ANALYSIS OF SMALLHOLDER FARMERS' ADOPTION OF SOYBEAN PRODUCTION TECHNOLOGIES IN TIRO AFETA WOREDA, JIMMA ZONE, OROMIA REGION, WESTERN ETHIOPIA

MSc. THESIS

BOJA TARESA

FEBRUARY 2020

JIMMA, ETHIOPIA

ANALYSIS OF SMALLHOLDER FARMERS' ADOPTION OF SOYBEAN PRODUCTION TECHNOLOGIES IN TIRO AFETA WOREDA, JIMMA ZONE, OROMIA REGION, WESTERN ETHIOPIA

A Thesis Submitted to the School of Graduate Studies Jimma University, College of Agriculture and Veterinary Medicine, Department of Rural Development and Agricultural Extension in Partial Fulfillment of the Requirements for the Degree of Master of Science in Rural Development and Agricultural Extension (Agricultural Communication and Innovation).

BY

BOJA TARESA

MAJOR ADVISOR: DEREJE HAMZA (PhD)

CO-ADVISOR: ADUGNA ENEYEW (PhD SCHOLAR, ASS.PROF.)

February 2020

Jimma, Ethiopia

Jimma University College of Agriculture and Veterinary Medicine

Thesis Submission Request Form (F-07)

Name of Student: Boja Taresa Gilo ID No. RM1108/10-0

Program of Study: Degree of Master of Science (M.Sc.) in Rural Development and Agricultural Extension (Specialize in Agricultural Communication and Innovation)

Title: Factors Affecting Adoption of Soybean Production Technologies in Tiro Afeta Woreda, Jimma zone, Oromia region, Western Ethiopia.

I have incorporated the suggestion and modification given during the internal thesis defense and got the approval of my advisors. Hence, I hereby kindly request the department to allow me to submit my thesis for external thesis defense.

Boja Taresa Gilo ______________________

Name of student Signature of student

We, the thesis advisors have verified that the student has incorporated the suggestion and modification given during the internal thesis defense and the thesis is ready to be submitted. Hence, we recommend the thesis to be submitted.

Major Advisor: Dereje Hamza (PhD) _____________ ______________________

Name Signature Date

Co-advisor: Adugna Eneyew (PhD scholar's. Prof.) _____________ __________________

Name Signature Date

Decision/suggestion of Department Graduate Council (DGC)

____

____

Chairperson, DGC Signature Date

________________________ __________________ ____________________

Chairperson, CGS Signature Date

_______________________ ___________________ _____________________

DEDICATION

I dedicate this Thesis manuscript to my Grandmother Sakatu Wake who passed away without seeing my achievements and to my parents, brothers and sisters for nursing with affection and for their wholehearted partnership in the victory of my life.

STATEMENT OF THE AUTHOR

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

This Thesis is submitted in partial fulfillment of the requirements for M.Sc. degree at Jimma University. The Thesis is deposited in the Jimma University College of Agriculture and Veterinary Medicine library and is made available to borrowers according to the rules of the library. I solemnly declare that this Thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Brief quotations from this Thesis may be made without special permission, provided that accurate and complete acknowledgment of the source is made. Requests for permission for extended quotations from or reproduction of this Thesis in whole or in part may be granted by the head of the department when in his or her judgment the proposed use of the material is in interest of scholarship. In all other instance, however, permission must be obtained from the author of the Thesis.

Name: Boja Taresa Signature___________

Date of submission__________________

Department: Rural Development and Agricultural Extension (Specialize in Agricultural Communication and Innovation)

BIOGRAPHICAL SKETCH

The author was born from his father Taresa Gilo and his mother Bokashe Negasa on August 20, 1988 in Abay Choma district, Horo Guduru Wolega zone. He attended his grade one to Six at Genji Ketala elementary school and from grade Seven to eight at Fincha senior elementary school. The author also attended from grade nine to twelve at Fincha Preparatory high school. He joined Jimma University, Department of Rural Development and Agricultural extension in 2009 and graduated with B.Sc. on June 2012. He was employed under Oromia agriculture and Natural Resource office at Limmu Seka District Agricultural and Natural Resource Office. He has been working there for last Five years on different positions and in different sectors. He then joined Jimma University Department of Rural Development and Agricultural Extension in September 2017 to pursue his M.Sc degree.

ACKNOWLEDGEMENTS

First and foremost, I praise the Almighty God, who sustained me to bear the rigorous of academic life and research work and made my dreams be true.

I wish to express my sincere gratitude to all persons and institutions that assisted me in one way or another to complete this study. It is indeed difficult to mention every person and institution here, but I humbly appreciate for their contribution. However, I would like to take this opportunity to mention and appreciate a few key contributors.

I express my very frank and deep gratitude to my advisors namely Dereje Hamza (PhD) and Adugna Eneyew (PhD scholar, Ass. Prof) for their guidance and constructive comments from the beginning to the completion of this study.

I am indeed grateful to my employer, Limmu Seka district Office of Agriculture and Natural Resources for giving me the opportunity and the time for this study. Along the same lines, I would like to thank Limmu Seka Agricultural sectors for their different aspects of assistance.

I would also like to thank my families and workmates for their moral support during the study. The last, but not the least I would like to thank all Experts, Development Agents and respondents participated for the success of my study.

ABBREVIATIONS AND ACRONYMS

AI	Adoption Index
ANROTAD	Agriculture and Natural Resource Office of Tiro Afeta District
AT	Agricultural Technology
CADU	Chilalo Agricultural Development Unit
CGIAR	Consultative Group on International Agricultural Research
CSA	Central Statistical Authority
EPID	Extension and Project Implementation Development
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
IFC	International Finance Corporation
IATP	International Agricultural Training Program
TLU	Tropical Livestock Unit
MEDAC	Ministry of Economic Development and Cooperation
MoA	Ministry of Agriculture
OLS	Ordinary Least Square
PPS	Probability Proportional to Sample
Qty	Quantity
VIF	Variance Inflation Factor
WHO	World Health organization

TABLE OF CONTENTS

Contents **Page №**

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Adoption of improved technologies is seen as a key driver to increase agricultural production and productivity in Ethiopia. The purpose of this study was analyzing factors affecting adoption and intensity of soybean production technologies adoption in Tiro Afeta District, Ethiopia. In this study two-stage sampling technique was employed to select rural kebeles and households. Structured interview schedule was developed and used for collecting the essential quantitative data for the study from 188 randomly selected households. Focus group discussion and key informant interview were also used to generate qualitative data to get in-depth information for the study. Moreover, secondary data were collected from published and unpublished sources. Descriptive statistics, econometric models and Kendall's Coefficient of Concordance (W) analysis were employed to analyze the data. The result from Heckman two step model indicated that education level of household, total livestock holding, improved seed availability, frequency of extension contact, credit use and farm income were positively and significantly influenced where as market distance do negatively and significantly affected adoption of soybean production technologies. Also the, result indicated that age, land holding size, and farm income determine the intensity of adoption of soybean technologies positively and significantly whereas distance from market affect negatively and significantly. Based on the findings of this study it can be concluded that policy and development interventions should give emphasis towards improvement of such economical and institutional support system so as to achieve wider adoption of soybean production technologies, increased production and productivity as well as to secure food of smallholder farmer.

Keywords: Adoption, Intensity, Smallholder, soybean, Technology

1. INTRODUCTION

1.1. Background of the Study

As the world's population is expected to reach 9.1 billion by 2050, the production of food, mainly staple crops is expected to increase accordingly (IFC, 2013). This suggests that the dominant role of agriculture as the primary source of food and employment creation in the developing economies should be stepped up. A study by Alexandratos and Bruinsma (2012) indicated that agricultural production needs an increase of 60% by 2050 to meet the world's consumption demand. Malnutrition and specific nutrient deficiencies are the leading underlying cause of immune deficiency, leading to infections and other diseases. Thus, diversification of food consumed with protein-rich legumes such as soybean is best solutions to protein-calorie malnutrition, particularly in developing countries (Burstin, *et al*., 2011).

Agriculture is a dominant sector of Ethiopian economy which makes a lion share contribution to the Gross Domestic Product, employment and foreign exchange earnings. It is still believed to remain a sector that plays an important role in stimulating the overall economic development of the country in the years to come. This would be realized if and only if strenuous efforts are made by the government and other concerned stakeholders including farmers to increase agricultural production and productivity (CSA, 2016).Ethiopian economy and employment are largely depending on agriculture sector. Its GDP reached 55 billion USD and per capita was 631 USD by the end of 2013/14. Agriculture, industry and services sectors contributed 40%, 14% and 46%, respectively to the GDP. Despite its declining contribution to GDP over the years, agriculture leading sector in the contribution to the country's overall economy. It is a major source of food, raw material for the domestic industries and commodities export (UNDP,*et al*., 2016).

Soybean is relatively new crop in Africa. Till today, it was seen as being applicable only for large- scale commercial farming for production of seed that are used in making livestock feed. The major soybean producing countries in the world are the United States, Brazil, China, Nigeria, India, Argentina, South Africa and Uganda (IITA, 2009). It is the most important legume worldwide due to its versatile uses as a human food, animal feed and its role in soil amelioration. Soybean can grow in ***Woina Dega*** (middle highland) and ***Kola*** (low land) areas of the country. Depending on its varieties, the crop grows in an altitude ranging from 700-1800, rain fall 450-1500 mm. Day temperatures ranging from 23-25 °C are ideal for growing the crop. Potential areas for soybean are: Southern Nations Nationalities People region, Oromia region, Benshangul Gumuz region (Metekel, Kamashe and Asosa areas); Amahara region and Tigray region are expected to be more appropriate for soybean production (Miruts 2016).

Soybean is a high value and profitable crop. The economic viability of soya bean production is determined by the commercial utilization of both its sub-products, meal and oil, which, respectively, account for about two thirds and one third of the crop's economic value. Soya bean oil and meal is consumed worldwide as food and animal feedstuff respectively (FAO, 2015). Currently agricultural policy of Ethiopia gives high priority for increasing food production and decreasing malnutrition problems through the promotion of improved production technologies among smallholder farmer in the national extension package. In a similar sense, producing and consuming more soybeans improves the situation of food security as it can provide a nutritious combination of both calorie and protein. It is also cheap and rich source of protein for poor farmers, who have less access to animal source protein, because of their low purchasing capacity. Besides better nutritional status, the crop has a great significance in improving the status of soil nutrients and farming system when grown solely and in combination with cereal crops (CDI, 2010).

