, 19.44%, 7.89% and 18.42% respondents perceived that the traits yield, drought resistance, early maturity, shattering, disease resistance, and non-logging of the improved soya bean varieties are inferior to the local ones. About 44.74%, 13.16%, 41.67%, 71.05%, 23.68% and 21.05% respondents perceived that the traits drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging of the improved soya bean varieties are the same to the local ones while About 97.37%, 52.63%, 78.95%, 38.89%, 28.95%, 68.42% and 60.53% respondents perceived that yield, drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging of the improved soya bean varieties are superior to the local one.

Table 11: Perceptions about soya bean technology attribute

| Attributes | Percent | | |
|---|---|---|---|
| | Inferior | The same | Superior |
| Yield | 2.63 | 0 | 97.37 |
| Drought resistance | 2.63 | 44.74 | 52.63 |
| Early maturity | 7.89 | 13.16 | 78.95 |
| Shattering | 19.44 | 41.67 | 38.89 |
| Marketability | 0 | 71.05 | 28.95 |
| Disease resistance | 7.89 | 23.68 | 68.42 |
| Non-logging | 18.42 | 21.05 | 60.53 |

Source: survey result, 2017

Therefore the most perceived preference attributes of new varieties are yield, early maturity, disease resistance and non-logging.

### 4.1.7. Sources of improved seed

According to sample respondents about 68.75% obtained improved soya bean varieties from research center (BARC) in collaboration with N2Africa project. About 16.67% respondents obtained improved soya bean varieties from market while about 14.58% respondents obtained from other farmers.

Table 12: Sources of seed for improved soya bean varieties

| Sources of seed | Frequency | Percent | Cumulative |
|---|---|---|---|
| Researcher center(BARC) | 33 | 68.75 | 68.75 |
| Purchase from market | 8 | 16.67 | 85.42 |
| From farmer | 7 | 14.58 | 100.00 |
| Total | 48 | 100.00 | |

Source: survey result, 2017

## 4.2. Econometric Results

In this sub-section, the results of the Double hurdle regression model is presented and discussed. Adoption decision of farm households is influenced by different socioeconomic, technical and institutional factors. Different variables are important across different space and over time in explaining adoption of technologies by farmers. Many factors are hypothesized to influence the adoption of improved soya bean varieties based on theoretical models and empirical evidences.

Table 13: Test statistics of Double-hurdle model

| | **Probit, D** | **Truncated Regression,** | **Tobit** |
|---|---|---|---|
| Wald $\chi^2$ | 163.46 | 18.52 | 206.72 |
| Prob > $\chi^2$ | 0.000 | 0.0295 | 0.000 |
| LOG-L | -10.73 | 57.66 | -27.32 |
| Number of observation (N) | 146 | 48 | 146 |
| $x^2$-Test Double Hurdle versus Tobit: $\Gamma = 148.5 > \chi^2(16) = 30.58$ | | | |

Since $x^2$-Test Double Hurdle versus Tobit: $\Gamma = 148.5 > \chi^2$ (15) = 30.58, double hurdle is appropriate model than Tobit model for this study.

Out of 15 explanatory variables included in the model, six were found to be significant in influencing farmers' decision to adopt improved soya bean varieties at 1%, 5% and 10 % significant levels. The variables include sex, age, education, farm experience, training on soya bean and distance to nearest market in hour and four variables were found to be significant in influencing intensity of adoption at 1%, 5% and 10% significant levels. The variables include age, soya bean farm experience, training and livestock holding (table 14).

Table 14: Determinants of adoption and intensity of adoption improved soya bean varieties

