



**COLLEGE OF DEVELOPMENT STUDIES
CENTER FOR FOOD SECURITY STUDIES**

DETERMINANTS OF ADOPTION OF IMPROVED SOYABEAN
VARIETIES AND ITS CONTRIBUTION TO FOOD SECURITY IN ANNO
AREA OF OROMIA REGION

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A THESIS SUBMITTED TO THE CENTRE FOR FOOD
SECURITY STUDIES, COLLEGE OF DEVELOPMENT STUDIES,
ADDIS ABABA UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND
DEVELOPMENT

DECLARATION

I, **Diriba Bekele**, hereby declare to Addis Ababa University School of Graduate Studies that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. Materials and information other than my own are duly acknowledged.

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**DETERMINANTS OF ADOPTION OF IMPROVED SOYABEAN
VARIETIES AND ITS CONTRIBUTION TO FOOD SECURITY IN
ANNO AREA OF OROMIA REGION, ETHIOPIA**

MSC THESIS

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1. ACKNOWLEDGEMENT

At the outset, I have special thanks for the everlasting Prince of love and peace, the Almighty GOD who is always with me in the mass of unfinished work to be completed.

The authors secondly would like to thank the respondents of soybean producing farmers for their time, Development Agent extension staff enumerators in Sombo Kejo, G/Tare and Anno area woreda Agricultural Office staff for their successful support of this study primary data collection inputs.

My particular appreciation and deepest gratitude goes to Dr.Admasu Keraga , my teacher and major advisor. Without him, the accomplishment of this study would have been difficult. Besides, his gentle advisory from the early designs of the work to the final write-up of the thesis by adding valuable, constructive and ever-teaching comments, frequent assistant, subsequent and unreserved technical support are admirable. I want to extend my deepest gratitude and special thanks to co-advisor, Dr.Solomon for his helpful comments, advice, guidance and cooperation.

I would like to express my sincere appreciation and gratitude to some unforgettable classmates for their friendly support, contribution in my study was great and remarkable. I also wish to thank all other employees of the Food Security department for their contributions along my journey to graduation. Also, I would like to thank my beloved Wife who always helped me in indefinite issues since I started a class up to my graduation.

2. 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
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
HFIAS	Household Food Insecurity Access Scale
MT	Metric Tone
MoARD	Ministry of Agriculture and Rural Development
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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Abstract

Food insecurity is one of the biggest issues affecting emerging nations like Ethiopia right now. Improved soybeans in particular, as well as other pulse crops generally, play a significant role in enhancing food security for households and boosting the income of smallholder farmers. Despite the crop's significant economic value and great production potential, a number of problems prevent better soy bean varieties from being widely adopted and spread. To that end, the Anno region of the Oromia Region, Ethiopia, was the focus of this study, which sought to determine the variables influencing the adoption of improved soya bean varieties and examine the impact of the adoption of improved soya bean varieties on food security. A multistage sampling procedure was used to select 196 sample soybean-producing farmers from primary data collected. Regression analysis and correlation analyses were employed to reveal the direction and strength of the relationship among the variables, particularly between households' status of adoption of improved varieties of soya beans and their food security status. Household food security has been positively influenced by the education level of the household head, the value of livestock owned, farm size, access to extension services, access to credit services, adoption of improved technologies, and so on. The study's overall finding is that raising smallholder farmers' knowledge of improved varieties, providing credit services for seed purchases based on need, and boosting farmers' trust in extension agents' expertise and practical skills all increase the likelihood and intensity of adoption of improved varieties, which ultimately improve household food security.

Keywords: adoption, improved seed varieties, food security, intensity of adoption, smallholder farmers'

1. INTRODUCTION

1.1. Background of the study

One of the most significant food plants grown as an industrial and adaptable crop worldwide is soybean (Afework & Adam, 2018). It is a relatively recent crop for Africa which was previously believed that it should only be used for large-scale commercial farming to produce the seeds used to make animal feed. The United States, Brazil, China, Nigeria, India, Argentina, South Africa, and Uganda are the world's top soybean producers (IITA, 2009). The state of Benue is the leading soybean producer, while Kaduna, Plateau, and Nasarawa are among the states that are expanding production. Soybean cultivation has recently moved outside of normal production areas to include non-native sites.

Soybean was first introduced to Ethiopia in the early 1950s, and it has since become one of the most important low-land crops, suitable too low to medium agro-ecology and primarily grown by smallholder farmers. Ethiopia's ability to combat malnutrition, particularly among smallholder farmers who cannot afford animal source proteins, depends on the production of soybeans (Hagos & Bekele 2018). Soybean consumed directly by humans in large quantities, particularly by rural low-income comete of Tropical Agriculture (IITA) began promoting the use of protein-rich soybeans in ordinary diets in the early 1990s to combat malnutrition (International Finance Corporation, 2013).

According to studies, eating soy foods on a regular basis can reduce the risk of rectal cancer by 80%, mammary cancer by 40%, and breast cancer by 50%. As a result, the US Food and Drug Administration approved the ingestion of 25 grams of soy protein per day as a way to minimize the risk of heart disease in 1999. Countries with soybean-based diets, such as China, Japan, and Korea, are noted for having long life expectancies and low cancer rates (Collison et al. 1994). Soybean cake, soya oil, soya milk, drinks, and snack food bakeries are examples of soybean industrial products (IITA, 2009). Soybean oil is currently a major complement to palm oil in Nigeria's domestic supply equation for edible vegetable oils, with major producers reporting an increase in demand as Nigerians become more aware of the higher quality and health benefits of soybean oil (Michael, 2011).

Soybean is a high-value, high-profit crop. The commercial utilization of both its sub-products, meal and oil, which account for around two-thirds and one-third of the crop's economic worth, respectively, determines the economic feasibility of soya bean cultivation. Soya bean oil and flour are used as food and animal feed all over the world (FAO, 2015). One of the most significant food plants farmed as an industrial and adaptable crop worldwide is soybean (Afework & Adam, 2018).

One of the crops prioritized in the national effort to increase household income and food & nutritional security is soybeans. In response, the national research system has created and distributed a number of improved soybean varieties to smallholder farmers. Over the last two decades, the International Institute for Tropical Agriculture (IITA) has worked hard to improve the crop's production by generating high-yielding, early-maturing types that can modulate in conjunction with indigenous rhizobia and have other desirable agronomic characteristics. TGX 306-036c, TGX 1485—IED, TGX 53-02D, and TGX 440—1E are some of the improved soybean varieties released in Nigeria. Farmers were planting the following kinds, according to seed gathered from farmers: M351-1E, TGX 1448-2E, TGX 306- 036C, and TGX 1485-IED IITA, 2009.

Better shatter resistant and high yielding soybeans were produced (Musa et al, 2002). Depending on the variety and time of sowing, soybeans are harvested 3- months after planting. Soybeans can help increased communities that cannot afford animal protein sources such as meat, fish or eggs. International Instituting systems are more sustainable by improving soil fertility through nitrogen fixation, allowing longer ground cover during the growing season and providing valuable crop residues for forage (Rolling and Wagemater, 1998).

According to Hailegiogis (2010), soybean is a multipurpose crop that are used for a variety of purposes in Ethiopia's economy, including the preparation of various soy bean foods, animal feed, soy milk, raw materials for the processing industry, and preventing soil fertility loss brought on by continuous mono-cropping of cereals, especially maize and sorghum. By offering a nutrient-balanced calorie and protein intake, more soya bean production and consumption will boost food security and nutrition. With the greatest protein and oil content among grain legumes (40 to 42 percent protein, with a good

balance of essential amino acids), and the highest oil content among dry seed weight crops (18 to 20 percent), it is the most nutrient-dense crop (FAO, 2010).

Despite its importance, agriculture still faces a lot of difficulties. Limited adoption of agricultural technologies and the dominance of smallholder farmers' subsistence agriculture are difficulties Ethiopian agriculture has faced (ATA, 2014). A deeper examination of Ethiopian agriculture's performance over the last several decades indicates that it has been unable to produce enough food to support the nation's rapidly expanding population. Even worse, the nation has frequently faced droughts that have killed many lives (CDI, 2010). As a result, improving agricultural technology and management methods are being introduced with a strong emphasis on raising agricultural production. It is possible for improved agricultural technology to contribute to long-term increases in worker productivity, earnings, food security, and overall economic growth (Doss, 2006; Maertens & Barrett, 2012).

Ethiopian agriculture is dominated by a rain-fed subsistence farming system with low input and output. Despite the government's efforts to encourage the adoption of modern, intensive agriculture practices, the usage of chemical fertilizers and improved seeds is still fairly limited. Limited access by smallholder farmers to agricultural inputs, financial services, improved production technology, irrigation, and agricultural markets, as well as poor land management practices, have all contributed to low agricultural output (MoARD, 2010).

Soybean's productivity is low in Ethiopia. Its national average yield is low (1.998ton/ha) which is below the global average 2.31ton/ha (CSA, 2014). The low national yield could be attributed to various reasons. Some of these are related to low adoption of improved soybean production technologies; lack of improved varieties and poor cultural practice (Miruts, 2016). By the provision of extension services, our government is promoting the use of these technologies throughout the nation, and several advancements in agriculture have already been made. Nevertheless, these initiatives Ethiopia's overall rate of agricultural technology adoption is extremely low (FAO, 2010).

Despite the importance of improved soya bean varieties in addressing Ethiopia's food security and malnutrition issues, insufficient attention is paid to the production, supply,

and export of this crucial commodity. The soya bean is currently grown in the country's western and southwestern regions, particularly in Benishangul Gumuz, Gambela, and parts of Oromia Region. The areas of Oromia and Benishangul Gumuz produce the most soya bean in the country, accounting for 51% and 40% of total production, respectively (Sopov, et al., 2015).

Soybeans consumed in the study area Anno directly by humans .Soybean is a multipurpose crop used for a variety of purposes in the area, including preparing various types of soya bean seasoning foods (in Amharic-Shiro Wote), Nifiro, animal feed, soy milk, for market (to increase income) and counteracting depletion of plant nutrients in the soil in thereby contributing to soil fertility. These positively associated with household food security, several other factors were also found to be as or more important in increasing household food security (Anno area Agriculture Office, 2022).

In the Anno area, it was not possible to determine how widely the suggested technologies were being adopted by farmers. Understanding the spread of the technologies and how the causes of the technologies making informed policy decisions are crucial.

1.2. Statement of the Problem

The use of various techniques, including improved varieties, seed rates, and fertilizer rates at the recommended level, are all part of the improved soybean production. The variation includes both the underlying causes and the degree of adoption of the most recent agricultural technologies. Governmental and non-governmental organizations have made a variety of attempts to change soybean production and productivity in order to address these issues. They have introduced new agricultural technologies that increase crop production and productivity, such as the use of fertilizers, high yielding varieties, improved farm tools, etc. However, unlike what was anticipated, farmers in various regions of the country did not readily adopt the introduced technologies (FAO, 2010).

Numerous agricultural technologies have been created thus far, many of which offer extension services to encourage the adoption of agricultural technologies throughout the nation. Despite these efforts, Ethiopia's overall rate of adoption of agricultural technologies, including that of soybeans, are quite low (FAO, 2010). For instance, land-improving

technologies like enhanced seed, fertilizer, enhanced agronomic practices, and natural conservation measures are not commonly used (Million, 2010).

Even though Ethiopia has been breeding and producing soybeans since the 1950s, it was difficult to spread the crop and increase production. The main obstacles included local farmers' lack of knowledge regarding the crop's use, the lack of a market that would be attractive to consumers, and the lack of a systematic approach to popularizing the crop that focused on educating farmers about soybean production, use, and market potential (Mekonnen and Kaleb, 2014).