Soybean's productivity is low in Ethiopia. Its national average yield is low (19.98 quintal per hectare) which is below the global average, 23.1 quintal per hectare (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). So far, many agricultural technologies have been developed and providing extension service to promote agricultural technologies adoption in the country. Despite such interventions, adoption of agricultural technologies in Ethiopia as a whole is quite poor (FAO, 2010), including Soybean adoption. For example, land improving technologies such as improved seed, fertilizer, improved agronomic practices and natural conservation measures are not widely adopted (Million, 2010).

In Tiro Afeta district, a number of soybean production enhancing technologies and practices have been extended to smallholder farmers. Yet, the distribution and utilization of the technologies and determinant factors have not been known in the area. There is a need for location-specific empirical information on the adoption of improved soybean production technologies and the various factors affecting them in the study area, in order to understand the adoption scenario and design appropriate policy action to improve the production of the crop. Since, studies were not conducted in the study area this study was planned and conducted using research methods.

1.2. Statement of the Problem

Ethiopia faced severe food shortages within the past two decades and still, the country is on constant threat of famine according to Alene et al. (2000). One major reason for the low agricultural productivity in Ethiopia is the low rates of adoption of improved agricultural production technology.

Low level of adoption of agricultural technology is among the major factors contributing to low productivity in the country (Ahmed *et al.,* 2014). This low level of adoption holds true for soybean production technologies as well.

The improved soybean production involves use of different practices; improved varieties, seed rate and fertilizer rate at the recommended level. The variation is not only level of adoption of the latest agricultural technologies but also the underlying determinants. To solve these problems, governmental and non-governmental bodies have made different efforts to bring change in production and productivity of soybean. They have introduced improved agricultural technologies like use of fertilizers, high yielding varieties, improved farm implements, etc. which improves the production and productivity of the crop. However, the introduced technologies were not widely accepted by farmers in different parts of the county as expected (FAO, 2010).

Even though, a lot of studies have been conducted to explain the factor affecting adoption and intensity of adoption of soybean production technology in Ethiopia at different places and time by using different models, the currently available knowledge about the adoption and intensity of adoption of soybean production technology is not sufficient. The study conducted by Fabiyi, and Hamidu (2011) Socio-economic characteristics significantly influenced soybean innovation adoption both positively and negatively. These included: age positively, educational level, farm size , social participation and awareness are negatively, while other four factors were not significant, similarly Double-hurdle model analysis result indicated that sex of house hold head had positive and significant influence on the adoption of improved soya bean production technology, (Abebe 2017).Study conducted by Miruts (2016) used tobit model reveals a positive relationship between extension contact and adoption and level of soybean production technologies.

This indicates that there are different factors directly or indirectly influencing the adoption of technologies that believed to bring change in smallholder farmers' production and productivity. But, the reasons why farmers do not accept the soybean production technologies are not yet well understood. The intensity of adoption of the soybean technologies among farmers has not been determined in the study area. Knowledge of the distribution of the technologies and the factors triggering the technologies is very important in order to make informed policy decisions (Jain et al. 2006). Therefore, the main focus of this study was to assess the level to which soybean production technologies are adopted by farmers and to identify the factors influencing adoption of the soybean production technologies in the study area. The recommended soybean production technologies include (improved soybean seed, seed rate, and fertilizer (NPS) rate.

1.3. Objectives of the study

1.3.1. General objective

The general objective of this study is to assess the factors that affect adoption and intensity of adoption of soybean production technologies among the smallholder farmers in Tiro Afeta district.

1.3.2. Specific objectives

- ❖ To assess the level of adoption of soybean production technologies in the study area.

- To analyze the determinants of adoption and intensity of adoption of soybean production technologies in the study area.
- To explore the constraints that hinders smallholder farmers' soybean adoption technologies in the study area.

1.4. Research Questions

- What is the current level adoption of the soybean production technology in the study area?
- What are factors affecting adoption and intensity of adoption of soybean production technologies in the study area?
- What are the constraints of soybean adoption technologies in the study area?

1.5. Significance of the study

This study is mainly based on the adoption of crop production technologies in general and intended to examine the status of adoptions of soybean production technologies in particular through the evaluation of soybean production technologies and analyzing factors determining the intensity of adoption of recommended soybean production technologies in Tiro Afeta district, Jimma zone, Oromia regional state, Ethiopia. The study was designed to give valuable information on factors influencing adoption of soybean production technologies that might assist extension experts at various levels. Identification of factors that accelerate the adoption of technology can enhance the formulation and implementation of technology dissemination programs. Researchers can utilize the results of this study in fine-tuning research and extension activities. Hence, this study attempted to find out factors affecting adoption of soybean production technologies and its intensity of adoption by smallholder formers' in the study area. It was also help as a guide to policy makers on the short and long terms agricultural development plans relevant to farmer's local needs. It was also be useful to researchers and extension agents in fashioning out the best means for farmers to adopt relevant innovations. Furthermore, this study was seek to show the relationship between adoption and various independent variables considered in getting desired change in farmers for increased productivity. Finally, the research was aid extension experts and policy makers as an analytical frame of reference that can be used in planning, executing and evaluating present and future agricultural development concerning farmers‟ adoption of new agricultural technologies.

1.6. Scope and Limitation

This study was undertaken in one District, namely Tiro Afeta District of Jimma zone. The adoption of new technology is influenced by many factors. The influence of these factors goes in opposite directions. A factor which is found to enhance adoption of a particular technology in one locality at one time might be found to hinder it or to be irrelevant for adoption of the same technology in another locality at the same or different time for the same or different crops or the other way round. From these conflicting results that it is difficult to identify universally defined factor either impeding or enhancing adoption of technology.

This study was restricted to estimate the level of adoption of the soybean production technologies and to analyze the factors affecting adoption and intensity of adoption of soybean production technologies in the study area. Hence, the results should be read with caution. The study also restricted to limited number of farmers who were sampled from the study area and its results have practical validity mainly to areas having similar features with the selected District.

1.7. Organization of the Thesis

The first chapter has presented the introduction of the study. Chapter two presents literature review. The reviewed studies are in the area of basic concepts of adoption, technology adoption, soybean overview, importance and production in Ethiopia. Chapter three presents research methodology; includes study area description, research design, data type, sources, methods of data collection, sampling procedure and data analysis. Results and discussions are presented in chapter four. Finally, chapter five concludes the study and presents policy recommendations.

1.8. Ethical Considerations

The research is conducted by taking basic ethical considerations into account. Among many considerations, respect for audiences and the use of nondiscriminatory language on gathering data, treatment of participants, and respect for participants, protecting autonomy and ensuring to become well-informed, voluntary participation were maintained throughout the research process starting from its onset. Reporting data honestly, without changing or altering the findings to satisfy certain predictions or interest groups was also a major issue of concern dealt in the research. Throughout the data collection and analysis procedures, confidentially of respondents was maintained to safeguard their rights.

2. LITERATURE REVIEW

2.1. Basic Concepts of Adoption and Technology

Adoption: Adoption as the degree of use of a new technology in a long run equilibrium when a farmer has all of the information about the new technology and it's potential. Adoption at the farm level reflects the farmer's decision to incorporate a new technology into the production process. On the other hand, aggregate adoption is the process of spread or diffusion of a new technology with in a region. Therefore, a distinction exists between adoption at the individual farm level and aggregate adoption with in a targeted region. If an innovation is modified periodically, the adoption level may not reach equilibrium, Feder*et al*. (1985)

Technology: According to Loevinsohn*et al*. (2012), technology is the vehicle that allows most people to participate in a rapidly changing world where technology has become central to our lives. Individuals who can't adopt will increasingly limit their ability to participate fully in the financial and convenience benefits associated with technology. Understanding the factors influencing technology adoption helps us predict and manage who adopt, when and at what conditions. Unfortunately, there is no clear definition of technology adoption, in large part due to the tremendous variability in types of technology and circumstances under which people adopt them.

Technologies play an important role in economic development. Various authors define the term technology in a variety of ways. Rogers (2003) explains as it is composed of two parts: hardware and software. While hardware is the tool that embodies the technology in the form of a material or physical object, software is the information base for the tool. And according to Swanson (1996) Technology is the application of knowledge for practical purpose, which is generally used to improve the condition of the human and natural environment, and in carrying out some other socio-economic activities. It is also considered as a complex blend of materials, processes and knowledge. Some technologies are in vogue over a long period of time, while others are changing or being replaced wholly or partly by improved ones for better use of resources. Technology is a dynamic concept thriving with betterment of techniques and embodies simple techniques to composite ones. Agricultural technology can be grouped into indigenous and improved technologies (Adeniji, 2002). Technology can also be expressed as the systematic application of scientific knowledge to practical purposes. It includes inventions, techniques, innovations, practices and materials (Okereke, 1983).

Diffusion of agricultural Technologies: Adoption of technological innovations in agriculture has attracted considerable attention among development economists because the majority of the population of less developed countries derives their livelihood from agricultural production and a new technology, which apparently offers opportunities to increase production and productivity (Feder*et al*., 1985). It is also believed that the use of new technologies in farming is a crucial means to lift up production and productivity of the resources used in the subsistence agriculture. New technologies enable the farmer to produce more by using available farm resources. More effectively, innovations in agriculture and their adoption are important in improving food security at the family, village and national levels (Ashri, 1996).

The adoption of an innovation within a social system takes place through its adoption by individuals or groups. According to Feder*et al*. (1985), adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. Dasgupta (1989) also noted that adoption, however, is not a permanent behavior. This implies that an individual may decide to discontinue the use of an innovation for a variety of personal, institutional, and social reasons one of which might be the availability of another practice that is better in satisfying farmers' needs. Rogers (1983) defines the adoption process as the mental process through which an individual pass from first hearing about an innovation or technology to final adoption. This indicates that adoption is not a sudden event but a process. Farmers may not accept innovations immediately; they need time to think over things before reaching a decision.

The introduction of agricultural innovation into a given geographical area in a given period of time may be through both private and public initiatives and the rate of diffusion depends on, among other things, extension communication, the extent to which farmers discuss agricultural issues among themselves on a day to day basis and consistency of performance with the message (Fliegel, 1984).