| Variables | Probit regression | | | Truncated regression | | |
|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Marginal Effect | Coef. | Std. Err. | Marginal Effect |
| DIST | 0.798 | 1.262 | 0.047 | 0.046 | 0.070 | 0.046 |
| SEX | 2.050* | 1.181 | 0.060 | 0.052 | 0.076 | 0.052 |
| MART | -0.700 | 23.683 | -0.052 | 0.032 | 0.138 | 0.032 |
| AGE | 0.218** | 0.1027 | 0.030 | 0.010*** | 0.003 | 0.010 |
| EDUC | 2.779** | 1.176 | 0.012 | -0.004 | 0.046 | -0.004 |
| FARMEXP | 0.190* | 0.101 | 0.003 | 0.009* | 0.005 | 0.009 |
| FAMSIZE | 0.175 | 0.320 | 0.006 | -0.003 | 0.018 | -0.003 |
| CONSUDA | 0.031 | 0.031 | 0.006 | 0.001 | 0.001 | 0.001 |
| DEMO | 0.842 | 1.193 | 0.016 | 0.403 | 0.2293 | 0.403 |
| TRAINING | 5.995*** | 2.036 | 0.342 | 0.627*** | 0.181 | 0.627 |
| DISTMARK | -6.370** | 2.925 | -0.506 | 0.058 | 0.077 | 0.058 |
| OFFFARM | -1.083 | 1.136 | -0.065 | -0.118 | 0.055 | -0.118 |
| NONFARM | 0.937 | 1.217 | 0.094 | -0.001 | 0.047 | -0.001 |
| CREDIT | 0.331 | 6.445 | 0.076 | -0.007 | 0.079 | -0.007 |
| LIVESTOCK | -0.069 | 0.079 | 0.008 | 0.021** | 0.010 | 0.021 |
| constant | -3.124 | | | 0.756 | | |
| sigma | | | | 0.060 | | |
| | Number of obs =146<br>LR chi2(15) =163.46<br>Prob > chi2 = 0.0000<br>Log likelihood = -10.73<br>Pseudo R2 =0.884 | | | Limit: lower = 0<br>Upper = +inf<br>Number of obs = 48<br>Wald chi2 (15) = 18.52<br>Log likelihood = 57.66<br>Prob > chi2 = 0.0295 | | |

Source: Own Estimation Result, 2017 *, **and*** significant level at10%, 5% & 1 % respectively.

The six explanatory variables which have been found to significantly influence the decision by the sample farm households with regard to whether or not to adopt improved soya bean varieties and the five explanatory variables which have been found to significantly influence intensity of adoption of improved soya bean are interpreted and discusses below.

**Sex of household head (SEX):** Sex of a house hold head is one of the determinants of improved soya bean adoption. As the probit model indicates sex of house hold head had positive and significant influence on the adoption of improved soya bean production technology at 10% significance level. This shows that being male headed households have better access to information on improved soya bean production technologies and are more likely to adopt new varieties than female headed households and also increase their soya bean production. Yenealem (2013) the binary logit model results revealed that the adoption of improved maize variety is biased by gender, where female headed households adopt the improved varieties less.

**Age (AGE):** Age was positively related to adoption and intensity of adoption of improved soya bean varieties at 5% and 1% level of significance respectively. The result of the probit model showed that one more unit (year) increase in farmers age increases the probability of adoption of improved soya bean varieties increase by 3%. The result of truncated regression indicate that old age households are more likely to devote significant amount of land to improved soya bean varieties than less old households. One more unit (year) increase in farmers age increases the intensity of adoption of improved soya bean varieties increase by 1%. The implication is that the increase in farmer's age increases farmers' experience in farming and understanding more the benefits of the technology. Studies by Fitsum (2016), Sisay (2016) also obtained a similar result in their studies.

**Education (EDU):** Education level of the household head, which is one of the important indicators of human capital, has a positive and significant effect on adoption of improved soya bean varieties at 5% level of significance, implying that the likelihood of adoption increases with farmer's formal education level. Each additional year of education of the household head increases the probability adoption of improved soya bean varieties by 1.2 %. This is consistent with the research results of Hassen *et al.* (2012), Moti *et al*. (2013), Afework and Lemma (2015) and Sisay (2016), who stated that education, affect adoption of improved technologies positively.

**Farm experience (FARMEXP):** Experience of the household head in soya bean farming is one of the factors that affect technology adoption process in soya bean farming. That is, experienced farmers are expected to have greater access to productive resources (such as land and labor) and be able to apply improved agricultural technologies and expected to be faster in adopting improved soya bean varieties than inexperienced farmers. Farm experience has a positive and significant relationship at 10% level of significance with probability of adoption and intensity of improved soya bean varieties. Each additional year of farm experience of the household head increases the probability of adoption of improved soya bean varieties by 0.3% and intensity of adoption of improved soya bean varieties by 0.9%. This is consistent with the research results by Aman and Tewodros (2016) and Musa *et al* (2016).