Commercial soybean cultivation is located in the Chewaka woreda's Buno Bedele zone. Notwithstanding the significance of soybean in addressing the country's ongoing issues with food and nutrition insecurity, insufficient attention has been paid to its production, supply, and export.

The Anno area is renowned for its unpredictable rainfall patterns, scarce supply of resources, and diverse, intricate, and risky farming practices. Agriculture in the area is primarily rain-fed. Similarly unpredictable in nature, rainfall has low amounts and is dispersed unevenly. Food insecurity is a result of the inconsistent and inadequate crop output. According to CSA (2017), soya bean is grown on about 36,635 hectares of land in Anno. The amount of soybean production was down by about 2000 hectares in 2017 compared to 2016. Comparing the study area to national averages, Production (in quintals) and Yield (Quintals/Hectare) are both lower.

Despite such measures, farmers' adoption of improved soya bean varieties remains low, with differences in intensity of adoption across farmers. It's production very scant and limited among few smallholder farmers of the study area. The willingness and interest of production by the farmers is declining from year to year. Moreover, the determinant factors of improved soybean varieties adoption were not known, and information is lacking to promote improved soybean production and to fill this production/productivity gap. Some farmers grow enhanced soya bean types, whereas others do not. There are also variances in adoption levels among the adopters. We need to figure out why some people adopt and others don't, as well as why adoption rates differ. Improvement and

dissemination of soya bean cultivars are critical for correcting the current food insecurity scenario in the study area.

The information currently available on the adoption and intensity of adoption of the soybean production technique is insufficient, despite the fact that numerous studies have been conducted to explain the factors affecting adoption and intensity of adoption of soybean production technology in Ethiopia at different places and times using different models. This suggests that there are a number of factors that affect the adoption of technologies that are anticipated to transform smallholder production and productivity, either directly or indirectly. However, it is still unclear why farmers reject the suggested technologies for soybean production (Jain et al. 2006).

Furthermore, the empirical studies conducted related to adoption of improved soybean variety were limited in its content and area coverage (Miruts, 2016). Therefore, it is essential to find answers to determinants of adoption of improved soybean technology, existing knowledge gap, and intensity of adoption to measure smallholder farmers' improved soybean productivity, total farm income and finally its contribution to improve food security in Anno area.

Agricultural research innovations have no value if they are not taken by the end users. Hence this study is aimed at providing research, extension, and development institutions with valuable information that assists in improving the efficiency of communication and agricultural research, technology transfer by analyzing adoption of soybean varieties and identify socioeconomic and institutional factors that influence the adoption of improved soybean varieties at Anno area.

Even though Anno area in Oromia's East Wollega zones is one of the prospective areas for soya bean production, which is why BARC and the N2 Africa project have been promoting enhanced soya bean varieties few studies have been done. This study looks at the factors that affect adoption and the intensity of adoption of improved soy bean varieties in order to better understand and assess the major barriers to adoption of improved soy bean varieties in the study areas, as well as to improve informed decision-making about how to increase

productivity and evaluate the contribution of soya bean production to food security in the study areas.

1.3. Objectives of the Study

The general objective of the study is to analyze the determinants of adoption, impact on income & food security, constraints to adoption of improved soya bean varieties among farm households of study area.

Specific objectives of the study:

1. To identify factors affecting the adoption of improved soya bean varieties & intensity of adoption in the study area.
2. To analyze the contribution of adoption of improved soya bean varieties to food security in the Anno area.

1.4. Research Question

The study tries to answer the following research questions:

- I.What are the determinants of adoption of improved soya bean varieties in the study area?
- II.What are the extents of adoption of improved soya bean varieties in the study areas?
- III.What are contributions of adoption of improved soya bean varieties to food security in the study areas?
- IV.What are the socio–economic characteristics of farmers in the study area?
- V.What are the constraints to adoption of improved soyabeans technologies in the study area?

1.5. Significance of the Study

There are various motivations to invest in research into the factors that influence agricultural technology adoption. The factors that influence adoption of enhanced soya bean cultivars and their contribution to food security are currently being researched. Adoption and intensity of improved soya bean varieties are known to be influenced by socioeconomic, institutional, and farmer views. As a result, the study sought to identify key variables that impede the acceptance and widespread usage of enhanced soya bean

varieties. This might make it easier to allocate large amounts of money to research, extension, and development activities.

The research findings provide feedback to BARC and the N2Africa project, which has been promoting improved Soyabean varieties in the study area, as well as national and international organizations, and indicate local governments how to deal with the determinants of adoption findings and increase production. The findings of the study used policymakers and organizations interested in adoption programming. More significantly, this study assists farmers in better understanding the factors that influence adoption as well as the various coping mechanisms employed by farmers, and most likely result in the creation of a learning platform. Based on the first-hand data from this study, governments and development partners use the findings to construct relevant interventions aimed at improving the food security condition of rural farmers in urban areas. In general, this study aims to add value to the academic world by providing insight into the subject matter as the title is one of the least studied but most important to developing regions literature, contribute to existing academic knowledge by exploring food security, coping strategies and serve as a reference for future studies.

1.6. Scope and Limitations of the Study

Due to time and funding constraints, the researcher obliged to confine the study to only one district Anno area Oromia Region and limited to single crop type, enhanced soya bean variety. The generalizations based on the findings are more relevant to the study's location. Likewise, the findings of the study may be applied to other parts of the area and the country where comparable circumstances may exist.

As a result, the study was limited to determining factors of adoption of enhanced soya bean cultivars and its influence on food security. The study used cross-sectional primary data; it was further constrained by lack of funding, challenge in data collection due to current political conflicts in the area, time, and other resources. Nonetheless, the findings of this study have practical applicability, particularly in places with comparable characteristics, and will be utilized as a guide for other similar locations.

1.7. Organization of the Thesis

The thesis is organized into five 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 reviewed in the second chapter. The third chapter discusses the research methodology used to undertake the study. The fourth and sixth chapter includes result and recommendation respectively.

2. LITERATURE REVIEW

Key ideas, theoretical explanations, and empirical data relevant to technology adoption are discussed in this chapter. The first section covers the explanation of fundamental adoption terminology, followed by a discussion of the role of soya beans in Ethiopian food security. The following sections deal with varietal breeding, as well as an overview of increased soya bean output and productivity gaps in Ethiopia, constraints to Soybean production, a review of analytical studies on adoption for analyzing determinants of adoption, the intensity of adoption, the contribution of improved soya bean varieties based on insights gained from the literature review and the actual context of the study areas, empirical studies, conceptual framework on technology adoption, and the remaining section presents the conclusion of the literature review.

2.1. Definition of Basic Terms

Adoption: An innovation's adoption within a social system occurs when individuals, people or groups adopt it. Adoption has been defined by Tionenji (2011) and Rogers (2003) as the decision to accept, begin, and maintain an agricultural activity or application of an invention as the best course of action possible. Adoption, according to Feder et al. (1985), is defined as the long-term incorporation of an innovation into farmers' usual farming practices. Adoption, according to Dasgupta (1989), is not a permanent behavior. This means that an individual may decide to stop using an invention for a number of personal, institutional, and societal reasons, one of which may be the availability of a better method for meeting the demands of farmers.

Farmer: In this study, a farmer was defined as a household head that owns and supervises farming operations inside his or her land, according to Adebisi and Okunlola (2013).

Adopter: A farmer who has decided and agreed to plant one or more alternative crops, such as enhanced Soybean varieties, has been designated as an adopter in this study (Tionenji, 2011).

Non-adopter: In this study, a non-adopter was defined as a farmer who is cultivating local soybean but not any of the alternative crops to local soybean farming, in this instance enhanced Soybean varieties, according to Tionenji (2011).

The adoption process: According to Rogers (1983), is the mental process that an individual goes through from first hearing about an invention or technology through ultimate acceptance. This suggests that adoption is a process rather than a one-time event. Farmers are slow to adopt new ideas; they require time to consider them before making a choice.

Rate of adoption: The percentage of farmers who have accepted a specific technique is known as the adoption rate.

Intensity of adoption: The level of acceptance of a specific technology. The degree of adoption of the different technologies is measured by the number of hectares planted with improved seed (also known as the proportion of each farm planted to improved seed) or the quantity of input applied per hectare (Nkonya et al, 1997).

2.2 Theories of Agricultural Technology Adoption

Agriculture is still the most important economic sector in many developing countries (FAO, 2015). This sector is seen to be critical in ensuring food security and alleviating poverty by potentially increasing smallholder farmer earnings and lowering the market price of staple foods. Promoting agricultural ideas and technologies in underdeveloped nations is one way to attain these goals. They're specifically designed to help farmers by enhancing soil fertility, conserving soil nutrients, water, and other natural resources, boosting production, improving insect control, and assisting with farm mechanization. Because of the importance of new agricultural technology in realizing agriculture's full potential, scholars and politicians have studied it extensively over the years (Ogundari & Bolarinwa, 2018).

Before a particular agricultural innovation is released to the farmer, it is important to examine variables that influence adoption of its innovation. Adesina & Zinnah (1993) mentioned that there are three common models usually used to evaluate adoption of innovation in agriculture: the innovation-diffusion model, the economic constraint model, and the adopter perception model (focus of this study). Each of these three models suggest distinct factors that affect adoption, and stakeholders who are interested in gaining an overarching understanding of agricultural innovation adoption need to evaluate all of these models (Masangano & Miles, 2004). The innovation-diffusion model, based on the work of Rogers, reveals that an access to information about an innovation is the key factor determining the success of its adoption.

The characteristics of innovation passively modified, and the issues associated with technology adoption reduced by communicating information on the technology to the potential adopter (Adesina & Zinnah, 1993). Within peasant communities, communication is the driving factor behind the spread of ideas (Shaw, 1987). Agriculture extension, the media, and opinion leaders are commonly employed as communication outlets. Experiment field visits and on-farm experiments were also utilized to persuade "skeptical" non-adopters (Adesina & Zinnah, 1993). The five types of adopters in this paradigm are innovators, early adopters, early majority, late majority, and laggards, representing their propensity to accept an invention in a chronological sequence (Rogers, 2003). Economic constraints, according to the economic constraint model, are the primary drivers of adoption decisions.

The availability of capital, land, or labor has a substantial impact on a farmer's decision to adopt, and this model has been used in a number of previous studies (Chen et al., 1989). This method assumes that technology adoption is impacted by the end-resource user's restrictions and endowments (Masangano & Miles, 2004). The final model, known as the adopter perception model, proposes that subjective judgments of the innovation's qualities are important determinants in farmer adoption decisions. Perception factors pertaining to the farmer's judgments of the severity of the problem to be solved or perceptions of technological innovation are used in studies employing this approach.

Ethiopia's current agricultural strategy prioritizes raising food production and reducing hunger through promoting improved production methods among smallholder farmers through a national extension package. In a similar vein, increasing soybean production and consumption increases food security by providing a healthy balance of calories and protein. It's also a low-cost, high-protein alternative for impoverished farmers who don't have access to animal protein due to a lack of purchasing power. When cultivated alone or in conjunction with cereal crops, the crop has a significant impact on improving the status of soil nutrients and farming systems, in addition to improving nutritional status (CDI, 2010).

2.3. Concepts of Food Security

Food security occurs when all people have physical and economic access to enough safe and nutritious food that meets their dietary needs and preferences for a decent quality of life at all times. Though, currently, enough food is produced to feed the world's population of

around 7 billion. Nonetheless, one in six people still suffers from extended hunger in poor nations, making this a difficult issue. This might be due to a lack of purchasing power, food scarcity, unequal distribution of food, or inadequate food utilization at the family level (FAO, 2019).