Following a lucid and extended description of an innovation Presser (1969) concluded that an innovation is something new and novel in human knowledge and experience. Van den Ban and Hawkins (1988) define innovation as an idea, method, or object which is regarded as new by an individual, but which is not necessarily the result of recent research. An innovation has a point of origin in place and time. At its point of origin, it must be an innovation, but it is more commonly called an innovation, a research result, or a new development of some older idea (s). In time, as knowledge and use of the innovation diffuse to other people in the surrounding area, the idea ceases to be an innovation in that area. The rate of adoption is defined as the percentage of farmers who have adopted a given technology. The intensity of adoption is defined as the level of adoption of a given technology. The number of hectares planted with improved seed (also tested as the percentage of each farm planted to improved seed) or the amount of input applied per hectare will be referred to as the intensity of adoption of the respective technologies (Nkonya et al., 1997).

The importance of agricultural innovations in the transformation process of economies of developing countries has become, without doubt, the major concern of governments, citizens and development agencies alike. Agricultural economists in the development field have made a particular study of the adoption and diffusion of technical innovation because of the opportunities for increased output and higher levels of income which technological change can offer (Colman and Young, 1989).

2.2. Theoretical Review on adoption of technologies

Leathers and Smale (1991) have identified the following adoption patterns from the large body of empirical evidence: for the most part, farmers choose to adopt inputs sequentially, adopting initially only one component of the package and subsequently adding components overtime, one at a time; in some instances, farmers adopt a component and subsequently revert to traditional practices; adoption patterns vary by agro ecological zones, between farmers facing different markets and institutions. Adoption is not the final event of change but rather a decision-making process. Individuals pass through various learning and experimenting stages from becoming aware of a problem and its potential solutions to finally adopting or rejecting the innovations under considerations (Enters, 1996).

A number of studies on adoption behavior pointed out that a host of explanatory factors influence adoption behavior of farmers. For instance, Hansel (1974) identified factors such as individual characteristics (like education, access to change agents, size of holding, etc.); regional characteristics (system and organization of rural change agencies, population densities, etc.); and innovation characteristics (like accordance with local norms, economic advantage, etc.) as influencing the adoption of technologies. Giger et al. (1999) stated that if the technology promoted is not profitable from the farmers' point of view, it is highly doubtful that the use of direct incentives will lead to sustained adoption of a technology in the long term. The technology will almost be abandoned as soon as the project is phased out, and no replication beyond the boundaries and the lifetime of project can be expected. They further explained that rapid economic benefits are very important conditions for success and it is most probably much more important than the use of incentives in terms of achieving genuine, durable adoption.

According to Cary et al. (1997) there is an obvious need to understand the relative importance of factors, which may influence individual adoption of conservation practices, which ameliorate land degradation. The economic costs to landholder of many conservation practices may exceed the on-farm benefits on a short-term and possibly long-term basis. The lack of immediate financial incentive in a dynamic economy may result in many landholders not to adopt conservation practices. Rogers, (1983) Views and findings are not, however, consistent with respect to the role of these factors on adoption behavior of farmers and the subject is of considerable controversy around the globe. No single conclusion has been drawn with respect to the key factors which favor or impede adoption decision at a given time and place becomes lest impotent or even induce an impediment on the adoption behaviors of farmers at another time and /or place. Hence review of empirical works is important for various reasons. First, it helps to assess the present state of knowledge of the adoption process. Second, it helps to enhance the interpretation of empirical models and their results and its implications as against the conceptual or theoretical models (Feder*et al*., 1985).

2.3. Overview and Importance of Soybean production in Ethiopia

The foundation and early history of soybeans are unknown. It is not uncommon to read in agronomic publications that the earliest recorded origins of soybeans date back to 2800 B.C. in

China (D. K. Whigham, (1974). There are favorable climatic and soil conditions for soybean production in South and Western Ethiopia which is essential both for commercial purposes as well as for subsistence farming. Soybeans were tentatively tried in Ethiopia in the 1950s. A growers' manual was even published in Amharic and instructions on how to use the "foreign pea," as the soybeans were called at that time in Ethiopia, were also included (D. K. Whigham (1974).

The growing season of soybean ranges from 90 to over 150 days and three different soybean varieties have been distinguished: Early maturing group with 90-120 days (Awassa-95, Williams, Crawford and Jallale), Medium maturing group with 121-150 days (Clarck-63K, Cocker-240 and Davis), and Late maturing group with >150 days (Belessa-95 and Ethiougozlavia) (Gurmu,2010).

Including soybean in the crop rotation is an indigenous practice in Ethiopia that has agricultural and social benefit. Soybean offer the benefit of nitrogen sparing, they use less of the available nitrogen in the soil compared to a none-fixing plants, thereby “sparing” it for the succeeding crop. It may also supply a residual effect, where the biomass of the legume plant is returned to the soil and the nitrogen available in the plant will be released in an inorganic, plant-available form to the crop that follows the legume in rotation (Giller, 2001).

Products from soybean are exceedingly required for the populations in Ethiopia who are often affected by protein-energy malnutrition and for those who have constraints to include animal sources of foods in their diets. Moreover, soybeans are a source of high value animal feed. In Ethiopia, particularly in the capital city, Addis Ababa, Faffa Food Share Company, East African Flour Factory, and Health care food manufacturing private limited companies etc. are using local and imported soybeans in the preparation of enriched food products for children and adults (WHO, 2003).

Table 1: Estimate of Area, Production and Yield of soybean Crop in Ethiopia

Crop	Area in Hectares			Production in Quintals			Yield(Quintals/Hectare)		
	2016/17	2017/18	% Change	2016/17	2017/18	% Change	2016/17	2017/18	% Change
Soy bean	36,635.79	38,072.70	3.92	812,346.59	864,678.69	6.44	22.17	22.71	2.44

Source: CSA, 2018

2.4. Empirical Studies on Adoption of Technologies

However, the studies were mainly conducted around major cereals and due to this study conducted in the area of coffee, perennial crop are scanty. As a result of this, the review mainly included the studies conducted mainly on cereals, particularly maize, wheat and legumes crops with very few related horticultural crops. For ease of grouping, the variables so far identified as having relationship with adoption are categorized as household personal and demographic variables, socio-economic factors, technology related factors, and institutional factors.

According to Bezabih (2012) study factors influence adoption and intensity of adoption of improved wheat production technology, sex, education of household head, total land holding, total livestock ownership of house hold and participation in field day in the Tobit model were found to significantly influence adoption and intensity of adoption of improved wheat production technology. Study done by Abebe (2018) on determinants of adoption of improved forages in selected districts of Benishangul-Gumuz, Western Ethiopia explores that access to agricultural extension services, and participation in forage training sessions had the greatest positive influence on adoption of forage technologies.

According to Tegegne (2017) study on Factors affecting adoption of Legume Technologies and its Impact on Income of Farmers: The Case of Sinana and Ginir Woredas of Bale Zone, the results of logit model presented that access to improved farm inputs, credit accessibility, had a significantly influenced on the adoption level of both improved seed and fertilizer technology. On the contrary, high price of improved technology and family size had negatively affected the adoption level of improved farm inputs.

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

Farmers can also acquire new knowledge through demonstration to improve production and productivity of agriculture. The Tobit result indicates that the probability of haricot bean production package adoption was positively and significantly affected by demonstration at 10% significant level. This implies that demonstration approach is important to transfer agricultural production technologies to farmers practically. When farmers conducting a new practice, they can weigh the advantage and disadvantages of the new technology and this can facilitate adoption and helps them to implement the new technology properly. This result shows that farmer who conducts demonstration is more likely to adopt new improved technology than others. This suggests that wider demonstration coverage would speed up the adoption of the package and hence calls for development of the existing limited demonstration practices Mulugeta (2011).

Chickpea production experience has a positive and highly significant influence on the status and level of adoption of bio-inoculant fertilizer at one percent level of significant in the production of chickpea crop. This indicates that, more experienced farmers in chickpea production have better knowledge and information on the chickpea production and marketing condition. Therefore, more experienced farmers in the production chickpea crop are better to adopt bio-inoculant fertilizer in the study area. A year increase in experience on production chickpea crop leads to an increase the probability of adoption by 0.89% Fenta, M. (2017).

According Samuel *et.al.* (2017).Study done on Factors affecting adoption and degree of adoption of soya bean in Ilu-Ababora Zone; Southwestern Ethiopia which based on cross sectional data of 185 soybean producing farmers , result used by the Logistic regression model to identify factors affecting probability of adoption and Tobit model to identify intensity of adoption. Training affected positively and significantly while age affected negatively and significantly adoption of Soybean. Sex of a house hold head is one of the determinants of improved soya bean adoption. As the probit model indicates sex of house hold head had positive and significant influence on the adoption of improved soya bean production technology at 10% significance level. This shows that being male headed households have better access to information on improved soya bean production technologies and are more likely to adopt new varieties than female headed households and also increase their soybean production Abebe (2017)

The study conducted by Miruts (2016) on analysis of the factors affecting adoption of soybean production technology in Pawe district, Metekel zone of Benshangul Gumuz regional state, Ethiopia Land holding as a variable had a positive and significant influence on adoption of soybean production technology at 10% level of significant. One more unit (ha) increase in land size increases the level of adopting soybean production technologies by 0.0256 units. This indicates that farmers who have large farm land are more likely to adopt soybean production technology. The reason for this was a farmer with large farm size means relatively harvest more and likely to generate sufficient income, which could help them to buy agricultural inputs. According to the model output of marginal effect, if land size increases by one more unit, would increase the probability of adopting soybean technology 1.7% and its level by 2.2% respectively.

2.5. Conceptual Framework of the Study

Adoption of new and improved agricultural technologies can only be effective when the right conditions for their successful implementation are in place. Farmers face many complex challenges in adoption and scaling out of agricultural and natural resource management technologies and practices (Shiferaw*et al*., 2009). Context specific empirical understanding of factors affecting household decision is important for promotion and scaling up of adoption of productivity enhancing technologies (Bewket, 2007). Researchers have argued that numerous factors can affect the farmer's decision to adopt agricultural technologies (Yu *et al*., 2010). Based on theoretical and empirical reviews of the literature on technology adoption various factors that influence technology adoption and intensity of use can be identified and grouped into the following four broad categories. (1) Demographic and personal factors (2) socio-Economic factors (3) Institutional factors (4) psychological/behavioral factors. The framework emphasized mainly on the relationship of the explanatory variables with the dependent variable and each other.