**Training (TRAINING**): Training was positively related to adoption and intensity of adoption of improved soya bean varieties at 1% level of significance. The result of probit regression indicate that as compared to  farmers who participated on soya bean training, those farmers who did not participated on soya bean training their probability of adoption of improved soya bean varieties decrease by 34.2%. The result of truncated regression indicate that households who participated on training are more likely to devote significant amount of land to improved soya bean varieties than households who did not participated on training of improved soya bean varieties. As compared to households who did not participated on training, the intensity of adoption of improved soya bean increases by 62.7% for households who participated on training. This is in line with previous studies by Alemitu (2011), Hadush (2015) and Wuletaw and Daniel (2015) who found that training influence adoption and intensity of adoption of new technology positively. According to Alemitu (2011), Hadush (2015) and Wuletaw and Daniel (2015)  training affect adoption and intensity of adoption improved haricot bean varieties in Dale Woreda, SNNPRS , upland rice in Tselemti district, North Western zone of Tigray and malt-barley technology in North Gondar positively and  respectively.

**Distance to nearest market (DISTMARK):** Distance to market center has a negative and significant relationship with probability of adoption of improved soya bean varieties at 5% level of significance.. The model result indicates that as the distance from market center increase by one hour, the probability of adoption of improved soya bean varieties decreases by 50.6%. The possible explanation for this is that farmers who are far away from market centers might face greater transaction and transport costs and lack of information on the availability of the latest released technology provided by extension system. This is in line with previous studies by Yenealem *et al.* (2013), Berihun e*t al.* (2014), Debelo (2015) and Sisay (2016) who found that distance to nearest market influence adoption of new technology negatively. According to Yenealem *et al.* (2013), Berihun e*t al.* (2014), Debelo (2015) and Sisay (2016) distance to nearest market affect adoption of improved maize varieties in West Harerghe zone, agricultural technologies in southern Tigray,  Quncho Tef in Wayu Tuqa District and maize technology in Jimma Zone negatively and respectively.

**Livestock (LIVESTOCK):** Livestock holding positively and significantly related to intensity of adoption of improved soya bean varieties at 5% level of significance, implying that farmers with more livestock holding are more likely to devote significant amount of land to improved soya bean varieties than those households with less livestock holding. A household with large livestock holding can obtain more cash income from the sales of animal products. This income in turn helps smallholder farmers to purchase farm inputs. A one unit increase in livestock holding (TLU) increases the intensity of adoption of improved soya bean varieties by 2.1%. This is consistent with the studies by Solomon e*t al.* (2011), Hassen e*t al.* (2012) and Leake and Adam (2015). According to Leake and Adam, Hassen e*t al* and Solomon e*t al* livestock holding affect intensity of adoption of improved chickpea varieties in Ethiopia , chemical fertilizer technology adoption in North Eastern highlands of Ethiopia and improved wheat variety in northern Ethiopia positively and respectively.

# 5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 5.1 Summary and Conclusion

This study aimed at analyzing the determinants of adoption of improved soya bean varieties in Chewaka and Gobusayo districts, Buno Bedele and East Wollega zones of Oromia region, Ethiopia with the specific objectives of the identifying factors affecting adoption and intensity of adoption of improved soya bean varieties and to assess the profitability of improved soya bean varieties adopted in the study areas.

The data were generated from both primary and secondary sources. The primary data were generated from individual interview using pre-tested semi-structured questionnaire. The primary data for this study were collected from 146 randomly selected households from 5 Kebeles (3 Kebeles from Chewaka district and 2 Kebeles from Gobusayo district).

The analysis was made using descriptive statistics and econometric model. Different analytical techniques were applied to analyze the collected data. Percentage, frequency, means, standard deviation, chi-square and t-tests were used. Chi-square and t-tests were used to compare between the independent variables and farmers adoption decisions of improved soya bean varieties. Double hurdle model was applied to analyze factors affecting adoption and intensity of adoption of improved soya bean varieties. Cost and benefit analysis was used to assess profitability of improved soya bean varieties adopted in the study areas.

Out of the total interviewed soya bean producers 94 (64.38%) were from Chewaka district and the remaining 52 (35.62%) were from Gobusayo district. Among the sample respondents from Chewaka district, 74 (78.72%) were male respondents and the remaining 20 (21.28%) were female while in Gobusayo 47 (90.38%) and 5 (9.62%) were male and female respondents, respectively. Out of the total respondents 97.26%, 1.37% and 1.37% are married, single and widowed respectively.

The average age of the adopters was 40.17 years and while it is about 38.55 years for non-adopters. The t-test of age between adopters and non-adopters was found to be insignificant. The average family size of the adopters was 2.83 people and while it is about

2.66 persons for non-adopters. The t-test of family size between adopters and non-adopters was found to be insignificant. The average years of soya bean production experience for the adopters was about 10.44 years and 8.58 years for non-adopters respectively. The t-test of farm experience between adopters and non-adopters was found to be insignificant. According to the survey results, on average adopters have about 6 grades of formal educations while non-adopters have 3. The t-test result indicates that education level of household was found to be significant between adopters and non-adopters at 1% level of significance. That means adopters have higher level of education compared to non-adopters.