For two main reasons, this deplorable situation may worsen in the future. The first is the rapidly changing socio economic landscape. By 2050, the global population is expected to reach about 9 billion people, with the vast majority living in developing nations (Andréosso-O'Callaghan percent Taylor, 2016). The second factor is climate change, which alters agricultural practices as well as pest and disease distribution patterns, putting crops and animals at risk. Climate change has also altered the frequency of extreme weather occurrences, increasing the likelihood of natural catastrophes in the future. Agricultural technology must evolve in order to deal with the effects of these events. Under social and ecological pressure to feed the whole world population, developing technically possible, socio-culturally acceptable, and commercially successful (e.g., Shah et al., 2016) innovation appears to be the key focus.

Food insecurity, on the other hand, is a greater concern in developing countries than in rich countries. Importantly, food insecurity continues to be a major issue in numerous countries in Sub-Saharan Africa, including Ethiopia. According to FAO (2019), the number of undernourished persons in Sub-Saharan Africa remained high in 2018, at 239 million. Despite the fact that these Sub-Saharan African countries have made significant progress in terms of welfare and economic growth in recent decades, food security has not been entirely achieved in these countries (Mota et al., 2019). Ethiopia is a developing country in Sub-Saharan Africa, and it is no exception.

Household food security is directly linked to the physical availability of food, the ability of households to access the available food, and the ability of individuals to secure entitlement to it. Education, clean water, population growth, displacement, health care, urbanization, availability and accessibility to livelihood assets, and human resource development have all been linked to food and nutritional security (Drammeh et al., 2019). Other characteristics include the cost of labor, the quantity of land held, the crop, income diversification, livestock units owned, safety net programs, availability to financing, household indebtedness, agricultural inputs and extension services, and participation and performance

of inputs. O'Ajao et al., 2010; Harris-Fry et al., 2015) discovered that -output markets affect family food security. These elements assist smallholder farmers in increasing their total income by boosting their subsistence output to a surplus level.

Ethiopia's current agricultural strategy prioritizes raising food production and reducing hunger through promoting improved production methods among smallholder farmers through a national extension package. In a similar vein, increasing soybean production and consumption increases food security by providing a healthy balance of calories and protein. It's also a low-cost, high-protein alternative for impoverished farmers who don't have access to animal protein due to a lack of purchasing power. When cultivated alone or in conjunction with cereal crops, the crop has a significant impact on improving the status of soil nutrients and farming systems, in addition to improving nutritional status (CDI, 2010).

2.4. Contribution of improved Soya bean in Food Security

The agricultural practices we use today are not sustainable because they use up a lot of resources and damage the environment. Scientists are working on ways to improve plant growth in situations where there are limited resources available. Exclusively, abiotic and soybeans are recent advances in research and applications to biotic stresses caused by global climate change that gradually affected cropping systems, and will pose serious threats to the world's food production (Yadav, et al., 2015). Therefore, basic plant science research and demand-based plant breeding should change in order to enable plants to grow well in typical and limited resource environments in a sustainable manner.

Grow soybeans to help better cope with changing climates and to take advantage of their multiple benefits. According to Adesina (1993), *Journal of Sustainable Development in Africa*, soybean is regarded as a major economic crop in smallholder farming systems due to its ability to maintain soil fertility, provide feed for livestock, and enhance rural households' food security, nutrition, and income. 2009; 10 (4):324-344. Nevertheless, it is anticipated that the demand in 2030 will increase to be about 1.7 times greater than it was in 2010. Regardless of which production scenario becomes a reality in the future, climate change has

the potential to enable a significant increase in soybean production in Africa (Fodor et al., 2017).

The production of soybeans is rising over time despite biotic and abiotic stresses. Due to the rising demand for soybean production in recent years in Africa and the high potential role of soybean in agriculture for food security, soybean is known as "Africa's Cinderella crop." (Kolapo et al., (2011)

Soybean seed has a unique chemical makeup that comprises a variety of nutraceutical components such as isoflavones, tocopherol, and lecithin, as well as 20% oil and 40% protein, making it one of the most valuable agronomic crops on the planet. Soybean-based cuisine has a variety of health advantages and is a less expensive source of high-quality protein. The crop has the potential to eliminate protein deficiency in the country's poorest communities. The foreign cash obtained through soy meal exports encourages the exodus of high-quality protein from the country, which the poorest sectors of society require at a low cost. Soybean is underutilized in culinary applications, and it requires more work in terms of combining with other foods to create palatable flavors. To combat widespread energy-protein deficiency, high-quality soybean protein should be added in daily diet bulk. Governments, research institutes, academic institutions, and the corporate sector should all work together to boost soybean use in food in all parts of the world. Malnutrition is prevalent among children. One child in every two under the age of five is stunted or underweight for their age (chronically malnourished). Stunting is permanent and has an impact on physical and mental development, resulting in lower labor productivity (Sopov, et al., 2015).

The soya bean offers a variety of options for enhancing household food and nutrition security, as well as a valuable revenue source. The majority of Ethiopians lack access to costly animal protein sources like egg, milk, and meat, and child and maternal malnutrition rates are among the highest in the world. This, along with the fact that approximately 40 million Ethiopians abstain from consuming animal protein for nearly 200 days a year during the fasting season, suggests that domestic soya bean consumption has a lot of potential. A variety of soy food items have been used into Ethiopian cuisine. As a result, it is critical to encourage local or home milling and food processing. To get the soy food

chain off the ground, practical coaching and training in home economics is required in addition to the technology. Soy is in a tough market condition since all processing, including animal feed, culinary oils, and emergency feed, is focused around the Addis Ababa market (Sopov, et al., 2015).

2.5. Improved seed varieties

Classical breeding methods were used to improve yield and other characteristics. In the last 60 years, yields have increased by 60% and 3,900 different soybeans have been released worldwide. Soybean processing has been accelerated thanks to the use of molecular methods. The most widely planted GE crop in the world is the glyphosate-tolerant Roundup-ready (RR) soybean. These molecular approaches are the breeding techniques of the future. As a result, soybeans can become an important crop for high quality protein, healthy oil and biodiesel oil. (Sumarno and, Fehr 1982).

Improved varieties are critical to increasing production of all crops. Unlike traditional varieties, these varieties have special characteristics such as higher yield, resistance to various biotic and abiotic challenges, and appropriate maturity length for a particular crop rotation. Soybean is a day length sensitive plant with a short day length. Therefore, the adaptability of individual soybeans to latitudes and planting dates is limited. The history of soybean cultivation in India is quite recent. Ensuring the sustainability of soybean production requires aggressive breeding to create varieties with versatile disease resistance

2.6. Empirical Studies on Technology Adoption

It's important to distinguish between adoption, which occurs at a single moment in time, and diffusion, which occurs over time and involves the spread of a new technology over a population. Adoption is not a one-dimensional process, as previously claimed. Early adopters may become non-adopters in the future. Late adopters, on the other hand, may join the adopters club and become potential adopters. As a result, many adoption studies aim to chronicle adoption history in addition to analyzing contemporary practices. Obtaining information on previous seasons takes more time, but it might be very valuable. Ideally, baseline surveys would include information on historical practices and adoption history, but this information is frequently unavailable. This type of analysis can be beneficial for a variety of reasons. It might be used to forecast future input demand,

evaluate if extension should be enhanced, or measure the change in the number of technology users over time in order to analyze the impact on households and regions. (Assefa and Gezahegn,2009).

Agricultural technology adoption has a number of steps, as it does in many developing nations with an agrarian economy. It has a spatial as well as a temporal dimension. It is stated that technology adoption is a dynamic process in which knowledge collecting, learning, and experience play critical roles, particularly in the early stages of adoption and spread. Various adoption studies in Ethiopia's smallholder agriculture sectors were conducted by various experts. The following are some of the studies that were discussed:

Adoption of Improved Soya Bean Technologies in Bauchi Local Government Area, Bauchi State, Nigeria was investigated by E. F. Fabiyi (2015). The research was based on cross-sectional data from 45 maize growers. Multiple regression analysis was performed in this investigation. Household size and labor source had a favorable and substantial impact on adoption of enhanced Soya bean Technologies varieties, but processing experience had a negative and significant impact.

In the West Harerghe zone, Yenealem et al., (2013) investigated the factors that influence the adoption of enhanced maize varieties by male and female heads of households. The research was based on cross-sectional data from 148 maize growers. The logistic regression model was employed in the study to estimate the likelihood of improved maize varieties being adopted. Cultivated farm size, quantity of livestock (TLU), and Extension contact all had a positive and significant impact on the likelihood of adopting better maize varieties, but age and distance to the nearest input market had a negative and significant impact.

In Ethiopia's Kobo district, north Wolo zone, Ermias (2013) performed research on the adoption of enhanced sorghum varieties and farmers' varietal trait preferences. The research was based on cross-sectional data from 150 sorghum growers. Tobit was used in the study to track the factors that influence the acceptance and intensity of enhanced sorghum varieties among the sample homes. Participation of tropical livestock units in off-

farm activities, perception of improved sorghum taste quality, striga infested land (ha), perception of improved sorghum yield capacity all influenced adoption of improved maize varieties positively and significantly, whereas farm size (ha), proportion of sorghum area from total crop land, distance from farmers training center to home, active labor ratio all influenced adoption of improved maize varieties negatively and significantly.

In Ethiopia's Gorogutu Woreda, Mekuria (2013) found variables impacting the adoption of enhanced maize cultivars. The research was conducted using cross-sectional data from 130 enhanced maize growers. The Tobit model was used to investigate the factors that influence the likelihood and intensity of enhanced maize seed uptake. Household head's educational level, size of own cultivated land, off-farm employment, access to credit, contact with extension agent, membership in cooperative, income from chat, and land size all influence adoption of improved maize varieties positively and significantly, whereas cosmopolitanism has a negative and significant impact.

Afework and Lemma (2015) investigated the factors that influence the adoption of improved rice varieties in Ethiopia's Fogera area. The research was based on cross-sectional data from 151 rice growers. In order to address factors that impact the choice to engage in the adoption of enhanced rice varieties, the researchers utilized a univariate probit model. Household size, the household head's education, land, rice farming experience, access to new rice cultivars, off-farm income, and institutions all influenced participation in improved rice cultivation positively and significantly, whereas distance to the nearest village market, access to the main market, and distance to the agricultural extension office all influenced participation in improved rice cultivation negatively and significantly.

Sisay (2016) performed research in Jimma Zone, South-Western Ethiopia, on agricultural technology adoption, crop diversification, and efficiency of maize-dominated smallholder farming systems. This study employed cross-sectional data from 385 farm families selected using multi-stage sampling approaches throughout the 2013/14 crop season. For identifying factors impacting status and intensity, pace of technology adoption, and choice to adopt recommended agronomic practices in maize farming, the researchers employed Tobit, Count data, and Multivariate probit models. Age, family size, level of

education, family education, mobile phone ownership, extension services, cooperative membership, livestock holding, and farm size all positively and significantly influence adoption of improved agricultural technologies, while distance to development has a negative and significant impact. Age, extension services, livestock holding, landholding, cooperative participation, and mobile phone ownership all favorably and substantially influence the pace of enhanced maize variety adoption, but sex, distance to development and market centers have a negative and significant impact. Family education, mobile phone ownership, livestock holding, and extension services positively and significantly influence decision to adopt recommended agronomic practices, whereas sex and distance to development centers negatively and significantly influence decision to adopt recommended agronomic practices.

In the Ilu-Ababora Zone in Southwestern Ethiopia, Samuel et al., (2017) explored the factors that impact soya bean adoption and degree of adoption. Cross-sectional data from 185 soya bean producers was used in the study. To evaluate the intensity of adoption, the Tobit model was employed, while the Logistic regression model was used to determine factors influencing adoption probability. Training and family use of soy food had a favorable and significant impact on Soya bean adoption, but age, farm size, and distance to nearest market had a negative and significant impact on Soya bean adoption. Distance to cooperatives and consumption of soy food at home impacted adoption of Soya bean intensity negatively and considerably, whereas sex, farm size, and training influenced adoption of Soya bean intensity positively and significantly.