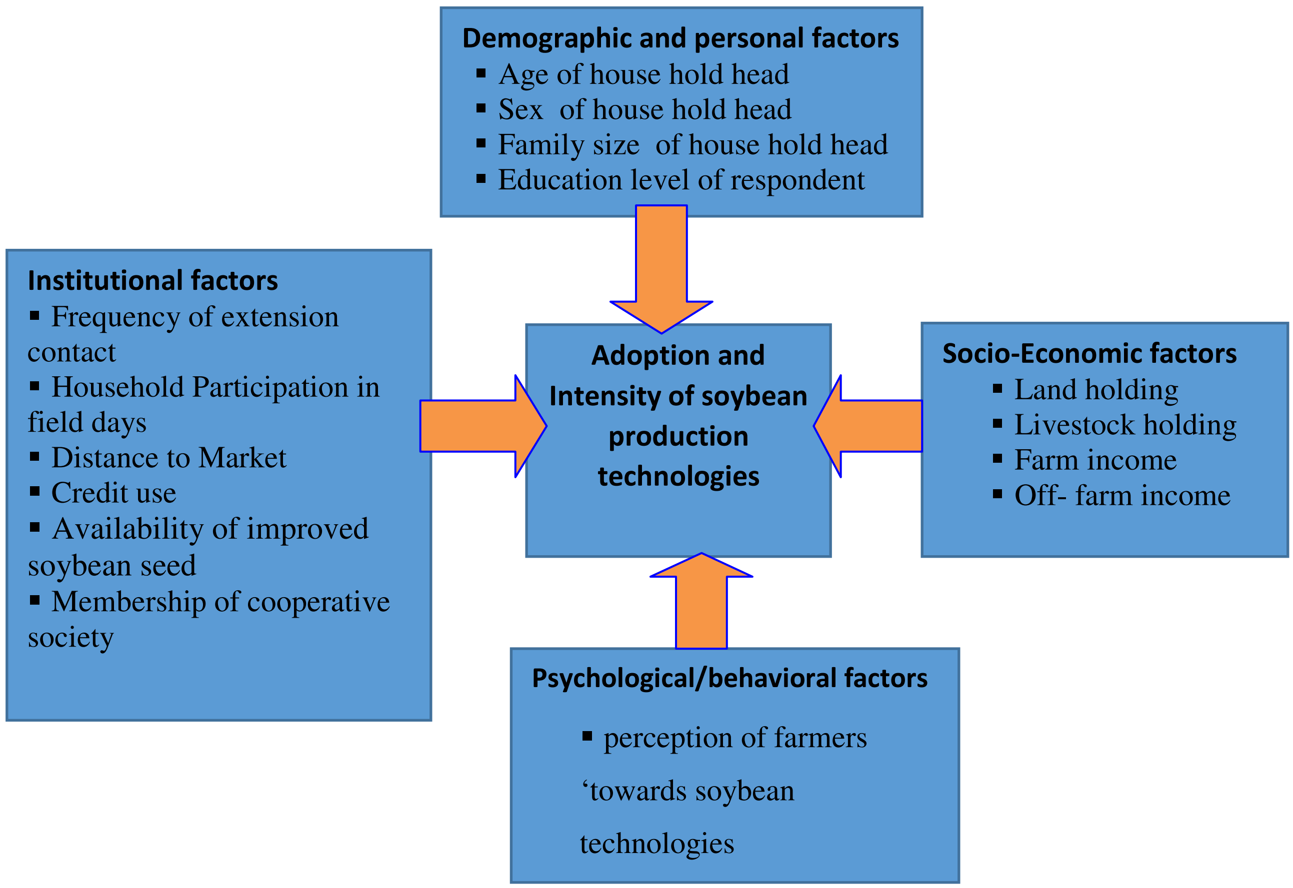

Figure 1: Conceptual framework of adoption of agricultural technologies

Source: sketched after Own literature review, 2019

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

This section includes description of the study area's location, population characteristics, climate and soil characteristics and economic activities as they related to the study topic.

Location of the District

The study was conducted in Tiro Afeta District, Jimma zone, Oromia regional state in Ethiopia. The District is located at a distance of 68 km north east of Jimma town and 263 km West of Addis Ababa. The District is bounded by Sokoru from East, Botor Xoliy from North, Kersa from south and Limu kosa from west Districts of Jimma zone respectively. The administrative town of the District is called Dimtu and the second town is Ako. Tiro Afeta District consists of 23 rural kebeles and 2 urban kebeles. Tiro Afeta District lies at an approximate altitude of 1432-2500m above sea level (Tiro Afeta District Land Administration and Use Office, 2019).

Land use pattern of the District

The total land area of the District is 82,894.11 hectares. Regarding land use pattern during the recent years, cultivation land 34,382 hectares, pasture land 9,882.4 hectares, forest land (including bushes & shrubs) 14,775.9 hectares, Religion land 383 hectares, School and FTC land 399 hectares and the rest is others (settlement, roads etc.). Average land holding is estimated to be 3.5 hectares per household (Tiro Afeta District Land Administration and Use Office, 2019).

Climate of the District

Relatively the climate of the District is divided into three agro-ecological zones, namely low land 28%, midland 43%, and highland 29%. The topography of the District is complex and consists of hills, undulating landscape and plains. The District experienced minimum and maximum temperatures of 14°C and 30°C respectively and relative humidity between 80 and 90% that falls to about 40% in the dry season. There are two distinct seasons: the rainy season starting in late March and ending in October and the dry season occurring during November to early March. The rainfall pattern is unimodal and it ranges from 780-2000mm with about 70% of the precipitation falling in a two months' period i.e., July and August. The mean annual rainfall is 1800mm. The soil of the district was fine textured heavy loamy clay soil with a pH of 6.0.

Population of the District

Based on (CSA report, 2013) the district has total population of 130,554 of male 66,732 and female 63,822. The total number of households in the district is about 15,436 of which 14,574 are male headed and the rest 862 are female headed. (ANROTAD, 2018).

Economic base of the District

The economic base of the residents of the District is agriculture, which the majority of the population depends on agriculture for their livelihood. Individual smallholder farmers are the sole and dominant production unit. The agriculture sector is based on rain fed and is characterized by low productivity. Moreover, the agricultural sector in the District is characterized by low use of agricultural inputs, traditional farm practices and poor soil fertility. Mixed agriculture (crop production and animal rearing) is a typical practice in the District. The major crops produced in the District are: *teff*, maize, sorghum, wheat, soybean and others. The area covered by these crops is 6424, 5918, 3391, 2182 and 738 hectares, respectively. The average yield per hectare of these crops is 1600, 4975, 3100, 2500 and 1800kg, respectively. Livestock are also kept as one part of agricultural practice in a District. Most of the farmers of the District farms for only subsistence live (ANROTAD, 2018/19).

Irrigation development also practices in the District by smallholder farmers. According to the report of irrigation development office of the District, 2472 smallholder farmers were participated in irrigation to produce different vegetables and other crops during 2019 production season on 1034 hectares of land. However, the participation of farmers on irrigation development is low with the potential available irrigable land in the District, which is above 10,000 hectares of land (Tiro Afeta Irrigation Development Office, 2019).

Regarding the agricultural technology utilization, especially inorganic fertilizer and improved maize variety utilization started in the District before two decade. But the utilization of the technology in a District is still low. Therefore, this nature of economic practice requires encouragement of agricultural technologies.

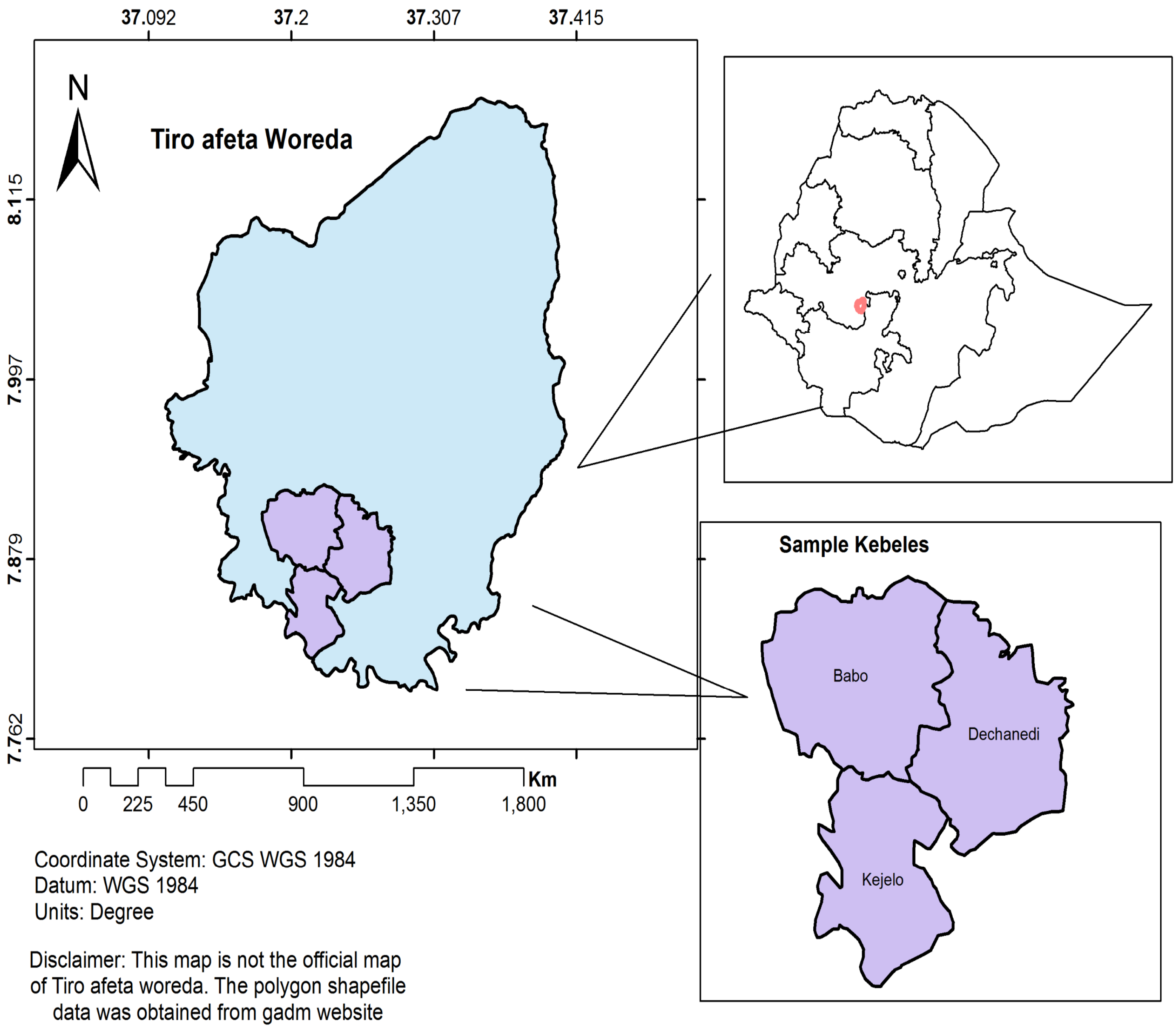

Figure 2: Map of study area

Source: Drawn using GIS (Geographic Information System)