The average livestock ownership was 5.17 and 4.13 TLU for adopters and the non-adopters respectively. The average annual off farm income received by improved soya bean adopters and non- adopters were about 1725.83 and 264.28 Birr respectively and it is about 2806.25 and 1082.65 from non-farm activities. The average total land holding, total cultivable land and land allocated for improved soya bean for adopters is 2.00, 1.84 and 0.25 hectares respectively while it is 2.2, 1.97, and 0 hectares for non-adopters.

The mean extension contact of adopters and non-adopters was 10.56 and 1.7 respectively. About 81.25% and 40.43% adopters and non-adapters access credit respectively while about 18.75% and 59.57% does not access credit. The result of $x^2$ test revealed that there is difference in access to credit between adopters and non-adopters farmers at 1% level of significance. Adopters and non-adopters travel on average 0.24 and 0.97 hour respectively to reach nearest market.

In the study areas, maize is the dominant crop produced with mean 20.77 quintals for adopters and 20.36 for non-adopters and it is the basis of livelihood in the study areas. The second dominant crop produced is sorghum with mean of 8.9 and 5.6 quintals for adopters and non-adopters respectively. Rice is the third dominant crop produced with mean of 5.41 and 4.07 quintals for adopters and non-adopters respectively. Soya bean is also the major crop produced in the study areas with mean of 5.12 and 1.65 quintals for adopters and non-adopters respectively.

About 2.63%, 2.63%, 7.89%, 19.44%, 7.89% and 18.42% respondents perceived that the traits yield, drought resistance, early maturity, shattering, disease resistance, and non-logging of the improved soya bean varieties are inferior to the local ones. About 44.74%, 13.16%, 41.67%, 71.05%, 23.68% and 21.05% respondents perceived that the traits drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging of the improved soya bean varieties are the same to the local ones while About 97.37%, 52.63%, 78.95%, 38.89%, 28.95%, 68.42% and 60.53% respondents perceived that yield, drought resistance, early maturity, shattering, marketability, disease resistance, and non-logging of the improved soya bean varieties are superior to the local one.

About 68.75% obtained improved soya bean varieties from BARC in collaboration with N2Africa project. About 16.67% respondents obtained improved soya bean varieties from market while about 14.58% respondents obtained from other farmers.

Sex of household head, age of household head, education, soya bean farm experience, participation in training affect adoption of improved soya bean variety positively and significantly while distance to nearest market affect adoption of improved soya bean varieties negatively and significantly. On the other hand, intensity of adoption was affected by age, soya bean farm experience, participation in training and size of livestock holding.

## 5.2. Recommendations

On the basis of the results of this study, the following recommendations are suggested as to be considered in the future intervention strategies which are aimed at promotion of improved soya bean varieties.

Sex has a significant positive impact on adoption of improved soya bean varieties. To increase and instigate the likelihood of adopting modern agricultural technologies like improved soya bean by smallholder farmers, policy makers should put emphasis on empowering female headed households to be participants and agents of change by considering a comprehensive and an integrated development of the country where their involvement is pertinent in all endeavors of the country’s overall development. From the finding of the study adoption of improved soya bean varieties has a positive impact on farm income; therefore, scaling up and diffusion of improved soya bean varieties in the study area should be broadened.

The results of the study revealed that age of household head influences the adoption of improved soya bean positively and significantly. Older household heads are more likely to adopt a new technology such as use of improved soya bean varieties. Hence, introduction of new agricultural technology in the areas may be successful if it focuses more on old farmers.

Education has a significant positive impact on adoption of improved soya bean varieties. Hence, strengthening adequate and effective basic educational opportunities to the rural farming households in general and to the study areas in particular is required. In this regard, the regional and local governments need to strengthen the existing provision of formal and informal education through facilitating all necessary materials.

Farm experience increases probability of adoption and intensity of adoption of improved soya bean varieties. This indicates that as farm experience get increases the household acquires new information, know the benefits of new technologies and develop confidence to use improved technologies. Thus, concerned bodies need to give emphasis to involve farmers to exercise and use new technologies through demonstration, training and field days. Besides, development agents, local leaders, and other participants should create the room for experience sharing among farmers regarding the importance of improved technologies.