2.7. Summary of literature review and identification of research gap

According to a literature assessment, social and economic variables influence the adoption of new or enhanced agricultural technology and farms. According to the most research, farmer characteristics such as age, education level, gender, income, and household size, as well as farm characteristics such as land size and net returns, are significant determinants in determining the adoption of an agricultural operation (Adebisi and Okunlola, 2013; Tionenji, 2011). Farmers' income, education level, farm size, and frequency of interaction with extension workers are all key variables influencing the farmer's decision to embrace or not adopt a certain agricultural technology or practice. The size of the farm, the age of the farmer, his or her farming experience, the quantity of finance available, and the

frequency of extension contact with farmers have all been demonstrated to have a higher impact on the rate and degree of adoption of agricultural technology or crop enterprises. In Borno State, Nigeria, Idrisa et al. (2012) discovered that education, access to extension services, yield, and credit affected adoption of enhanced maize seed varieties. Furthermore, institutional considerations such as market and financing facilities, as well as access to extension services have a larger role in deciding whether agricultural companies are adopted or not.

However, according to the above empirical findings; most adoptions are focused on the same crop, but with the goal of improving crop yield through the adoption of improved agricultural methods that influences household food security either positively or negatively which makes connection with my study. But the limitations of the above studies where they did not inspect statistically intensity of Adoption, contribution of adoption to food security on the status of farmer food security. This study fills the gap of the above studies by examining statistically the influences of Adoption, contribution of adoption to food security on household food security in Anno area and giving possible policy recommendations to curb the problem of food insecurity in the study area.

2.8. Conceptual Framework of the Study

The adoption and diffusion of agricultural technology varies a lot from place to place. Because there are differences in agro ecological, institutional, and social variables, there are variances in adoption trends. Farmers' adoption behavior is also impacted by a complex pool of socioeconomic, demographic, technological, institutional, and biophysical variables, particularly in low-income nations (Feder et al., 1985).

Adoption of technologies is the outcome of several interactions of farmers' internal and external contexts. Household level characteristics: Demographic factors (sex, marital status, age and family size), socioeconomic factors (livestock ownership, land holding, education and off/non-farm income), farm characteristics (size of farm and farm experience), institutional factors (distance to nearest market, access to credit, frequency of extension contact, demonstration, training and participation on field day), Perception of farmers: marketability, disease resistance, drought resistance, early maturity, shattering resistance and technology related factors (price of new technology to farmers, farmer's familiarity with the

technology, lack of abundant Information,) are factors hindering the adoption of appropriate technologies for sustainable farming systems that expected to influence the adoption of improved soya bean varieties in the study areas are summarized in figure 1.

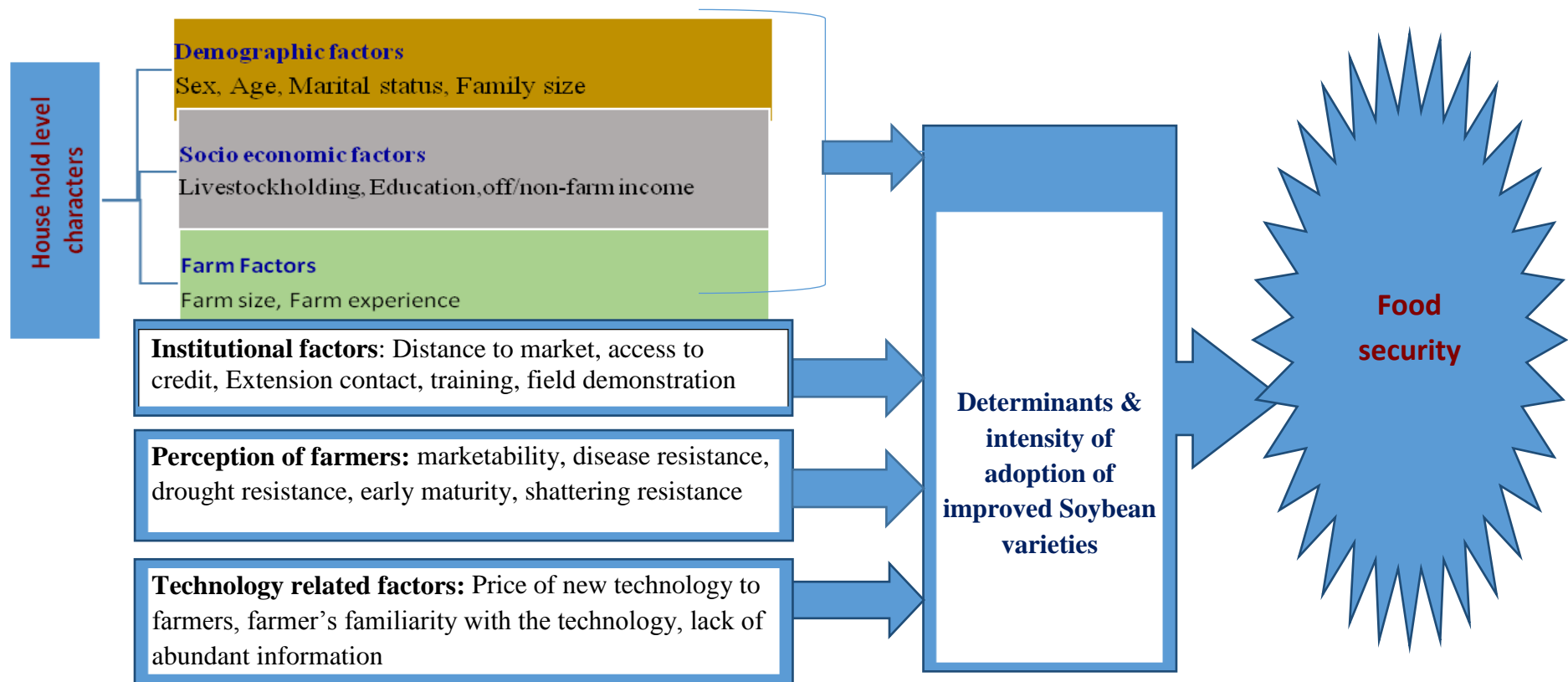


Figure 1: Conceptual framework of determinants of adoption of improved soya bean varieties & its contribution to improve food security

3. DESCRIPTION OF THE STUDY AREA & RESEARCH METHODOLOGY

3.1 Location and physical features

Anno area was part of the old Bila Seyo woreda and is located in the East Wellega Zone of Oromia region, 268 kilometers west of Addis Ababa on the road to Nekemte. It is bordered in the East by the West Shewa Zone, in the West by Sibu Sire, in the North by Gudeya Bila, and in the South by Bonaya Boshe. The altitude of the Anno region is between 1556 and 1680 meters above sea level. The district is divided into nine Kebele Administrations (Kombo Kojo, Ago Laften, Gembela Tare, Ulmaye Cala, Ongoboo, Adate Tiksa and Alami Sayo).

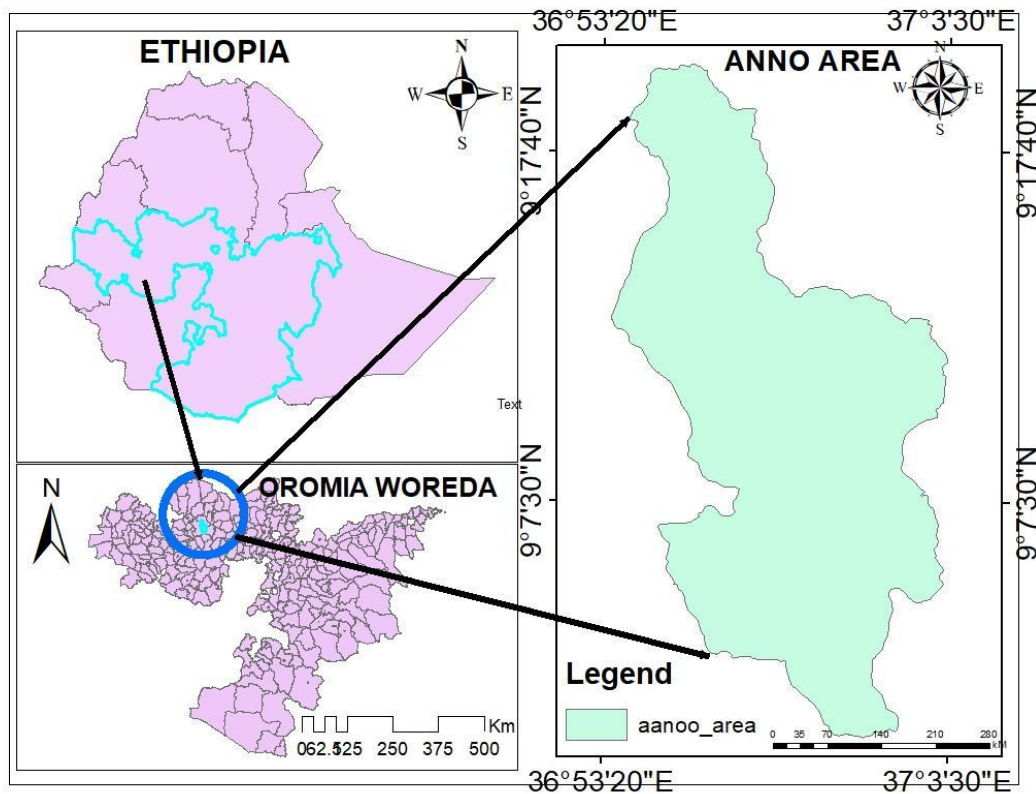


Figure 2: Map of the study area, own sketch, 2022

3.2. Agriculture

The Anno area economy is based Agriculture as other regions. The type of Agriculture is primarily rain-fed and characterized by poor production level. It is the main source of income for the majority of the population. Farmers use traditional farming methods and have limited

access to Agricultural inputs. Farmers in the study region cultivate agricultural products for both personal use (food consumption) and commercial interest. There is also the possibility of animal rearing in the region. Maize, sorghum, and soya bean are the main crops grown in the area.

3.3. Population

According to the 2015 national census, Anno woreda had a total population of 46,867 people (49.44 percent men, 50.56 percent women), with 7,741 male-headed households and 1,555 female-headed households. In total, there were 15,272 men and 23,319 females' families. 4,752 people, or 11.59 percent of the population, live in the city. The religion of the people is: 40.81 percent appealing Protestants, 40.09 percent appealing Ethiopian Orthodox Christians, and 17.57 percent appealing Muslims (CSA, 2015)

3.4 Research Methodology

3.4.1 Research design

The study design was a cross-sectional survey with a mixed approach- employing both quantitative and qualitative techniques. Descriptive and inferential methods are employed to explain the factors that influence adoption, the intensity of adoption, and the contribution of improved Soyabean varieties to food security in a specific area.

3.4.2 Sampling procedure and Size

To select the desirable sample for the primary data collection, a three-stage sampling technique was used. Purposive or judgmental sampling technique was employed because it helps to identify the population of interest that could not be obtained through other methods. Anno area is selected purposefully among the districts in East Wollega Zone in the first stage because soya bean varieties were promoted by Bakko Agricultural Research Center (BARC) and N2 Africa project in the study area better than other areas in the zone. In the second stage, two kebeles were identified for this study from a total of five kebeles Bakko Agricultural Research Center and N2 Africa projects implemented. Households in the sample two kebeles were stratified into soya bean producers and non-producers, with representative

samples drawn from soya bean producers in order to research a real-life occurrence rather than making statistical generalizations about the whole population.