3.2. Research Design

This study adopts a cross sectional and mixed method research design, which involves qualitative and quantitative data. This design is suitable for this study since it sought to provide insights and understanding of the factors influencing the adoption of soybean technology among small holder farmers in Tiro Afeta. This study also wants to test specific hypotheses and examine relationships as captured in the sub-section of the research objectives. It details the procedures necessary for obtaining the information needed to structure or solve research problems. The target populations were all the household heads found in the selected three *kebeles* of Tiro Afeta district.

3.3. Data type, sources and methods of data collection

To achieve the objectives of the study, both primary and secondary data source were used. The interview schedule was used as a data collection tool. Both quantitative and qualitative data were collected from selected households. Before the administration of the interview schedules, the respondents were informed about the objectives of the survey. The interview schedules were also first pre-tested using non-sample respondents before actual data collection and amendments were made accordingly. Data collection was made with local trained enumerators. These local enumerators was recruited and trained to administer the interview under close supervision of the researcher. During the respondents interview, primary data on key demographic (such as age, sex and education.), institutional (such as membership in cooperative societies, extension contact, credit use and socio-economic (such as land holding, family size, off farm income, farm income and number of livestock owned) factors affecting intensity of adoption of soybean production technologies were collected. The interview method was mainly emphasized. In addition to this, three FGD which contain (8) for each groups, and key informant interview which contains (4 females and 8 males) were employed to supplement the research finding with qualitative information. For the focus group discussion and key informant semi-structured check list were used.

3.4. Sampling Procedure and Sample Size Determination

This study was conducted in Tiro Afeta District, which is one of the potential District involving in soybean production, where government organization such as Jimma Agricultural Research center and non-government organizations disseminated and popularized improved soybean production technologies. Two-stage sampling procedures were employed to select representative sample households. In the first stage of sampling procedure, using sampling frame of the list of *kebeles* in Tiro Afeta district, three *kebeles* were selected randomly by using simple random sampling method among soybean producer rural *kebeles.* Soybean producer kebeles were identified with collaboration of district office of agriculture. Secondly, among the identified three *kebeles* total 2352 farm household were stratified as adopter and non-adaptor. Then 188 farm households were selected using simple random sampling method based on probability proportional to size of households from adopters and non-adopters in each *kebeles.*

Sampling error: The maximum expected difference between a probability sample value and the true value (EPA, 2008). At a confidence level of 95%, sampling error is generally recommended to be less than 10% for reliability purposes. Confidence interval: An estimate of a population parameter that consists of a range of values bounded by statistics called upper and lower confidence limits, within which the value of the parameter is expected to be located (EPA, 2008).As the variability in the population was not known before hand, the maximum variability (50%) was taken in the current study. Often, an acceptable margin of error used by survey researchers falls between 4%, 5%,7% and 8% at the 95% confidence level (Data Star, 2008). So a margin of error of 7% (0.07) was taken for this study.

The maximum numbers of respondents for this research was determined by using a formula developed by Yamane (1967). $n = \frac{N}{1+N(e)^2}$, $n = \frac{2352}{1+2352\,(0.07)^2} = 188$

Where, n = sample size, N= total number of households in the selected kebeles, e= margin of error (level of error deviation of the sample value from the population parameter) and 1=designates the probability of the event occurring.

Table 2: Soybean producers selected from each identified *kebeles*

S. no	Name of the Kebeles	Adopter Households		Non-adopter households		Total Sample households selected
		Total	Sample	Total	Sample	Total sample
1	Decha Nedi	499	39	426	35	74
2	Babo	336	27	412	33	60
3	Kejelo	312	25	367	29	64
Total		1147	91	1205	97	188

Source: Tiro Afeta district office of agriculture and Natural Resource, 2019

3.5. Methods of Data analysis

In this study, both descriptive statistics and econometric model were used to analyze the data. SPSS version 20.0 and Stata version 13.0 software were used as a tool. Appropriate techniques and procedures were used in the analysis to identify the influence of personal, socioeconomic, psychological and institutional variables on the adoption decision process of the technologies. Descriptive statistics was used to provide a summary statistics related to variables of interest. Chi-square test and t-test were used to identify variables that vary significantly between adopters and non-adopter. The chi-square test was conducted to compare some qualitative characteristics of the adopters and non- adopters. The t-test was run to see if there is any statistically significant difference between the mean of the respective adopter and non-adopter categories with respect to continuous variables. The Hackman model was employed to identify the determinants of the adoption decision of soybean production technologies and analyze intensity of adoption of soybean production technologies. Kendall's Coefficient of Concordance (W) analysis was also used to rank and identify the smallholder farmers' constraints in soybean production.VIF (Variance inflation factor) for tests of multi-colinearity. Among the metric explanatory variables and contingency coefficients association for categorical variables were used.

3.5. 1. Analytical Techniques

Under this sub topic the study used different tools for analysis of primary data collected in qualitative and quantitative form.

3.5.2. Estimation of the Adoption Index

Before analyzing the factors affecting adoption of soybean production technologies, it is important to calculate the level of adoption for the entire sampled household. There are two options of measuring level of adoption when there are multiple practices in the technology. i) Adoption index: measures the extent of adoption with some specified period of time. ii) Adoption quotient: measures the degree or extent of use with reference to the optimum possible without taking time in to account. In this study the first option was employed. Accordingly, in order to know the level of adoption of soybean production technologies, adoption index of individual household was calculated using the following formula (Saidur, 2007) cited in Miruts,2016

$$\mathbf{AIi} = \sum_{i=1}^{m} \left(\frac{SRi}{RSR} + \frac{FAi}{RFA} + \text{Row pl}\right) / NP \ldots\ldots\ldots 1$$

AIi= Adoption index of the ith farmer

I=1, 2, 3………n, and n= 188, total number of respondent farmers

SRi= Seeding rate applied per unit of area for the ith farmer,

RSR= Recommended seeding rate per unit of area,

FAi= Fertilizer amount applied per unit of area

RFA= Recommended amount of fertilizer per unit of area

Row pl =Row planters take 1 and 0 other wise

NP = Number of practices

The adoption index is a continuous dependent variable calculated using the formula presented above with a value ranging from zero to one. Non-adopters are defined as those farmers who did not grow any improved soybean varieties. Among the adoption soybean production technologies practices (improved soybean varieties, seed rate, fertilizer rate and row planting) were included to calculate the index value. Thus, non-adopters are given the adoption index score of zero while adopters can get adoption index score ranging from greater than zero to one.

3.5.3. Econometric analysis; Heckman's selection model

Heckman's selection model

The choice to be selected to participate in any program may not necessarily be random as a result selectivity bias may exist. In this scenario because the sample that was included in the study was based on the selection of adopters, there could be selection bias. Thus Heckman selection model was used to control for the selection bias problem. In the Heckman's selection model, it is assumed that technology adopters are not randomly selected but there is a self-selection bias that needs to be corrected in obtaining unbiased estimates of the intensity of adoption. According to Heckman (1979), sample selection bias may arise in practice for two reasons, first there may be self-selection by an individual or data units being investigated. Second sample selection decision by analysts or data processors in much the same fashion as self-selection.

Selective samples may be the result of rules governing collection of data or the outcome of economic agent’s own behavior. The latter situation is known as self-selection. Statistical analysis based on those non-randomly selected samples can lead to erroneous conclusions and poor policy (Heckman, 2008). The Heckman's correction, a two-step statistical approach, offers a means of correcting for non-randomly selected samples. The first stage formulates a model for the probability of adoption used to predict the probability for each individual and then in the second stage, removing the part of the error term correlated with the explanatory variables and avoiding the bias. So in this study heckman two steps model was use to analyze factors affect adoption and intensity of adoption of soybean production technologies.

Some adoption studies in Ethiopia and East Africa used the Heckman’s selection model to identify the probability and intensity of different agricultural technologies in different locations. (Deressa et al., 2008; Jaleta et al., 2013; Yirga and Hasan, 2013; Atupokile, 2016). Heckman’s selection model follows two-steps estimation procedure where in the first stage, an ‘adoption equation’, attempts to capture factors affecting adoption decision and Inverse Mill’s Ratio (IMR) is obtained. In the second stage, the intensity of adoption is estimated using the IMR as one of the explanatory variables to correct selection bias. The probability of adoption was modeled by Maximum Likelihood Probit, from which the inverse Mill’s ratio was estimated. The specifications for Heckman’s two-step models are as follows:

1. The adoption equation: The Probit model is specified as:

$Yi = \beta iXi + \varepsilon i$, i= 1, 2, n -- (1)

$yi^* = 1$, if $yi^* > 0$ or 0, if $yi^* < 0$

Where, yi^* is the latent dependent variable which is not observed and Yi is a binary variable that assumes 1 if household i, use improved soybean and 0 otherwise.

βi is a vector of unknown parameters in adoption equation.

Xi is a vector of explanatory variables in the probit regression model.