Training on soya bean production was found to be positively and significantly influenced adoption and intensity of adoption of improved soya bean varieties. Hence, concerned bodies should provide adequate and effective training on soya bean production to the rural farming households in general and to the study areas in particular. Thus, systematic arrangements of farmer training should be implemented in order to acquaint farmers with different agricultural technologies. In this regard, N2 Africa and BARC need to focus on training of farmers about improved soya bean varieties.

Distance to nearest market was statistically significant and negatively affected adoption of improved soya bean varieties. Hence, concerned bodies need to establish market center for the farmers around their home which increase the probability of adoption of improved soya bean varieties.

The size of livestock owned has a significant positive impact on intensity adoption of improved soya bean varieties. Strengthening the existing livestock production system through providing improved health services, better livestock feed (forage), targeted credit and adopting agro-ecologically based high-yielding breeds and disseminating artificial insemination in the areas improve intensity of adoption of improved soya bean varieties.

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# 7. APPENDICES

# Appendix I: Tables

Appendix Table 151: Maximum likelihood estimation of Double-hurdle Versus Tobit model

| Variables | Probit regression | | Truncated regression | | Tobit regression | |
|---|---|---|---|---|---|---|
| | Coef. | Std. Err. | Coef. | Std. Err. | Coef. | Std. Err. |
| DIST | 0.798 | 1.262 | 0.046 | 0.070 | -0.102 | 0.128 |
| SEX | 2.050* | 1.181 | 0.052 | 0.076 | 0.151 | 0.126 |
| MART | -0.700 | 23.683 | 0.032 | 0.138 | .021** | 0.009 |
| AGE | 0.218** | 0.1027 | 0.010*** | 0.003 | -0.204 | 0.216 |
| EDUC | 2.779** | 1.176 | -0.004 | 0.046 | 0.374*** | 0.092 |
| FARMEXP | 0.190* | 0.101 | 0.009* | 0.005 | 0.017* | 0.010 |
| FAMSIZE | 0.175 | 0.320 | -0.003 | 0.018 | 0.016 | 0.031 |
| CONSUDA | 0.031 | 0.031 | 0.001 | 0.001 | 0.002 | 0.002 |
| DEMO | -0.842 | 1.193 | 0.403 | 0.2293 | 0.063 | 0.176 |
| TRAINING | 5.995*** | 2.036 | 0.627*** | 0.181 | 1.135*** | 0.159 |
| DISTMARK | -6.370** | 2.925 | 0.058 | 0.077 | -0.895*** | 0.212 |
| OFFFARM | -1.083 | 1.136 | -0.118 | 0.055 | 0.019 | 0.119 |
| NONFARM | 0.937 | 1.217 | -0.001 | 0.047 | 0.051 | 0.112 |
| CREDIT | 0.331 | 6.445 | -0.007 | 0.079 | 0.304*** | 0.109 |
| LIVESTOCK | -0.069 | 0.079 | 0.021** | 0.010 | -0.001 | 0.009 |
| constant | -3.124 | | 0.756 | | -0.769** | 0.349 |
| sigma | | | 0.060 | | 0.325 | 0.035 |
| Wald $\chi^2$ (LR $\chi^2$) | | 163.46 | | 18.52 | | 206.72 |
| Prob > $\chi^2$ | | 0.000*** | | 0.0295** | | 0.000*** |
| LOG-L | | -10.73 | | 57.66 | | 27.32 |
| Number of observation | | 146 | | 48 | | 146 |

**, **and*** significant level at10%, 5% & 1 % respectively.*

Appendix Table 162: Goodness-of-fit test of the model

Probit model for goodness-of-fit test

Number of observations = 146

Number of covariate patterns = 146

Pearson chi2 (93) = 70.69

Prob > chi2 = 0.9589

Appendix Table 173: Conversion factor for adult equivalents

| Age groups (years) | Male | Female |
|---|---|---|
| < 10 | 0.6 | 0.6 |
| 10-13 | 0.9 | 0.8 |
| 14-16 | 1.0 | 0.75 |
| 17-50 | 1.0 | 0.75 |
| > 50 | 1.0 | 0.75 |

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

Appendix Table 184: Conversion factor for livestock unit

| Animals | Livestock units | Animals | Livestock units |
|---|---|---|---|
| Heifer | 0.75 | Donkey (young) | 0.35 |
| Calf | 0.25 | Camel | 1.25 |
| Weaned calf | 0.34 | Sheep and goat (adult) | 0.13 |
| Cow and Oxen | 1.00 | Sheep and goat (young) | 0.06 |
| Horse | 1.10 | Chicken | 0.013 |
| Donkey (adult) | 0.70 | | |

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

## Appendix II: The questionnaire used for the survey

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**Adoption of Improved Soya bean Varieties: The Case of Chewaka and Gobusayo Districts, Buno Bedele and East Wollega Zones of Oromia Region, Ethiopia**

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MSc Thesis Research

Survey Questionnaire

Prepared by Galmessa Abebe (MSc Student, Haramaya University)

**Instruction**: Please introduce yourself before starting the interview, the institute you are working in and explain the objective of the survey. Please ask each question patiently until the farmer get the point. Fill the answers to the question accordingly to the farmer's response.