Finally, sample houses for the study were selected using a stratified random selection procedure. To this end, at each sample kebele, a list of soya bean producers were obtained from the district agricultural office and development agents and then families in the area were divided into two strata: adopter households of enhanced soybean technologies and non-adopter households. As a result, the study target groups included both adopters/ farmer farm improved varieties and non-adopter /Farmer farm locals /. The household is considered as the unit of analysis, with heads of households included in both adopters and non-adopters. Agreed the study resource constraints, the total sample calculated using Cochran's (1977) stratified sampling approach. The sample determined was distributed to each kebele using a probability proportionate to household size. 196 soybean producers sample respondents (64 improved and 132 local soybean Producers) selected using systematic and random sampling from each group based on likelihood proportional to sample size (PPS).

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

$$n = \frac{z^2 pq}{e^2} \quad n = \frac{z^2 pq}{e^2} \quad \text{-----} \quad 1$$

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 adopters population, which is 0.5 in this study. q = 1-p that is 0.5 as there is no prior information on the variance of adoption in the area, and e is the desired level of precision/correctness, which is 0.07 margin of error.

Table 1: Sample size of soya bean producers by kebeles

District	kebeles	Population		Selected Sample		
		Improved soya bean producer	Local soya bean producers	Adopters in #	Non-adopter in #	Total sample size in #
Anno area	Sombo Kejo	156	312	34	68	102
	Tare	146	289	30	64	94
	Total	302	601	64	132	196

Source: Districts agricultural office, 2022

3.4.3 Data Sources & Collection Techniques

Both primary and secondary data were used in the study. Primary data obtained using data collection methods during one-on-one interviews using a standardized survey questionnaire that was pre-tested and administered by well-trained and experienced enumerators who are familiar with the area as well as agricultural systems who know the local language. The primary sample respondents were household heads male and female members who directly participated in the adoption of enhanced Soyabean varieties as well as having power in administering the farm. During the personal interview, information on soybean 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 factors, technology adoption factors and other relevant) factors etc. were collected. Secondary data sources include books, journals, published and unpublished documents from Anno area woreda agricultural office, Bako agricultural research center, internet and other related sources.

3.4.5 Questionnaire survey

A questionnaire-based survey was conducted to collect quantitative data from sample household heads or household primary male or female farmers who were directly involved in the production of Soyabean crop. 196 sample respondents were interviewed using this data collecting tool in order to obtain information on demographic, socioeconomic, institutional, agricultural, and technology-related aspects that are likely to impact the adoption of enhanced soya bean varieties in the study area Anno. From two sample of kebeles, 9 enumerators selected from the district agricultural office and area development agents and educated on the questionnaire collected the data.

3.4.6 Techniques of Data Analysis

The questionnaire was reviewed for completeness, cleaned, coded to reflect replies to particular questions, and entered into the computer's Statistical Package for Social Sciences (SPSS) for analysis after data collection. Simple descriptive statistical analysis, such as frequency distributions, percentages, and totals, were used to assess quantitative data. The

descriptive analyses were used to analyze the distribution of the respondents based on their socioeconomic and agricultural characteristics. The links between the variables were investigated using regression analysis and correlation to reveal the direction and strength of the relationship between the variables.

3.4.7 Descriptive statistics

Mean, standard deviation, percentages, frequency, and graphs are descriptive statistics that were used to explain distinct categories of sample units in terms of the desired socioeconomic attributes. In addition, inferential statistics like the chi-square test (for categorical variables) and the t-test (for continuous variables) were employed to compare and contrast different categories of sample units with regard to the desired characteristics in order to make some key findings.

3.4.8 Econometric model

Objective -1: identify factors affecting the adoption of improved soya bean varieties in the study areas.

When considering soya bean production, a farmer confronts two challenges, according to Cragg's model. The first step is to determine whether or not a farmer grows soya beans. The second step is determining the intensity of adoption, or how much area or resource to devote to soya bean farming. A farmer may adopt to plant soyabean at the start of a cropping season without making specific arrangements for the amount of land required. Many considerations, such as the price and availability of inputs, the possibility to plant rival crops, information about production techniques, and so on, might impact a farmer's decision later on. Cragg's model has two stages: a probit model for determining the determinants of adoption, and a truncated model for determining the determinants of adoption level (Cragg, 1971). Let d_i^* be the latent variable representing a farmer's adoption choice, y_i^* be the latent variable describing its adoption level decision, and d_i and y_i be their observed counterparts. The two barriers for a farmer can be written as follows, based on Cragg (1971) and Moffatt (2005) specifications:

$$d_i^* = \alpha z_i + v_i \dots\dots\dots (2) (3)$$

$$y_i^* = \beta x_i + \varepsilon_i ,$$

Where

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

Where z_i is the vector of variables explaining whether a farmer adopts improved soya bean varieties, x_i is a vector of variables explaining level of adoption, and v_i and ε_i are the error terms.

The farmer's adoption choice is the dependent variable in the first stage. This variable is binary in nature, with 1 representing adopters and 0 representing non-adopters. The dependent variable in the second stage is the area of improved soya bean types cultivated per hectare. Both hurdles have equations connected with them in the double hurdle model, reflecting the influence of the farmer's qualities and surroundings. Explanatory variables might occur in both equations or in only one of them (Teklewold et al., 2006). According to Carroll et al. (2005), equations 2 and 3 are considered to be independent, therefore the error terms, $v_i \sim N(0,1)$ and $\varepsilon_i \sim IN(0,2)$, are randomly and independently distributed.

For the double hurdle model, the log likelihood function is:

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

Where Φ and ϕ are the standard normal cumulative distributions 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 $\Phi(z_i \alpha) = 1$. 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 are made simultaneously. Developed Tobit model also 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:

$$y_i = \begin{cases} y_i^* & \text{if land allocated for soybean} > 0 \\ 0 & \text{otherwise} \end{cases} \dots\dots\dots (5)$$

Where, β_0, \dots, β_k are the unknown parameters to be estimated and $\mathbf{x}_{1i}, \dots, \mathbf{x}_{ki}$ 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:

$$L = \prod_{V_i > 0} \frac{1}{\sigma} f\left(\frac{y_i - \beta x_i}{\sigma}\right) \prod_{V_i < 0} F\left(-\frac{\beta x_i}{\sigma}\right) \dots\dots\dots (6)$$

Through maximizing the function with respect to β and σ , 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):

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

Whereas 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.

3.4.9 Household Food Insecurity Access Scale (HFIAS)

Objective -2: Analysis of how improve soybean has affected the food security of households. The Household Food Insecurity Access Scale (HFIAS) was used with ordered logit or probit to examine the contribution of improved soybean adoption to household food security. HFIAS is a method based on the premise that experiencing food insecurity (consumption) leads to predictable behaviors and responses that can be recorded and measured through research. The HFIAS is based on a short survey that collects behavioral and psychological indicators of household food insecurity, such as reduced food quality or food frequency due to lack of resources. The household was able to place itself on a spectrum that indicates the severity of food insecurity based on survey responses.

HFIAS data were analyzed for the frequency of household food insecurity and its change over time. In addition, the HFIAS has been found to be particularly effective in identifying aspects of food security that include inadequate food availability or quality. According to HFIAS, there

are three universal causes of household food insecurity: concern about food safety, inadequate quality and inadequate access to food.

3.5 Definitions of Variables and Hypothesis

3.5.1 Dependent variables

Adoption: defined as a binary variable that is "adopters" and "non-adopters" assigned a value of 1 and 0, respectively.

Adopter: A farmer who adopted soybean, "adopter", defined as one who had soybean in the field during the time of the interview, planted soybean for at three consecutive seasons from March, April and May season in the year 2022 and who plan to continue growing soybean with the improved varieties.

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 hectares. Adopters are farmers who produce either of the improved Soyabean varieties.

Non-adopters: are farmers who did not use those improved varieties during the production year.

3.5.2 Independent variables

The independent variables that are thought to have impact or the factors that influence the adoption of enhanced soyabean varieties. The variables were divided into five groups: Household characteristics (demographic, socioeconomic, and farm elements), institutional factors, and technology-related factors. A broad list of elements that may impact the adoption

of agricultural technology may be found in the literature on adoption. Farmers' decisions to employ better agricultural technology, as well as the intensity with which they use over time, is thought to be determined by a combination of variables such as household characteristics, socioeconomic conditions, and the physical surroundings in which they work. 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 counterparts (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, resources, 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, the age of the household head may have positive or negative effects on the adoption and intensity of adoption of improved soya bean varieties.

Education level of the household head: It is a continuous variable that is assessed in terms of a farmer's degree of education. It is assumed that the longer a person is exposed to education, the more receptive he or she would be to new ideas. Educated farmers may also be more aware of the advantages of current technology and have a stronger ability to acquire new knowledge, making new technologies easier to embrace. As a result, the household head's educational level has a beneficial impact on the status, intensity, and promptness of technology adoption (Sisay, 2016, Hassen et al., 2012, Afework and Lemma, 2015). As a result, education was predicted to have a favorable impact on the choice to adopt enhanced soya bean varieties as well as the intensity with which they were adopted.

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 of 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 has a value of 1 if the farmer had participated in soya-bean varieties related training at least once in the last three years and 0, otherwise. Farmers participated in training, their probability of adoption and intensity of adoption of new technologies increased (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 has a value of 1 if the farmer had 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's a dummy variable that takes the value 1 if a family has access to credit and 0 if they don't. Farmers with loans may be able to overcome their financial limits and thereby purchase inputs. The availability of finance has a favorable impact on the adoption of new technology (Tihamiyu et al., 2014; Leake and Adam, 2015). As a result, access to financing is predicted to boost the likelihood and intensity of adoption of improved soya bean types.

Livestock holding: A continuous variable, it is. Tropical livestock unit (TLU) conversion of the livestock number. Based on Storck et al. (1991), the conversion factors were used. Large livestock holding households can make more money from the sale of animal products. Smallholder farmers can then use this income to buy farm inputs. The adoption and intensity of improved soy bean varieties are therefore thought to be positively correlated with livestock ownership.

Family size: It is a continuous variable measured in terms of the adult equivalent of persons living together in the household. Adoption of soya beans 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.

Farm experience: It's a continuous variable that's measured in soya bean production years. Farmers with sufficient farm expertise are projected to be more inclined to accept new technology than farmers with less experience. According to Aman and Tewodros (2016), farm experience has a favorable impact on better variety uptake and intensity. As a result, it is projected that farm experience would influence the acceptance and intensity of enhanced 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 the 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-farm activity: A household head is considered to have participated in non-farm income-generating activities if this variable is treated as a dummy and has the value of 1 otherwise. Households involved in non-farm activities are better off financially, having extra money to spend on inputs. According to Olalekan and Simeon's (2015) study, involvement in non-farm income-generating activities influences the adoption of new technologies in a favorable way. Therefore, it is anticipated that the acceptance and intensity of enhanced soy bean varieties will be positively correlated with participation in non-farm income.

4 RESULT AND DISCUSSIONS

The study result assessed determinants of adoption of improved soyabean varieties and its contribution to food security in Anno area of Oromia region. The survey sample size handled 196 respondents. Both descriptive, econometric and HFIAS methods were used to analyze the primary data. Descriptive statistics were employed to describe the general demographic, socio-economic and institutional characteristics of sample soyabean 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. Household's food insecurity status measured by HFIAS (Household Food Insecurity Access Scale).

4.1 Descriptive Results and discussion

4.1.1 Households level characteristics (demographic factors)

Out of the total interviewed 196 soya bean producers 180 (91.8%) were male headed and the remaining 16(8.2 %) were female headed producers (Table-2). The result shows, 96.88% males adopters & 3.13% females adopter, 89.39% males non adopter & 10.61 % females non adopter.

The expressions is male farmers were more likely to adopt new technologies than females. Sex difference is found to be one of the factors influencing adoption of new technologies, in general. This can be justified because males better have access to information than female headed and the study area socio-cultural value inclined & allowed the more freedom for male to participate in different extension programs and make female headed households less efficient. The study (Samuel et al. 2017) on soya bean in Ilu-Ababora Zone showed that females were immobilized to adopt new technology as compared to their male counterparts.