ε_i is random error term that are assumed to be independently and normally distributed with zero mean and constant variance. Lambda (λi), which is related to the conditional probability that an individual household was deciding to adopt (given a set of independent variables) is determined by the formula.

$\lambda i = \frac{f(x\beta)}{1-F(X\beta)}$--- (2)

Where λi is Inverse Mill's Ratio (IMR), f (Xβ) is the standard normal probability density function and 1−F (Xβ) is the cumulative distribution function for a standard normal random variable. The value of Xi is not known, but the parameters (β) can be estimated using a probit model based on the observed binary outcome (Yi). Then it was used in outcome equation to make consistency of the model.

2. Regression (OLS): Outcome model is specified as:

Yi = αiZi + μλi + ηi -- (3)

Where, Yi is the intensity of soybean adoption technologies, αi is a vector of unknown parameters to be estimated in the level of soybean adoption technologies equation, Zi is a vector of explanatory variables determining the rate of soybean adoption, μi is the parameter that helps to test whether there is a self-selection bias in the adoption of soybean, λi is inverse mill ratio and ηi is the error term.

Before running the Heckman model all the hypothesized explanatory variables were checked for the existence of multi-collinearity problem. To avoid the problem, both continuous and dummy variables were checked before running the model. The problem for multi collinearity for continuous variables was checked using variance inflation factor (VIF) and to check the degree of association among dummy variables, contingency coefficient was used. For the continuous variables, if the value of VIF is 10 and above, the variables are said to be collinear and to compute the VIF values, STATA software was used. Similarly, contingency coefficients were computed for dummy variables to detect the problem of multi collinearity.

$$\mathrm{VIF} = \frac{1}{1 - R^2}$$

The larger the value of VIF is the more troublesome. As a rule of thumb, if the VIF of a variable exceeds 10 (this will happen if R_i^2 exceeds 0.95), that variable is said to be highly collinear

(Gujarati, 1995). Similarly, contingency coefficients were computed for dummy variables using the following formula.

$$C.C = \sqrt{\frac{x^2}{n + x^2}}$$

Where, C is contingency coefficient, x^2 is chi-square value and n = total sample size. For dummy variables if the value of contingency coefficient is greater than 0.75, the variable is said to be collinear (Healy, 1984 as cited in Mesfin, 2005).

3.6. Definition of Variables and Working Hypothesis

3.6.1. Dependent variable

The dependent variable for soybean technologies adoption was an index computed from the use and intensity of use of technologies related to improved variety, seed rate, NPS fertilizer and rate row planting in soybean production technologies. It is a weighted index, censored between 0 and 1, which is computed based on these technologies component as follows. Where soybean variety seed use intensity is the proportion of actual rate of soybean improved seed applied on soybean field to the recommended rate of improved soy seed(i.e.60kg-80kg per ha) JARC,2016; NPS/NPSB fertilizer use intensity is the ratio of the actual rate of NPS applied on a soybean field to the recommended rate of NPS (i.e. 100kg per ha) (JARC,2016); pesticide use is whether the farmers have used herbicides, insecticides, and fungicides; and row planting is whether the farmers have used row planting or not.

3.6.2. Explanatory Variables

The explanatory variables in this study are those variables, which are thought to have influence adoption and intensity of adoption of improved soybean production technologies. These include household's personal and demographic variables, economic variables, institutional variables and psychological variables. The explanatory variables are about 15 and defined as follows:

Age of the household: It is defined as the period from the respondent's birth to the time of the interview measured in years. It is continues variable and usually considered with the assumption that older farmers have more knowledge and skill with farming which enables them to easily understand the benefits of the technology better than others. Kidane, (2001) on the study he conducted on factors influencing adoption of improved wheat and maize varieties in Hawzien woreda of Tigray found that age is negatively related with farmers' adoption of improved wheat variety. In this study age was expected to have negative relationship with adoption decision and intensity of adoption of soybean.

Sex of household head: Is one of the most important factors influencing adoption of improved agricultural technologies. This is because of different socio-cultural values and norms, males have freedom of mobility, participation and interaction in various groups. These help male to have greater access to get information. It was used as dummy variable. Male farmers are more likely to adopt soybean improved varieties than female (Abebe, 2017 and Kedir, 2017). Therefore, in this study Sex was hypothesized to show positive relationship with adoption decision and intensity of adoption of Soybean production technologies.

Family size: refers to total number of family members who live under one roof; they may or may not be related by blood. It is a continuous variable measured in terms of adult equivalent. Household size is believed to be a good source for labor. Availability of labor is likely to influence the adoption of agricultural technologies. The variable was hypothesized to influence positively adoption decision of soybean production technologies. This was confirmed by (Yishak and Punjabi N, 2011).

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

Livestock holding: livestock is an important source of income and draft power. A household that has large number of livestock is likely to have more income and draft power this helps smallholder farmers to purchase inputs and to cultivate more land. It is measured in terms of Tropical Livestock Units (TLU). A TLU is equivalent to 250 kg of live weight and refers to total livestock ownership of the household. Livestock holding will be hypothesized to increases level of adoption of soybean production technologies. According to study of Miruts (2016).The model output also indicates that the number of livestock owned by a household in TLU affects positively and significantly the level of adoption of soybean production technologies.

Total Land holding Size: The size of the family farm is a factor that is often argued as important in affecting adoption decisions). It measured in hectares. Therefore, it will be expected to be positively associated with the decision to adopt and intensity of adoption of soybean production technologies. It is frequently argued that farmers with larger farms are more likely to adopt an improved technology (especially modern varieties) compared with those with small farms. Hailu (2008) reported that farm size exerts a positive influence on adoption of improved technologies. 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

Perceptions of household head: is operationally defined as the degree of positive or negative opinion of farmers towards improved soybean production technologies and is measured by a 5 Likert-scale type for this study, in order to evaluate the overall of improved soybean production technologies, an index is developed. The procedure involves counting the number of strongly agree, agree, neutral, dis agree and strongly dis agree characters regarding soybean production technologies and multiple them by their corresponding grades (i.e. 2, 1, 0,-1 and -2, respectively), adding up and dividing the sum by the number of characters. This variable measures farmers' recognition of the positivity/negativity of improved soybean attributes that is expected to influence adoption of new technology. Hence, it is hypothesized that good perception is expected to positively influence adoption of improved chickpea technologies (Solomon et al., 2011; Akalu et al., 2016), in which the result for each respondent was obtained by scoring procedure. Positive perception towards improved farming is one of the factors which could speed up the farm change process (Tadese, 2008). It was hypothesized that positive attitude towards improved soybean production technologies influences adoption of soybean production technologies positively.

Availability of improved soybean seed: It was measured as a dichotomous variable, with the value of 1 for timely and adequately availability of improved soybean seed and, 0 otherwise. Availability and access to improved wheat seed have a positive effect on adoption of wheat row planting technology Tolesa (2014) and Tolesa *et al*. (2014). They argued that availability of improved wheat seed had increased the probability of adoption and intensity of use of wheat row planting technology. This is because improved seed increase production at harvesting period when used with row planting technology than local seed. In this study, this variable was expected to have positive impact on the adoption decision and intensity of adoption of soybean production technologies.

Frequency of extension Contact: In this study, it was measured by number of contact between extension agent and farmers per year. The frequency of contact between the extension agent and the farmers will be hypothesized to be the potential force, which accelerates the effective dissemination of adequate agricultural information to the farmers thereby enhancing farmer's decision to adopt new technologies. Empirical results revealed that extension contact has an influence on farm households' adoption of new technology (Hailu, 2008). Farmers' visited by extension agents are believed to be exposed for different, new, updated information used to adopt new agricultural technologies thereby increase and double agricultural production (Wondimagegn *et al.*, 2011). It will be expected to influence adoption and intensity of adoption of soybean production technology positively.

Off-farm income: It is a continuous variable that represents an annual income earned (the natural log of off-farm income earned) and measured in ETB from off-farm economic activities through external labor supply, rentals of ox power, pack animals and land, handicrafts, petty trade, and so on (Hassen et al., 2012). The more off farm income the farmer generates, the higher he/she resolves his/her financial constraints, the faster to adopt soya bean adoption technologies. Hence, availability of off farm income was hypothesized as one of the factors that influence the likelihood of adoption of soya bean technologies.

Distance from Market: Market distance is one of the determining factors in the adoption of technology. It is a continuous variable measured in kilometers. Better access to the market can influence the use of output and input markets, and the availability of information. It is expected that farmers living near the market would easily access market for their farm produce hence readily adopt and intensively use new technology (Afework and Lemma 2015; Hassen*et al.,* 2012). Farmers nearer to the input and output markets have more access to input, technology and output market and also getting information about improved technology than those who are in distant areas and can make early decision of adoption(Mulugeta,2011). Therefore, it is hypothesized that market distance is inversely related to adoption and intensity of adoption of soya bean improved soya bean production technologies. Hence, in this study, market distance was hypothesized to affect adoption negatively and significantly.

Membership of cooperative societies: membership to cooperatives represents whether a household is member to cooperatives or not. Cooperatives worldwide are committed to the concept of mutual self-help. This makes them natural tools for social and economic development, and provides significant additional benefit to communities and social systems. Formal as well as informal associations, such as indigenous cooperation groups, enforcing widely agreed standards of behavior, and uniting people with bonds of community solidarity and mutual assistance. As such, they embody important forms of social capital representing forums where in local communities can unit and act collectively (Messer and Towensly, 2003). Membership to cooperatives also will increase households' access to services that might be granted by being member. This variable was expected to be positively related to adoption decision of soybean production technologies. Thus membership of cooperative societies in this study was positively hypothesized.

Household participation in field day: it was measured whether the farmers' participation in the field day regarding on soybean and it was treated as dummy variable taking values of 1, if the household head participated in field days and 0, if the household did not participate. Participation in field days was hypothesized to increase farmer's probability in adopting soybean production technology positively. The study on adoption of improved bread wheat production package by Menyahil (2008) showed that adoption has a significant relationship with participation in extension event.

Use of Credit: This variable is treated as dummy variable which takes a value 1 if the household head is users of credit and 0 if non-users. In this study, it was hypothesized to have positive relationship with adoption and intensity of adoption soybean production technologies. Credit is an important source of cash which improve farmer capital constraints and enable them to buy agricultural inputs. According to Simtowe*et al.* (2016) credit helps farmers to purchase inputs such as improved seeds, fertilizers and chemicals which are used as input for agricultural production. Hence, the amount of credit received has direct relationship with the adoption of new agricultural technology.