### 1. General information

**1.1.** Questionnaire no: _______ **1.2.**Date of interview (DD/MM/YYY):__________

**1.3.** Zone: __________________ **1.4.** District: _________________________

**1.5.** Peasant Association (Kebele) ________________________________________

**1.6.** Name of respondent_______________________________________________

**1.7.** Name of Enumerator______________________________________________

### 2. Household Characteristics

**2.1).** Name of household head: _______________________________

**2.2).** Sex of household head: 1. Male 2. Female

**2.3).** Age of household head (year): ___________________

**2.4.** Marital status of the household head 1. Married 2. Single 3. Divorced 4. Widowed

**2.5.** Educational level of household head (in grade):_____________

**2.6.** Farming experiences of household head, since he started farming [in year]:______

## 3. Demographic Characteristics

**3.1.** Number of family members by sex and age Composition

| No | By age category | By Sex category | |
|---|---|---|---|
| | | **Male** | **Female** |
| 1 | Below 15 years | | |
| 3 | 15 to 35 years | | |
| 4 | 35 to 65 years | | |
| 5 | Above 65 years | | |
| 6 | **Total** | | |

**3.2**. How many of your family members do permanently work on farm activities: ____

## 4. Socio economics Characteristics

**4.1.**What is the source of income for your household in order?

1. Crop cultivation 2.Animal husbandry 3. Crafts man 4. Employed (salary)

5. Trading 6. Other (*please specify*) _________________

**4.2.** Landholding status (ha):

4.1. Total landholding: _______

4.2. Total cultivable land: ______

4.3. Land allocated for improved soya bean production in 2008/2009 E.C: _____

**4.3.** What are the main uses of soya bean grain for you in 2008/2009 E.C?

1. for consumption 2. For sale 3. Source of livestock feed 4. Improving soil fertility

5. For other purpose (*Please Specify*)___________________________________

## 5. Cultural practices for soya bean

**5.1.** What are the farming culture that you implement in cultivation soya bean?

| **Practice used by farmers** | Soya bean |
|---|---|
| Frequency of land preparation | |
| Planting time | |
| Seed rate per hectare | |
| Fertilizer rate per hectare 1.DAP | |
| 2. Inoculant | |

| | |
|---|---|
| Planting method (1.row planting 2. Broadcast) | |
| Weeding frequency | |
| Harvesting time | |

**5.2**. List the major problems in soya bean production?

1. Lack of seed 2. Lack of inoculant 3.Disease 4. Lack of rainfall (drought) 5. Lack of market6. Others (specify) ________________________________________

## 6. Livestock production

**6.1.** Do you practice rearing livestock? 1. Yes 2. No

**6.2.** If yes, fill the table bellow

| Class of livestock | Number | | | Amount sold last year(2008 E.C) | | Unit price | | Total price |
|---|---|---|---|---|---|---|---|---|
| | Local | Improved | Total | Local | Improved | Local | Improved | |
| Cows | | | | | | | | |
| Oxen | | | | | | | | |
| Heifers | | | | | | | | |
| Bulls | | | | | | | | |
| Calves | | | | | | | | |
| Sheep | | | | | | | | |
| Goats | | | | | | | | |
| Donkeys | | | | | | | | |
| Horses | | | | | | | | |
| Mules | | | | | | | | |
| Poultry | | | | | | | | |

## 7. Adoption status of soya bean production practices

**7.1.** What is the length of time since you first heard about improved Soya bean varieties and inoculant bio-fertilizer? _______________Years (in E.C.)