Regarding the age of the households, the study result shows that 66.8 % were less than 50 years and 33% were fifty and above year's age. The age of sample farmers has a mean of 49.25% for adopters and 47.12% for non-adopters; which is an insignificant effect on adoption (Table-2). Though age of the household head may have positive or negative effect on the adoption and intensity of adoption of improved soya bean varieties, according to (Assefa and Gezahegn, 2010), depending on the survey study result above, I am inclined to, and it has a positive relationship.

Marital status: the result of the survey shows that 90.8% were married and 9.2% widowed. The chi-square test of marital status of distribution between the adopters and non-adopters was found to be insignificant (Table-2).

Family size: The numbers of family members who permanently work on farm activities were a mean of 3.32 for adopters and 3.07 for non-adopters. It is insignificant among adopter & non adopter.

Table- 2 **Sex, age and marital status of the household head**

		soya bean producers status						Chi-square test
		Adopters (N=64)		Non-adopters (N=132)		Total =196		
		N	%	N	%	N	%	
Sex of household head	Male	62	96.88	118	89.39	180	91.84	3.218
	Female	2	3.13	14	10.61	16	8.16	
	Total	64		132		196	100.00	
Age of HH	<50 years	34	53.13	97	73.48	131	66.84	8.061**
	≥ 50 years	30	46.88	35	26.52	65	33.16	
	Total	64		132		196	100.00	
Marital status of the household head	Married	56	87.50	122	92.42	178	90.82	1.253
	Divorced	8	12.50	10	7.58	18	9.18	
	Total	64		132		196	100.00	

Source; Own survey 2022

4.1.2 Socio economics Characteristics

Educational results of the study shows that about 14.8% households are illiterate, 38.78% of farmers were in grade between 3 -5, 26.53% HH were in grade between 6 -9 and 16.84% were in grade between 10 -11. From Table-3, on average, 31.25% adopter farmers were having formal education of grade 10-12 when compared with the 10% non-adopters in the same grade level, which is a very significant difference. As shown in the table below, the Chi-square test

result indicates that the education level of farmers was found to be significantly between adopters and non-adopters. Hence, educated producers were in a better position to get and use innovation, which played a role in improving their soya bean production practices and more likely to secure food for their family. This suggests Education can enhance production of producers and adoption of newly presented technologies and modernizations and finally result in household food security. This corresponds with previous similar studies (Sisay, 2016, Hassen et al., 2012, Afework and Lemma, 2015).

Table 3 Educational level of the household head

Grade	soya bean producers status						Chi-square test
	Adopters (N=64)		Non-adopters (N=132)		Total =196		
	N	%	N	%	N	%	
zero	2	3.13	27	20.45	29	14.8	45.592**
grade 3-5	20	31.25	59	44.69	79	40.30	
Grade 6-9	22	34.38	33	25	55	28.06	
Grade 10-11	20	31.25	13	9.85	33	16.84	
Total	64	100	132	100	196	100	

Source; Own survey 2022

Livestock production was common in the study area although its production technique was not improved. On average, about 3 and 1 local & improved cows were sold, respectively per household. The number of Oxen, owned by households, and the number of oxen sold is less than the cows.

The result indicated that adopters household with large livestock (TLU) holdings can obtain more cash income from the sales of livestock & animal products associated with the dietary variety of the household than non-adopters(table-4). This income in turn helps adopters smallholder farmers to purchase farm inputs, & increases their level of adoption of improved agricultural technology that contributes to household food security as well as nutrition. This study is consistent with that of Leake and Adam (2015). Therefore, livestock ownership has a positive correlation with adoption of improved soya bean varieties and enhances food security.

The source of income & use of Soya bean for HH

The main sources of income for the households in order of importance is crop cultivation 75 % for adopters & 71.21 for non-adopter households, animal husbandry 14.04% for adopters & 11.36 for non-adopters HHs, and non-farm practices 9.38% for adopters & 4.55% for non-adopters HH. Also the chi-square test shows there is difference among the two groups (table-4). As seen from the analysis result, the main sources of income of Soyabean were very higher in adopter farmers than non-adopters (Table 4).

Soybean cultivation has been used mainly for food consumption. It is 71.88% for adopters and 41.67% for non-adopters in the study area, rural low-income communities who cannot afford to buy animal protein sources such as meat, fish, or eggs in 2022. Secondly, 34.09% for adopters and 6.25% for non-adopters, soybean is cultivated to help improve soil fertility and even the farmers' use very poor/infertile farmlands for soybean cultivation. As seen from the analysis and chi-square test result, the uses of Soyabean were very higher in adopter farmers than non-adopters (Table 4).

Table 4. The source of income & uses of Soya bean

Variables		soya bean producers status				Total=196		Chi-square test
		adopters=64		non adopters=132				
		N	%	N	%	N	%	
Sources of income for households in order	crop cultivation	48	75.00	94	71.21	142	72.45	13.676**
	Animal husbandry	9	14.06	15	11.36	24	12.24	
	Non-farm	6	9.38	6	4.55	12	6.12	
	Non response rate	1	1.56	17	12.87	18	14.43	
	Total	64	100	115	87.12	196	100	
The main uses of soya bean grain in	For consumption	46	71.88	55	41.67	101	51.53	20.699**
	For sale	14	21.88	24	18.18	38	19.39	
	Improve soil fertility	45	34.09	4	6.25	49	25	

2021/2022	Non response rate	0	0	8	6.06	8	6.06	
	Total	64	100	132	100	196	100	

Source; Own survey 2022

4.1.3 Farm Characteristics

Farming experience on soya bean production: The result shows a mean 5.56 and 4.87 years of experience for adopter and non-adopters, respectively. Total cultivated land was a mean of 4.67 for adopters and 4.03 for non-adopter since he/she started farming. In theory, farmers with sufficient farm expertise are expected to accept new technology than farmers with less experience. The result of this study is consistent with the theory and the findings of Aman and Tewodros (2016).

Farm size & Area allocated under improved soya bean: the study result shows the total land holding per household on average is 5.10 hectare. The total cultivated land in hectares was 4.67 & 4.03 hectares for adopters and non-adopters, respectively. Land area allocated for improved soya bean production in 2021/2022 was very minimal, amounting to about 0.46 hectares.

The result indicates that farm size is positively associated with adoption. This means that farmers who have relatively large farm size can be motivated to adopt new technologies than farmers with small size. Previous studies also show the positive and significant relationship of farm size has with adoption of new technology (Yenealem et al., 2013; Solomon and Bekele, 2010)

4.1.4 Institutional related factors

Extension Service, Contact with extension agents: The survey results shows that farmers used to be frequently contacted & consulted by DAs on soya bean varieties production in the last cropping season. All for adopters and only 50.76% for non-adopters (Table-5) were found to be contacted by DAs. The result and the chi-square test pointed out that frequency of contact has a potential force which accelerated the effective dissemination of adequate agricultural information to the farmers, thus enhancing farmers' decision to adopt new technologies for the adopters. The results are similar with the studies conducted by Yemane (2014) and Hassen et al. (2012) on rice varieties.

Table.5 Soya bean producers contact with extension agents

Farmers contacted & consulted by DA in the last cropping season, 2021/2022	soya bean producers status						Chi-square test
	adopters=64		non adopters=132		Total=196		
	N	%	N	%	N	%	
Yes	64	100	67	50.76	131	66.84	29.881**
No	0	0	38	28.79	38	19.39	
Total	64	100	105	79.55	196	100	

Source; Own survey 2022

Participation in training: the result of the study shows that 71.8% farmers have participated in training on soya bean production but 24.9% did not participate in the last three years (Table.6). All of the adopter farmers have participated in training. The result is consistent with that of Wuletaw and Daniel (2019), indicating the positive effect of participation in adoption and intensity of adoption of improved soya bean varieties.

The first source of information about improved soya bean for about 43.4% of farmers was from BARC research center that of 31.1% farmers are from other neighboring farmers, that of 17.9% farmers is from relatives, and that of 7.7% farmers is from BOA. The result indicates that the presence of BARC in the study area was a good opportunity for adoption and enhancing food security of the study area (Table-6).

Participation in demonstration: From the study results, about 63.3% farmers were assisted by DAs at farm level; about 25.5% farmers were assisted by training provided at FTC, and about 11.2% farmers were assisted by demonstration services. 77.5% of farmers attended certain demonstration or field days that were arranged by DAs or research centers on soya bean production. The result is consistent with previous studies conducted by Alemitu (2011) and Hadush (2015), where participation in demonstration has positive influence for adoption and intensity of adoption of improved soya bean varieties.

Table.6 Farmers' participation & source of information about technology

Variables		Freq.	Valid%	Cum %
Farmer ever attended any demonstration	Yes	131	77.5	77.5
	No	38	22.5	22.5

	Total	169	100	100
How the Development Agents helped the farmers	Practical assistance at farm	124	63.3	63.3
	Demonstration	22	11.2	74.5
	Training at FTC	50	25.5	100
	Total	196	100	
Farmer ever participated in training on soya bean production	Yes	130	71.8	71.8
	No	45	24.9	96.7
	Total	181	100	
institutions first source of information about improved technology	BOA	15	7.7	7.7
	Other farmers	61	31.1	38.8
	research center	85	43.4	82.1
	Relatives	35	17.9	17.9
	Total	196	100	

Source; Own survey 2022

Credit availability and use: Out of the total respondents, only 25.4% have had access to credit for their farming operation, while majorities (74.6%) of them have not had access to credit. These sources of credit were: from microfinance (for 75.7% farmers) and cooperative/union (for 24.3% farmers). 95.8% of them (which is the majority of respondents) used credit to buy agricultural inputs. For those who were not having access to credit, the sources of finance for farming operations was: crop sales (for 80.7% of farmers), livestock sales (for 16.8% of farmers), and off farming activities (for 2.5% of the farmers). The problems of the farmer in accessing credit include: loans from informal sources not available (according to 51.2% of respondents), repayment terms were unfavorable for 16.7% respondents, bank loan is not available for 9.5% respondents, and 8.3% respondents said that they do not have required collateral. Majority (95.8%) of respondents used credit to buy agricultural inputs. This implies that farmers' access to loans helps to overcome their financial shortage. The study result concludes that the availability of finance has a positive impact on the adoption of new technology, as the case in Tiarniyu et al. (2014) and Leake and Adam (2015).

Market Distance: About 75.5% of the respondents have no access to the nearest market for soya bean while only 24.5% have access. 77.8% of respondents sold soya bean during the

study year cropping season, but 22.2 % of them do not sell. Among those who sell, 85% of them sold soya bean crops at village markets and 11.1% sold at district markets, while only 3.9% of them sold on farms. 78.1% respondents usually sell soya bean products any time when they face a problem. The distance to the nearest market center on average was 1.77 KM while distance to the all-weather road on average was 2.26 Km. These result shows; access to the market affects the prices of outputs and inputs, and availability of market information. Farmers who are living nearer to the market can easily access markets for their farm produce, and readily adopt and intensively use new technologies. The result is similar to the studies of Afework and Lemma (2015) and Hassen et al. (2012).

4.1.5 Perception related factors

Data of the sample Soyabean producing farmers' perception towards soybean production technology as a factor of determinants of adoption of improved Soyabean analyzed. Hence, a total of 8 perception statements comparing improved Soyabean varieties against local varieties developed & analyzed. The result shows (table-7) improved soya bean varieties preferred better by 85.7% from local variety for yield, improved soya bean preferred better by 77.6% for drought resistance, Improved soya bean varieties preferred better by 85.7% for early maturity, improved soya bean varieties preferred better by 74% for shattering resistance, Improved soya bean varieties preferred better by 68.9% for marketability, Improved soya bean varieties preferred better by 60.2% for disease resistance, improved soya bean varieties preferred better by 63.8% for logging, improved soya bean varieties lesser by 57.7% comparing local variety for availability of seed, indicated all of them have positive perceptions.