Farm income: The farm income refers to the whole annual cash earnings of the family from the sale of crops and livestock production after family requirement. This is to be essential source of capital for purchasing agricultural inputs. Thus, households with relatively higher level of farm income are more likely to purchase or exchange improved technologies. It is measured by the amount of Ethiopian birr obtain from sale of farm products (Afework and Lemma, 2015).

Table 3: Summary of independent variables, their definition and expected effect

Definition of variables	**Nature of variables**	**Unit of measurements**	**Expected sign**
Age of the household head	Continuous	Number of years	-
Sex of the household head	Dummy	1 if the household head is male and 0 otherwise	+
Family size	Continuous	Measured in adult equivalent	+
Education level of household heads	Continuous	Grade attended	+
Livestock holding	Continuous	Number of livestock in TLU	+
Total Land holding Size	Continuous	Hectare	-
Perception of household heads towards soybean technologies	Dummy	1 if a household perceived as a technology has positive attributes; 0 otherwise.	+
Availability of improved soybean	Dummy variable	(1, if available, 0 Otherwise)	+
Frequency of extension Contacts	Continuous	Number	+
Off-farm Income	Continuous	ETB	+
Distance from market	Continuous	Kilometer	-
Membership in cooperative societies	Dummy	1 if the household head is member and 0 otherwise	+
Household Participation in field days	Dummy	1 if the household head is participated in soybean field day and 0 otherwise	+
Credit use	Dummy	1, if yes; 0, otherwise	+
Farm income	Continuous	ETB	+

4. RESULT AND DISCUSSION

This chapter presents the results and discussions of the study. It provides the adoption and intensity of adoption of soybean production technologies among smallholder farmers, characteristics of the sample respondents, the level of adoption of soybean production technologies, the factors that affect adoption decision and intensity of adoption of soybean production technologies and rank of the constraints that hinders the sample respondents soybean production by using descriptive statistics, econometric models and Kendall's Coefficient of Concordance (W) analysis.

4.1. Descriptive Analysis

In order to identify the variables that vary significantly between the adopters and non-adopters inferential statistics tools such as chi-square and t-test were used in addition to descriptive statistics.

4.1.1. Sample Household heads' characteristics

Age of household head: In the current study, the age of the sampled respondents ranges from 26 to 72 years. The total average age of the sample respondents was 44.97 years. The average age of non-adopters was 45.71 years whereas the average age of adopters was 43.7 years. Therefore, the result of the analysis shows that, there was no statistically significant mean difference among adopters and non-adopters (Table 4).

Education level of household head: In the study area, the education level of the sampled respondents ranges from 0 (illiterate) to 12th Grade. The total average education level of the sample respondents were 2.95 grades (schooling years).The average education level of non-adopter sample respondents was 1.37 grades (schooling years) while that of the adopter sample respondents were 4.64 grades (schooling years). Hence, the analysis shows that, there was statistically significant mean difference among non-adopter and adopter at 1% level of significance (Table 4). This result implies that the schooling year of the adopters sample respondent was higher than the schooling year of non-adopter sample respondent. Moreover, the result implies that having education level of smallholder farmers improve the ability of adoption decision and intensity adoption of soybean production technologies. However, the result of this study showed that the education level of the sampled respondents in the study area was low.

Adult equivalent labor: Household's labor was the major source of farm labor in the study area. Soybean adoption decision production technologies were labor intensive business. Based on Storck*et al.,* (1991), household size was converted into adult equivalent labor, to facilitate comparison among the non-adopter and adopter of soybean production technologies. In the study area, adult equivalent labor of the sampled respondents ranging from a highly labor constrained which comprises 2 labor to a highly labor endowed households with a maximum of 12 adult labors. The total average adult equivalent labors owned by sample respondents were 5.395 in number which are comparable to national average family size 6.8 persons (EDHS, 2016). On average, non-adopter sample respondents had 5.35 adult equivalent labors whereas adopter sample respondents had 5.23 adult equivalent labors. Hence, the analysis indicated that, there was no statistically significant mean difference among adopter and non-adopter (Table 4).

Total land size holding: Land is a basic resource, as it is a base for any economic activity especially in rural and agricultural sector. In the study area, the farm size holding of the sampled respondents ranges from 0.5 to 11 hectares and the average farm size holding of total sampled respondents were 2.88 hectares. The average farm size holding of non-adopter sample respondent was 2.88 hectares while that of the adopter was 2.85 hectares. Hence, the analysis shows that, there was no statistically significant mean difference among non-adopter and adopters (Table 4).

Livestock holding: Livestock production is one of the major components of agricultural sector in the study area. Livestock is the smallholder farmers' relevant source of income, food and draught power for crop production in Ethiopian agriculture in general and particularly in Tiro Afeta District. Hence, households with large livestock holding can have good access for more draught power and it is one of the main cash sources to purchase inputs like soybean production technology. Based on Storck*et al.,* (1991), the livestock population number was converted into Tropical Livestock Unit (TLU), to facilitate comparison of livestock holding among the sample respondents. The maximum livestock holding by sample respondent was 21.01 TLU while the minimum was 0 TLU and the total average of livestock holding by sample respondents were 6.75

TLU. It was observed that the non-adopters and adopters sampled respondents had 5.80 TLU and 7.75 TLU respectively. Hence, the analysis has shown that, there was statistically significant mean difference among non-adopters and adopters at 10% level of significance (Table 4). This mean difference implies that the adopters have more chance of obtaining financial income by selling their livestock to purchase soybean production technologies and more chance of access to oxen power for crop land cultivation than non-adopter. In addition, adopters could use farm animals to transport their produce to the local markets and inputs from suppliers' center.

Off-farm income: Off-farm income is an additional source of income for smallholder farmers. Off-farm income has its own influence on the decision to use agricultural new technology. In this study, the maximum annual off-farm income of the sample respondent was 18,000ETB while the minimum was 0 ETB and the total average annual off-farm income of sample respondent was 762.29ETB. The average annual off-farm income for non-adopter sample respondent was 665.00ETB and for adopter sample respondent was 865.99ETB. Hence, the analysis indicates that, there was statistically insignificant mean difference among adopter and non-adopter (Table 4).

Frequency of extension contact: The major sources of agricultural information for farmers are extension agents. Frequency of contact with extension agent makes the farmers being aware of new technologies and how they can be applied. In this study, the frequency of extension agent contact with the sampled respondents for information and technical advice was ranges from 0 to 8 days per month and the total average frequency of extension agent's contact with sample respondent was 2.175 days per month during production season. The average frequency of extension agent contact with non-adopter sample respondents was 1.32 day per month while with adopters was 3.09 day per month. Hence, the analysis shows that, there was statistically significant mean difference among adopters and non-adopters at 1% level of significance (Table 4). The result implies that adopters were contacted more with DA than non-adopters and a continuous contact with extension agent enhances the exposure of smallholder farmers on the adoption decision and intensity of adoption of soybean technologies. On other hand, the report of respondents shown that, 40.2% of the sample respondent was got information for agricultural farm from training prepared by District and other bodies rather than from DA. Also, the same idea was raised during focus group discussion and key informant interview that conducted at each *kebele* level regarding DA. As the group and key informant were raised the development agent could not give proper technical advice for them. They pointed out that most of a time the development agents (DAs) were spent their time in urban rather than staying at the employed rural *kebeles* and giving extension services. This results into low agricultural production and productivity and less than the recommended rate of agricultural technologies like soybean production technology adoption of smallholder farmers in the area.

Distance from market: In this study, the distance between the respondent's residence and the nearest market place (measured in km) is negatively correlated with the decision to adopt soybean production technology. It is believed that a farmer was encouraged to adopt more soybeans when soybean technology is available near the consumption center at the right time. In this study, the sampled respondent travel ranges from 2 to 12 km and on average the total sample respondent was travel 5.32 km. The average non-adopter sample respondent was travel 6.08km while adopter was travel 4.51 km with statistically significant mean difference among the groups at 1% level of significance (Table 4). This implies that in the study area in the distance of soybean production technology market had more influences on the adoption and intensity of soybean technology adoption.

Household farm income: Household farm income refers to the total annual earnings of the household from sale of agricultural production after meeting household requirements. In this study the maximum household farm income of sample households head was 18,642 EB while the minimum was 0 Birr and the total mean of household farm income of total sampled households head was 7511.72EB. In this study farm income was includes both incomes from crop and livestock production. The result of the study indicated that the average farm income for non-adopter sampled household head was 5505.8EB and for adopter sampled household head was 9649.8 EB with a significant mean difference at 1% probability level as seen in table 4.

Table 4: Households' characteristics (for continuous explanatory variables)

Variables	Non-adopter(97)		Adopter(91)			Total sample(188)	
	Mean	Std.D	Mean	Std.D	T-value	Mean	Std.D
Age of household	43.67	6.30	45.71	6.46	-1.198	44.72	6.45
Education level	4.63	2.66	1.37	2.09	9.37***	2.95	2.89
Adult equivalent	5.23	1.47	5.35	1.61	-0.55	5.29	1.54
Total land size holding	2.88	1.45	2.85	1.43	-0.143	2.87	1.44
Livestock holding	5.8	2.97	7.75	4.22	3.66*	6.74	3.75
Off-farm income	665.00	2154.02	865.99	2569.4	-0.583	762.29	2359.9
Contact with extension	1.32	1.33	3.08	2.00	7.15***	2.17	1.9
Distance from market	6.08	2.02021	4.51	1.5	6.04***	5.32	1.94
Farm income	5505.8	5730.02	9649.8	5829.5	4.914***	7511.72	6125.6

Source: Own survey result, 2018/2019 *** & *significant at 1% & 10%

Sex of household head: In this study, the sample respondents were composed of both male and female headed households. According to the survey result, about 16.5 percent of the sample respondents are headed by females and the rest 83.5 percent are headed by male. The result of this study shown that from non-adopter sample respondent 23.72 percent and from the adopter 8.8 percent were females headed while from non-adopter sample respondent 76.28 percent and from the adopter sample respondent 91.2 percent were male headed. Hence, the result of the analysis shows that, there was statistical significant difference in sex of household head among the adopter and non-adopter at 1% level (Table 5)

Perception of household head toward soybean: In this study the perception of the respondent household head on adoption of soybean production technologies was gathered and analyzed as follow. The result of the study indicated that from a total sampled household head 33% and 67% of the farmers had perceived that negative and positive toward the soybean production technology adoption respectively. Also the result of the study revealed that from non-adopter sampled household head 57.73% and 42.27% was perceived that negative and positive toward the soybean production technology adoption respectively. From adopter sample household head 6.6% and 93.4% was perceived that negative and positive toward the soybean production technology adoption respectively. Hence, a chi-square ($\chi2$) analysis indicated that there was statistically significant difference in perception to ward soybean production technology among adopter and non-adopter at 1% level (Table 5).