**7.2.** From whom/where did you first heard about the improved Soya bean varieties and inoculant bio-fertilizer,

1. Development agent 2.Research Center 3.Neighbors 4. Farmers' organizations

5. Radio 6. Others (specify) ______________________________________________

**7.3.** Have you ever used improved seed varieties of soya bean on your farm? 1.Yes 2.No

**7.4.** If yes, when did you start planting? ________________year (in E.C)

**7.5.** If yes for Q#7.3 how much land did you allocated for improved soya bean varieties for the last three years?

| No | Name of varieties | 2006/07 E.C | | 2007/08 E.C | | 2008/09 E.C | |
|---|---|---|---|---|---|---|---|
| 1 | Dedessa | Area(ha) | Yield | Area(ha) | Yield | Area(ha) | Yield |
| 2 | Korme | | | | | | |
| 3 | EthioYugoslavia | | | | | | |
| 4 | Kata | | | | | | |

**7.6.** If yes, for Q#7.3, where do you get these seed?

1. Research Center 4. Supply of development partners (e.g. NGO)

2. Government supply 5. Other source (please specify)___________________

3. Purchase from market

**7.7**. Have you ever used inoculant on your farm? 1. Yes 2.No

**7.8.** If your answer is yes for Q #7.7 , fill the the following table

| S.N | Type of Fertlizer | Qunatity utilized per croping season/2008/09/ | Purchase Price per packet |
|---|---|---|---|
| 1 | Innoculant (bio-fertlizer) | | |

**7.10.** Why you are using improved soya bean varities (multiple answer is possible)?

1. Improving yield performance 2. Reducing cost of production 3.Offsetting environmental effect 4. Increasing income 5.improving soil fertility 6.food security
7. Other (*please specify…)* ________________________

**7.11.** If you say no for Q#7.3, why you are not in a position to use these improved technology inputs?

1.High purchase price 2.Acecebility problem 3.Incopatible weather condition 4.Lack of information 5. Fear of risk 6.Other (*please specify)* ______________________

**7.13.** Do you face any challenge in adoption process of farm inputs (*inoculants* bio-*fertilizer and improved seed)?* 1. Yes 2. No.

**7.14.** If your answer is Yes for Q#7.13 what are the major challenges that affect the use of these farm inputs (multiply answer is possible)?

1. Lack of improved seed 2. Lack of inoculant 3. Disease 4. Lack of information about these technology 5. Others (specify).____________________________________

**7.15.** Do you think the improved soya bean are better than local varieties in terms of the following traits (mark <X> for the better one in the table below)?

| Traits | Soya bean bean | |
|---|---|---|
| characteristics | Local | Improved |
| Yield | | |
| Colour | | |
| Taste | | |
| Drought resistance | | |
| Maturity period | | |
| Disease resistance | | |
| Storability | | |
| Other *(please specify..................)* | | |

**8. Extension Service**

**8.1.** Did you consulted by DAs in the last cropping season (20008/09 E.C)? 1. Yes 2. No

**8.2** If your answer is yes, for the question Q#8.1, how many days did DA contacted you in 2008/09 cropping season for purpose of soya bean production and mgt?___________

**8.3.** If yes for Q#8.1 how can the DA helped you?
1.Practical assistance at farm 2.Demonistartion 3.Training at FTC
4.other (please specify) _______________________________________________

**8.4.** Have you ever attended any demonstration or field days arranged by DAs or research center on soya bean? 1. Yes 2.No

**8.5.** Have you ever participated in training on soya bean production? 1. Yes 2. No

**8.6.** Which institution was your first source of information about improved soya bean and inoculant? 1) BOA 2) Other farmers 3) Research center (BARC)
4) NGOs (specify)_________________ 5) Relatives 6) other (specify) __________

## 9. Market service and price

**9.1.** Do you have market for soya bean? 1. Yes 2. No

**9.2.** Did you sold your soya bean crop during the 2008/09 E.C year of cropping Season?
1. Yes 2.No

**9.3.** If yes, where do you sell your crop? 1. at farm gate 2. village market 3. District market 4.Secondary market 5.Tertiary market 6.Others (specify)_________________

**9.4.** At what season do you usually sell soya bean product? 1. Right at harvest 2. Latter after harvest 3. Any time I face problem 4. Other (specify):_____________________

**9.5.** Distance to the nearest market center (in hr.) __________

**9.5.** Distance to the all-weather road (in hr.) ___________

## 10.) Uses of crop produced

**10.1)** what are the major crops you cultivate in your farm for 2008/09 cropping season? Please fill the requested information here below:

| Crop | Unit | Amount produced | Amount to be used for | | | |
|---|---|---|---|---|---|---|
| | | | Seed | Food | Sale | Price |
| Maize | | | | | | |
| Sorghum | | | | | | |
| Wheat | | | | | | |
| Soya bean | | | | | | |
| Barely | | | | | | |
| Chickpea | | | | | | |
| Field pea | | | | | | |
| Fababean | | | | | | |
| Haricot bean | | | | | | |