Table-7 Perception of farmers on improved soya bean & Technology

		Freq.	Valid %	Cumu. %
Improved soya bean varieties VS local variety for yield	Lesser	28	14.3	14.3
	preferred better	168	85.7	100
	Total	196	100	
Improved soya bean varieties VS local variety for drought resistance	Lesser	28	14.3	14.3
	the same	16	8.2	22.4
	preferred better	152	77.6	100
	Total	196	100	

Improved soya bean varieties VS local variety for early maturity	Lesser	28	14.3	14.3
	preferred better	168	85.7	100
	Total	196	100	
improved soya bean varieties VS local variety for shattering resistance	Lesser	28	14.3	14.3
	the same	23	11.7	26
	preferred better	145	74	100
	Total	196	100	
Improved soya bean varieties VS local variety for marketability	Lesser	28	14.3	14.3
	the same	33	16.8	31.1
	preferred better	135	68.9	100
	Total	196	100	
Improved soya bean varieties VS local variety for disease resistance	Lesser	35	17.9	17.9
	the same	43	21.9	39.8
	preferred better	118	60.2	100
	Total	196	100	
improved soya bean varieties VS local variety for logging	Lesser	51	26	26
	the same	20	10.2	36.2
	preferred better	125	63.8	100
	Total	196	100	
improved soya bean varieties local variety for availability of seed	Lesser	113	57.7	57.7
	preferred better	83	42.3	100
	Total	196	100	

Source; Own survey 2022

4.1.6 Technology related factors (Cultural practices for soya bean)

On average, the frequency of land preparation/cultivation in soya bean cultivation is two times. All respondents agree on the planting time for Soya bean to be in the month of June. Seeding rate per hectare was 71.14 kg and fertilizer rate per hectare was 91.15 kg. About 74.6 % & 25.4 % respondents use row and broadcast as planting methods, respectively. The frequency of weeding on average was 2.83. About 95.9 % responded that harvesting is in the month of December (Annex Table 3).

4.2 Adoption status of soya bean production practices

The result shows that the source of information about the improved soya bean varieties and inoculants bio-fertilizer differs from DAs (46.9%), neighbors (37.8%), and from research centers (15.3%). About 62.4 % respondents used improved seed varieties of soya bean, while 37.6% never used (Table-7). Among total households surveyed (91) 52.3 % used inoculants on their farm and (83) 47.7% did not use. The purpose of using improved Soybean varieties was to improve yield performance (accordingly to 60.9% respondents), improving soil fertility (15.9%), for reducing cost of production (14.6%), for increasing income (4.6%), and for food security aims (4%).

Table-8 Sources of improved soya bean varieties

		Freq.	Valid %	Cum %
Source of info about improved seed	research center	97	72.4	72.4
	government supply	11	8.2	80.6
	supply of development partners	13	9.7	90.3
	other source	13	9.7	100.0
	Total	134	100.0	

Source; Own survey 2022

4.3 Major challenges that affected the use of inoculant bio fertilizer & improved seeds

The reasons behind the non-adoption of the improved technologies include accessibility problems (according to 63% respondents), due to high purchase price (16.7%), fear of risk (9.4%). Majority (91.3%) of the respondents used to face challenges in the adoption process of farm inputs (inoculants, bio fertilizer and improved seed), while only 8.7% of them do not face challenges during production period. About 80% of them face shortage of inoculants, 12% of them face shortage of improved seed, 4.3% face crop diseases, and 3.8% of them face shortage of information about inoculant bio fertilizer technologies.

According to the result, almost all respondents found that the improved soya bean is better than local varieties in terms of yield, color, taste, drought resistance, maturity period, disease resistance and storability.

Table-9 why using & major challenges of improved soya bean varieties

		Freq.	Valid %	Cum %
why using improved soya bean varieties	improving yield performance	92	60.9	60.9
	reducing cost of production	22	14.6	75.5
	increasing income	7	4.6	80.1
	improving soil fertility	24	15.9	96.0
	food security	6	4.0	100.0
	Total	151	100.0	
Why not use these improved technology inputs?	high purchase price	23	16.7	16.7
	Accessibility problem	87	63.0	79.7
	Incompatible weather condition	7	5.1	84.8
	lack of information	8	5.8	90.6
	fear of risk	13	9.4	100.0
	Total	138	100.0	
major challenges that affect the use of inoculant bio fertilizer	lack of improved seed	22	11.8	11.8
	lack of inoculants	149	80.1	91.9
	Disease	8	4.3	96.2
	lack of info about the technologies	7	3.8	100.0
	Total	186	100.0	
Major challenges that affect the use of improved seed	lack of improved seed	39	31.7	31.7
	lack of inoculants	53	43.1	74.8
	Disease	17	13.8	88.6
	lack of info about the technologies	14	11.4	100.0
	Total	123	100.0	

Source; Own survey 2022

4.4 Econometric Results

Factors including age of the household , Education level of the household, Farming Experience, Family size, Area allocated under improved soya bean, Contact DA's, Training, Livestock holding, Access to credit positively & Market Distance negatively found significant for adoption decision at 1%, 5% and 10% significant levels. And factors including farming experience, area allocated under improved soya bean and training were found significantly and

positively to enhance the intensity of adoption, expressed in terms of the proportion of land allocated to improved soya bean varieties. (Table-10)

Age of the household: at a 5% level of significance, the age of the household was positively connected with the adoption of improved soybean cultivars. According to the results of the probit model, there is a 2.1% increase in the chance that improved soybean varieties will be adopted for every extra unit (year) of farmer age (Table-10). The implication is that as farmers age increases, their level of agricultural skill increases, and they become more conscious of the benefits of technology. Both Fitsum (2016) and Sisay (2016) studies reached the same conclusion.

Education level of the household: The adoption of improved soya bean varieties is positively and significantly influenced by the household head's education level, one of the key indicators of human capital, at a 5% level of significance, suggesting that the likelihood of adoption increases with the farmer's level of formal education. For every additional year of education the household head has, there is a 1.9% increase in the likelihood that improved soybean varieties will be adopted (Table-10). Education has a positive effect on the adoption of new technology. This result has closeness with studies by Hassen et al. (2012), Moti et al. (2013), Afework and Lemma (2015), and Sisay (2016).

Farming Experience: The household head's knowledge of the sector is one factor influencing the use of technology in soya bean farming. In other words, it is projected that more experienced farmers would embrace improved soybean varieties more quickly than less experienced ones. They should also have easier access to useful materials (such as land and labor). The frequency and intensity of adopting superior soy bean kinds are positively and significantly correlated with farm experience at a 5% level of significance. For every additional year the household head has worked on a farm, the likelihood of adoption of improved soybean varieties increases by 1.3%, and the degree of adoption rises by 1.0% (Table-10). This is supported by the results of the investigations conducted by Aman and Tewodros (2016) and Musa et al (2016).

Family size: In terms of labor demand, family size can have a favorable influence on the adoption of enhanced soybeans at a 5% level of significance. Household size has a negative impact on per capita food expenditure and a positive impact on productivity. Limited

resources are divided among a larger number of occupants, which lowers consumption costs per person. However, more members may act as a labor force, reducing the number of employees who may be employed for agricultural tasks and freeing up financial resources for the purchase of additional inputs such as improved seeds, and significantly contributing to the adoption of improved soybean varieties. For every additional productive family member working on the farm, the adoption of improved soybean varieties increased by 0.1% (Table 10). This result is consistent with the study by (Hassen et al., 2012; Debelo 2015) which was, the labor availability positively related with the adoption of improved new technologies.

Area allocated under improved soya bean: The adoption of soybean production technology was positively and significantly influenced by land holding at the 5% level of significance. The adoption of soybean production technologies increases by some units for every additional unit (ha) of land size. This suggests that farmers who own large tracts of land are more likely to adopt technology for soybean production. The reason for this was that a farmer with a large farm size would typically harvest more and be more likely to earn enough money to purchase agricultural inputs. The marginal effect model predicts that if land size increases by one more unit, the likelihood of implementing soybean technology will rise. As a result, the study's findings also indicate that 1.3% and 1.9% of soybean production technologies were adopted, respectively (Table 10). This concurs with the conclusions made by Gibeghe and Akubulo in 2013.

Contact DA's:- The adoption of enhanced soybean varieties technologies has a positive and 5% significant impact on extension contacts, according to the results of probit regression. This implies that farmers who frequently communicate with extension agents reap greater technological benefits than those who do not. As a result, home adoption has increased by 5.0 percent for every percentage point increase in the frequency of extension contacts. Farmers who collaborate with extension services frequently possess a better understanding of new technology and possible applications, quick access to information on weather variability, and simple access to input and output markets (table-10). The extension agent is contacted more frequently the more adoption knowledge the farmers have acquired. Extension services raise farmers' awareness of production and market excess by improving market pricing (Abrha et al., 2020; Usman, 2016).

Training: At the 5% significance level, training was positively correlated with adoption and strength of adoption of improved soybean cultivars. Probit regression results show that farmers without training in soybean production are 63.2% less likely to adopt better soybean varieties compared to farmers with training in soybean production. Censored regression results showed that families that participated in training were more likely to set aside a significant amount of land for improved soybean varieties than those that did not. There was a 94.7% increase in improved soy adoption compared to non-participating households (Table-10). This is consistent with previous studies by Alemitu (2011), Hadush (2015), Wuletaw and Daniel (2015), who found that training positively impacts new technology adoption and the intensity of adoption.

Livestock holding: At the 5% level of significance, there was a positive and significant correlation between livestock rearing and the adoption of improved soybean varieties. This means that farmers with large herds of livestock are more likely than farmers with small herds to devote a sizable portion of their land to improved soybean varieties. Families with a lot of livestock can make more money by selling their animal products. Small farmers can purchase agricultural inputs that boost production with the help of this income. The level of improved soybean adoption increases by 7% for every additional unit of livestock (TLU) (Table-10). Studies by Solomon et al. (2011), Hassen et al. (2012), and Leak and Adam (2015) support this. Leake and Adam claim that Hassen et al. and Solomon et al.

Access to credit: - Econometric results indicate that, at a 5% level of significance, household credit access was positively and significantly related to the adoption of different types of soybeans in households. This suggests that the marginal effect of credit access was significant, that farmers had access to credit facilities to improve in their farming activities at 16.3%, and that farmers with limited access to credit are less likely to adopt technologies that require significant up-front financial investment. Compared to households without access to credit, those that did had greater food security. Credit availability helps soybean farmers buy agricultural inputs like better seeds, fertilizer, and agrochemicals, so it is most likely connected to higher yields (Table-10). These inputs should increase agricultural output, resulting in higher yields for stable household consumption. (Asfaw et al, 2010).

Market Distance: At the 5% level of significance, distance from the market center has a negative and significant relationship with the likelihood of introducing improved soybean

varieties. According to the model's findings, a one-hour increase in distance from the market's hub will increase the likelihood that soybeans will be introduced, which will lead to a 40.6% decrease in Soyabean varieties. Farmers who are located far from market hubs might have to pay more for transactions and transportation, and they might not be aware of the availability of the most recent technologies offered by extended systems. This is in line with earlier research by Yenealem et al. (2013), Behrhun et al. (2014), Debelo (2015), and Sisay (2016), which discovered that the distance to the nearest market has an adverse effect on the acceptance of new technology.