## 11. Participation on off/non-farm income

**11.1.** Did you participate on off farm activities last year? 1. Yes 2.No

**11.2.** Did you participate on non-farm activities last year? ? 1. Yes 2.No

**11.3.** Cash income from livestock products

| Typeof product | Unit | Quantity produced | Quantity sold(Q) | Unit price(P) | Total (P*Q) |
|---|---|---|---|---|---|
| Milk | | | | | |
| Eggs | | | | | |
| Butter | | | | | |
| Cheese | | | | | |
| Others(specify) | | | | | |
| Total | | | | | |

## 12. Labor availability

**12.1.** Did you experience labor shortage in crop farm operation? 1. Yes 2. No

**12.2.** If yes, for which farming operation? 1. Land preparation 2. Planting 3.Weeding (manual) 4. Herbicide and/or pesticide application 5. Harvesting 6. Threshing 7. Storage

**12.3.** How did you solve the shortage? 1. Hiring labor 2. Debo

3. Others (Specify) ___________________________

**12.4.** Did you hire labor for crop production (ploughing of the land, planting, weeding, and harvesting for the last cropping season? 1. Yes 2. No

## 13. Credit availability and use

**13.1.** Do you have access to credit for you farming operation? 1. Yes 2. No

**13.2.** If yes, from where and how much did you obtained in last cropping season (2008/09) E.C?

| Source of credit | Amount or value | Interest rate |
|---|---|---|
| Microfinance | | |
| Cooperative/union | | |
| Bank(specify) | | |
| Traders | | |
| Iqub/Iddir | | |
| NGOs (specify) | | |

**13.3. I**f yes for Q #13.1 for what purpose did use credit you got?

1.To pay school fee 2. To pay tax 3. To buy agricultural inputs 4. To cover house hold expenditure 5.To buy livestock 6.Others(specify)__________________________

**13.3.** If no, what are your sources of finance for farming operation?

1) Crop sales 2) Livestock sales 3) Off-farm activities 4) Others (specify) ___________

**13.4.** How far is from your home to credit office (in Km) _______________

**13.5.** Do you have any problems in getting credit? 1. Yes 2. No

**13.6.** If yes, what is the nature of your credit problems?

1.) Bank loans not available 2.) Do not have required collateral

3.) Loans from informal sources not available 4.) Repayment terms are unfavorable

6.) Interest rates are too high 7.) Others (specify) _______________________________

## 14. Perception of farmers on soya bean technology attributes

**14.1** Characteristics of improved soya bean varieties as compared to local variety

| No | Characteristic | Inferior | The same | Superior |
|---|---|---|---|---|
| 1 | Yield | 1 | 2 | 3 |
| 2 | Drought resistance | 1 | 2 | 3 |
| 3 | Earl maturity | 1 | 2 | 3 |
| 4 | Shattering | 1 | 2 | 3 |
| 5 | Marketability | 1 | 2 | 3 |
| 7 | Disease resistance | 1 | 2 | 3 |
| 8 | Logging | 1 | 2 | 3 |

**15. Cost –benefit analysis**

**15.1.** How much did you get from soya bean production in 2008/09 E.C from improved varieties?

| No | varieties | Area(ha) | Quantity obtained in quintal(Q) | Price per quintal (P) | Total profit(p*Q) |
|---|---|---|---|---|---|
| 1 | Dedessa | | | | |
| 2 | korme | | | | |
| 3 | Ethio-Yugoslavia | | | | |
| 4 | Katta | | | | |

14.4. How much did you spent for soya bean production in 2008/09 cropping season on improved varieties?

| No | Input | Cost of input per unit | Price of input per unit | Total input cost |
|---|---|---|---|---|
| 1 | Land rent(ha) | | | |
| 2 | Seed(Kg) | | | |
| 3 | Herbicide(L) | | | |
| 4 | Pesticide (L) | | | |

| | | | | |
|---|---|---|---|---|
| 5 | Fertilizer<br>DAP | | | |
| | UREA | | | |
| 6 | Inoculant(bio fertilizer ) | | | |

| Operation | No of worker | No of days | Working hour | Wage rate per days | Total costs |
|---|---|---|---|---|---|
| Land preparation( Oxen and labor) | | | | | |
| Planting (Oxen and labor) | | | | | |
| Weeding | | | | | |
| Herbicide and/or pesticide application | | | | | |
| Harvesting | | | | | |
| Threshing | | | | | |
| Sack cost | | | | | |
| Cost of transportation to market | | | | | |
| Total | | | | | |