Table: 10 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
Sex of the HH	5.210	3.005	0.053	0.103	0.083	0.048
Age of the HH	2.145**	0.304	0.021	0.012	0.011	0.021
Educ. level of HH	3.334**	1.007	0.019	-0.080	0.056	-0.080
Farming Exp.	1.324**	0.502	0.013	0.110**	0.015	0.010
Family size	1.250**	0.570	0.001	0.001	0.009	0.001
Area allocated under improved soya bean	2.503**	0.321	0.013	0.3030**	0.019	0.081
Contact DA	0.078**	0.035	0.050	0.002	0.020	0.010
Demonstration	1.923	0.953	0.032	0.832	0.445	0.895
Training	8.115**	3.054	0.632	0.827**	0.382	0.947
Livestock	0.678**	0.006	0.070	0.001	0.009	0.089
Market Distance	-2.892**	1.225	-0.406	0.075	0.087	0.075
Non- farm activity	6.154	2.651	0.175	0.009	0.043	0.009
Access to credit	1.001**	0.056	0.163	-0.031	0.043	-0.031
constant	-1.625			0.913		
sigma				0.081		
	Number of obs =196			Limit: lower = 0 Upper = +inf		
	LR chi2(15) =104.67			Number of obs = 67		
				Wald chi2 (15) = 11.24		
				Log likelihood = 32.35		

Prob > chi2 = 0.0000 Log likelihood = - 12.05 Pseudo R2 =0.982	Prob > chi2 = 0.0001
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NB: *, ** & *** Means 10%, 5% & 1% significance level respectively.

4.5 HOUSEHOLD FOOD SECURITY

Household food insecurity status is measured by Household Food Insecurity Access Scale (HFIAS). The result shows that (49.6%) of households didn't worry about having not enough food. The remaining 50.4% used to worry about having not enough food. Moreover, the HFIAS finding shows that about (30%) are mildly food insecure, (11.3%) are moderately food insecure, and about (9.1%) are severely food insecure (Table-11). Hence, HFIAS result implies the adopter farmers and those who engaged with multiple sources of livelihood incomes were more food secured, indicating the positive relationship between adoption of soya bean variety and food security of the household. The result coincides with the theoretical evidence that explains adoption of improved soybean varieties production reducing the food insecurity of households.

Table 11: HFIAS or Categories of food insecurity prevalence asses

HFIAS standard assessment questions	Occurrence		Frequency		
	Yes	No	Rarely (1)	Sometimes (2)	Often (3)
1. In the past four weeks, did you worry that your household would not have enough food?	42	55	55	36	23
2. In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources?	59	97	0	23	20
3. In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources?	81	115	59	10	12

4. In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food?	81	115	59	11	12
5. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food?	40	156	12	10	18
6. In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food?	40	156	14	8	18
7. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food?	16	178	16	2	0
8. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food?	0	191	0	0	0
9. In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food?	0	191	0	0	0

5 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.5 SUMMARY AND CONCLUSION

The study was conducted to assess the determinants of adoption of improved soyabean varieties and its contribution to food security in the Anno area. The primary data were collected from randomly selected 196 households interviewed Soyabean producers farmers from two adjacent kebeles (Sombo Kejo and Tare). To realize the stated objectives of the study, descriptive and econometric analysis and HFIAS were used to identify the effect of independent variables on dependent variables as well as 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.

The results of the study revealed that Sex of the household, age of the household, educational level, increased farm experience, Cultivated farm size, training on soya bean production, the size of livestock owned, and extension contact had a significant positive impact on the likelihood of adopting improved soya bean varieties, while distance to the nearest market was statistically significant and negatively affected adoption of improved soya bean varieties.

Conclusion

This study found that different sets of factors had an impact on the variations in adoption and level of recommended Soyabean production technology among sampled households. These factors combined have a negative impact on the study area's low soybean yield and food insecurity. The indications were those adopters farmers increased production, income, experience and as a result secured food security comparing non adopters (local producers). Thus, raising smallholder farmers' knowledge of improved varieties, providing credit services for seed purchases based on need, and boosting farmers' trust in extension agents' expertise and practical skills all increase the likelihood and intensity of adoption of improved varieties, which ultimately improves household food security.

The conclusion suggests that concentrating extension activities on those variables that are significant in subsistence producers' adoption behavior of new technology would maximize the advantages from extension. Therefore, policies that increase the capacity of national institutions to provide extension services through technical assistance and short- and long-term training programs are crucial. The adoption of these technologies can, increase agricultural output, increase income, improves soil fertility and food security for farmers besides this balance living standards. This is significant given the contribution of soybean to household food security, nutrition, and soil fertility.

Recommendation

On the basis of the study's findings, the following suggestions are offered. According to the study, some of the difficulties and drawbacks were a lack of information about improved seed technologies, marketability, a lack of financial facilities, and a distance from the closest market. Thus;

- ❖ In order to boost access to inputs, information, and other resources, as well as to raise the likelihood that improved soybean varieties will be adopted and assure the security of their food supply, the appropriate agencies must build a soybean marketing center surrounding agricultural villages. Field days, field shows, and training have a good impact on adoption. Field days, field demonstrations, and training at the district, zonal, and national levels should therefore receive emphasis.
- ❖ The findings of studies on the spread of improved soybean varieties have a positive impact on farm incomes and enhance food security for adopters. As a result, the distribution and supply of improved soybeans must be increased. If effective DAs and a research center, among other things, were supporting the implementation of new agricultural technology in the regions, it would be more successful. In light of these, it is suggested that the DA and the research center improve their performance.
- ❖ Farmers are more likely to use soy production technologies if they have a lot of livestock. This suggests that motivating and assisting farmers in raising livestock production standards is essential. This suggests that efforts should be made to improve the veterinary and feed systems that support the production of livestock.

- ❖ Research institutions should set up a system for studies that supports genetic diversity of Soyabean.
- ❖ The study also showed that physical barriers to the primary market and far-off extension services have a significant, unfavorable impact on the likelihood of soybean technology adoption. The implication is that policymakers need to reevaluate the approach by which many remote rural villages could be given equitable access to infrastructure and extension services.

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ANNEXES

Annex- 1: farming practice implemented in cultivation of soya bean

	N	Min	Max	Mean	Sta.dev	Variance
Frequency of land preparation/cultivation	196	2	4	2.73	0.583	0.34
seed rate per hectare in kg	196	25	130	71.148	31.225	974.957
fertilizer rate per hectare	130	50	100	91.15	19.154	366.875
weeding frequency	196	2	4	2.83	0.716	0.513

		Freq	Percent	Valid %	Cumu%
planting time, month	June	196	100	100	100
planting method	row planting	141	71.9	74.6	74.6
	Broadcast	48	24.5	25.4	100
	Total	189	96.4	100	
harvest time/month	December	188	95.9	95.9	95.9
	November	8	4.1	4.1	100
	Total	196	100	100	
list major problems in soya bean production	lack of seed	109	55.6	55.6	55.6
	lack of inoculants	32	16.3	16.3	71.9
	Disease	16	8.2	8.2	80.1
	lack of rainfall(drought)	6	3.1	3.1	83.2
	lack of market	33	16.8	16.8	100
	Total	196	100	100	

Table Conversion Factor Used to estimate Tropical Livestock Unit

Animal Category	TLU	Animal Category	TLU
Calf	0.25	Sheep & Goats (adult)	0.13
Donkey (young)	0.35	Cow and Oxen	1.00
Weaned Calf	0.34	Sheep & Goats (young)	0.06
Chicken	0.01	Donkey (adult)	0.70
Heifer	0.75		

Source: Storck et al. (1991)

Annex-4: The questionnaire used for the survey

DETERMINANTS OF ADOPTION OF IMPROVED SOYABEAN VARIETIES AND ITS CONTRIBUTION TO FOOD SECURITY OF ANNO AREA OF OROMIA REGION

MSc Thesis Research Survey Questionnaire

Prepared by Diriba Bekele (MSc Student, Addis Ababa University)

Instruction: Introduce own self before starting the interview, Organization/institute working, confidentiality issues and at most explain the objective of the survey to the farmers was taken as a first priority/introduction.

1. General information

1.1. Questionnaire no: _____ **1.2.**Date of interview (DD/MM/YYYY):_____

1.3. Zone: East Wollega Zone**1.4.** District: Anno Area

1.5. Peasant Association (Kebele) _____

1.6. Code of respondent _____

1.7. Name of Enumerator _____

2. Household Characteristics

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 & age	Female & age
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): 4.2.1. Total landholding: _____ 4.2.2 Total cultivable land: _____ 4.2.3. Land allocated for improved soya bean production in 2013/2014 E.C: _____

4.3. What are the main uses of soya bean grain for you in 2013/2014 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 cultures 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 market 6. 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(2013 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 inoculants 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	2011/12 E.C		2012/13 E.C		2013/14 E.C	
		Area(ha)	Yield	Area(ha)	Yield	Area(ha)	Yield
1	Sombo						
2	Tare						

7.6. If yes, for Q#7.3, where do you get these seed? 1.Research Center 2. Government supply 3.Purchase from market 4. Supply of development partners (e.g. NGO) 5. Other source (please specify)_____

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 following table

S.N	Type of Fertilizer	Quantity utilized per cropping season/2013/14	Purchase Price per packet
1	Inoculant (Bio fertilizer)		

7.9. Why you are using improved soya bean varieties (multiple answers 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...) _____

7.10. 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 technologies 5. Others (specify).

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

Traits	Soya bean bean	
	Local	Improved
characteristics		
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 (2013/14 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 2013/14 cropping season for purpose of soya bean production and mgt? _____
- 8.3.** If yes for Q#8.1 how the DA can helped you?1. Practical assistance at farm
2.Demonistartion 3.Training at FTC4. 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 sell your soya bean crop during the 2013/14 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 harvest3. Any time I face problem 4. Other (specify):_____

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

9.6. 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 2013/14 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

Type of 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 (2013/13) E.C?

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

13.3. If 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) _____

13.4. If no, what are your sources of finance for farming operation? 1) Crop sales 2) Livestock sales 3) Off-farm activities 4) Others (specify) _____

13.5. How far is from your home to credit office (in Km) _____

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

13.7. 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

15.2. How much did you spent for soya bean production in 2013/14 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 DAP			
	UREA			
6	Inoculant(bio fertilizer)			

Operation	No of worker	No of days	Working hr	Wage rate / 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					

16. Household Food Insecurity Access Scale (HFIAS) Measurement Tool

16.1 In the past four weeks, did you worry that your household would not have enough food? 0= No (skip to Q2) 1=Yes

16.2 a. How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.3 In the past four weeks, were you or any household member not able to eat the kinds of foods you preferred because of a lack of resources? 0 = No (skip to Q3) 1=Yes

16.3a How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.4 In the past four weeks, did you or any household member have to eat a limited variety of foods due to a lack of resources? 0 = No (skip to Q4) 1 = Yes

16.4a How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.5 In the past four weeks, did you or any household member have to eat some foods that you really did not want to eat because of a lack of resources to obtain other types of food? 0 = No (skip to Q5) 1 = Yes

16.5a How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.6. In the past four weeks, did you or any household member have to eat a smaller meal than you felt you needed because there was not enough food? 0 = No (skip to Q6) 1 = Yes

16.6a. How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.7 In the past four weeks, did you or any other household member have to eat fewer meals in a day because there was not enough food? 0 = No (skip to Q7) 1 = Yes

16.7a How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.8. In the past four weeks, was there ever no food to eat of any kind in your household because of lack of resources to get food? 0 = No (skip to Q8) 1 = Yes

16.8a How often did this happen? 1 = rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.9. In the past four weeks, did you or any household member go to sleep at night hungry because there was not enough food? 0 = No (skip to Q9) 1 = Yes

16.9a How often did this happen? 1 = Rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)

16.10 In the past four weeks, did you or any household member go a whole day and night without eating anything because there was not enough food? 0 = No (questionnaire is finished)

1 = Yes

16.10.a How often did this happen? 1 = rarely (once or twice in the past four weeks) 2 = Sometimes (three to ten times in the past four weeks) 3 = Often (more than ten times in the past four weeks)