Availability of Improved soybean seed: In this study the result of the study indicate that, from non-adopter 77% and from adopter 29.67% were response that improved soybean seed is not available. On the other hand, from non-adopter 23% and from adopter 70.33% were response that improved soybean seed is available. Hence, a chi-square ($\chi 2$) analysis indicated that there was statistically significant difference on perception toward soybean production technologies among adopter and non-adopter at 1% level (Table 5).

Member of cooperative society: Cooperative societies are one of the important institutions in rural and agricultural sectors. In the study area, cooperative serves the society in different angles like as a source of credit, distribution of agricultural technologies like inorganic fertilizer and improved seed, market for agricultural output and supplying basic materials like sugar and oil to the society. This implies that a farmer who is a member of cooperative society has more chance of obtaining those services. Therefore, being a member of cooperative society is expected to have a positive and significant association with adoption and intensity of adoption of soybean production technologies. The result of the current study showed that from the total sample respondents 43.6% was member of cooperative society whereas 56.4% of the respondents were not a member of cooperative society. Out of non-adopters, sample respondent 38.47% was a member of cooperative society whereas 61.53% was not a member of cooperative society. From adopter sample respondents 45% was a member of cooperative society whereas 55% was not a member of cooperative society. According to the chi-square ($\chi 2$) analysis there was statistically insignificant difference in member of cooperative society among users and no- users (Table 5).

Household participation in field day: The result of the current study showed that from the total sample respondents 68.6% of household has participate in field day whereas 31.4% of the respondents were household has not participate in field day. From non-adopter 47.25% and from adopter 16.5% were response that has not participated in field day. On other hand, from non-adopter 52.75% and from adopter 83.5% were responses that participate in field day. Hence, a chi-square ($\chi 2$) analysis indicated that there was statistically significant difference in household participation in field day soybean production technology among adopter and non-adopter at 1% level (Table 5).

Use of credit: In the study area, there are formal and informal source of credit service. From the formal source of credit service; Oromia saving and credit institution is the most known institution and most of a time the smallholder farmers in the study area have got credit from this institution. The results of the current study indicated that from total sample respondents 37.8% was reported lack of used to input credit and 62.2% was reported having uses credit for purchasing of agricultural inputs like inorganic fertilizer and improved soybean seed. Out of non-adopter sample respondents 67% was adopters of credit whereas 33% was non-users of credit. From user sample respondents 57.73% were adopters of credit whereas 42.27% were non-users of credit. Hence, the chi-square ($\chi2$) analysis shows that, there were statistically insignificant difference in use of credit among adopters and non-adopters (Table 5). On other hand, regarding the use of input credit focus group discussion were conducted by researcher. During the focus group discussion, the groups were raised two main ideas. The first point raised on focus group discussion was the concern of credit institution especially Oromia credit and saving institution was focused on resource poor farmers and it gives input credit for resource poor farmers only. Other farmers were not got input credit by the assumption that they are better off to buy input like inorganic fertilizer on cash basis. However, as it was observed from focus group discussion and key informant interview, the reality that exists in the study area indicated that all the farmers need credit to buy inorganic fertilizer. The second point raised on focus group discussion by group was even they use credit on agricultural inputs, due to the high interest rate of input credit they were not benefited from the input credit. Hence, these two main points widen a gap between the soybean production technology and credit use in the study area.

Table 5: Household characteristics (for dummy variables)

Variable		Non-adopter		Adopter			Total sample	
		N	%	N	%	χ2- Value	N	%
Sex of household head	Female	23	23.71	8	8.8	7.59***	31	16.5
	Male	74	76.29	83	91.2		157	83.5
Perception of household towards soy	Negative	56	57.73	6	6.7	55.55***	62	33
	positive	41	42.27	85	93.4		126	67
Improved soybean seed availability	No	70	77	27	29.67	33.95***	97	51.6
	Yes	27	23	64	70.33		91	48.4
Member of cooperative society	No	56	61.53	50	55	0.15	106	56.4
	Yes	41	38.47	41	45		82	43.6
Household participation in field day	No	43	47.25	16	16.5	15.599***	59	31.4
	Yes	54	52.75	75	83.5		129	68.6
Credit use	No	36	33	35	42.27	0.036	71	37.8
	Yes	61	67	56	57.73		117	62.2

Source: Own survey result, 2018/2019

4.1.2. Level of adoption of soybean production technologies

Soybean adoption technology is one of agricultural production technology that improves production and productivity of smallholder farmers. In the study area, during 2018/2019 production season from the total sampled respondents 51.6% and 48.4% was non-adopter and adopter of soybean technology respectively (Table 6).

Table 6: Category of sample respondent by adoption of soybean production technologies

Category of sample household	Frequency	Percent (%)
Non-adopter of soybean production technologies	97	51.6
Adopter of soybean production Technologies	91	48.4

Source: Own survey result, 2018/2019

Technology application rate for adopter of soybean production technologies

Any agricultural new technologies like soybean production technologies have its own recommendation rate of application. However, the average application amount was below the recommended rate for land allocate, amount of improved seed and amount of fertilizer used. The same problem was observed in the study regarding the intensity of soybean production technology application rate. This also true in study area. In the study area, the extension recommended rate of soybean production technology application.

Sampled households have allocated 0.56 ha for soybean with standard deviation of 0.34 (Table 7). According to the result of the focus group discussions made with farmers, the difference in using soybean seed is resulted from soybean market price fluctuation and the unavailability of the soybean seed in the market as needed. In addition to this, the cost of purchasing the seed is high.

Seeding Rate

The recommended seed in soybean production technologies by JARC, 2016research to the study area is 60-80 kg/ha. As the research soybean production manual recommends the specified amount of seed is based on seed size which differs among different varieties and quality of the seed otherwise the amount can increase proportionally with decreased in seed quality. Thus, research recommends specified level of seed rate based on the range on the quality of the seed. The smallholder farmers in the study area were using varying rates of seed with the mean of 43.23kg/ha with standard deviation of 10.65(Table 7). On the other hand, according to the result of focus group discussion made with farmers, the farmers fall below the recommended seed rate amount, because of unavailability of improved seeds and not knowing the exact amount of seed rate recommended by research extension.

Fertilizer Rate

Soybean production requires use of different inputs. Fertilizer application is one of the most important practices that need to be adopted by soybean producers. Smallholder farmers in the study area use varying fertilizer rate especially NPS. The recommended rate of fertilizer for the study area by the JARC, 2016 is 121 kg/ha of NPS and Fertilizer application rate of sample respondents vary across adoption categories. Among the total sampled households. The average fertilizer application rate in soybean production by the sample households was 41.5kg/ha of NPS with standard deviation of 27.99 (Table 7). Respondent farmers from focus group discussion have mentioned different reasons for their use of lower fertilizer rates. In the first place, they were rising that application of the recommended fertilizer rate does not give much yield advantage. As to some farmers, they also claim even though they apply the recommended rate they get the same amount of yield as the previous harvests. This has an implication for research indicating the need to revisit the previous recommendation by conducting further site-specific fertilizer trials.

Table 7: Application rate of soybean production technology per hectare for adopters (N=91)

Soybean production technology	Mean	Std. Deviation
Land allocated	0.5618	0.34086
Amount of improved seed	43.2308	10.64876
Amount of NPS/DAP used	41.5009	27.98905

Source: Own survey result, 2018/2019

4.1.3. Classification of the sample respondents by level of soybean technology adoption

Regarding the level of adoption of soybean production technologies, the sample respondents were classified as follows. In this study, soybean production technology includes the use of improved varieties, seeding rate and fertilizer rate and row planting methods. Other technologies like rhizobium, weeding methods, land preparations were skipped because of they do not make varies on intensities and others are no practiced at the study area. Farmers who did not grow the improved soybean variety were considered as non-adopters while other farmers who grow improved variety of soybean with some of the recommended production technologies (improved variety, seed rate, fertilizer rate and row planting) were taken as adopters. Based on adoption index calculation three levels of adopters where identified with different range of adoption index score, these are 0.01-0.33, 0.34-0.66 and 0.67-1 which are assigned for low adopter, medium adopter and high adopter categories respectively (Mulugeta 2011) and non-adopters, those who didn’t cultivate the improved soybean variety, with a score of 0. From the total sample respondents, 51.6% are non-adopter of soybean technology adoption. On the other hand, depending on the results calculated from the adoption index score, intensity of soybean production technologies adoption indicated that 51.6%, 18.08, 17.02% and 13.3% of the sample respondents were classified in to non-adopter, low, medium and high rate of soybean production technologies adoption respectively (Table 8).

Table 8: Classification of sample respondents by the level of adoption of soybean production technologies

Adoption category	Frequency	Adoption index score range	Percent (%)
Non-adopter	97	0.00	51.6
Low adopter	34	0.01-0.33	18.08
Medium adopter	32	0.34-0.66	17.02
High adopter	25	0.67-1.00	13.3
Total	100	0-1.00	100

Source: Own survey result, 2018/2019

4.2. Econometric Model Results

In the descriptive analysis, it was dealt mainly with description of the sample respondents and test of the existence of association between the dependent and explanatory variables to identify factors determining adoption and intensity of adoption of soybean technologies. However, identification of these factors alone is not enough to stimulate policy actions unless the relative influence of each factor is known for priority based intervention. Accordingly, an econometric Heckman's selection model was employed. Before running the Heckman two-step model, the hypothesized explanatory variables were checked for multicollinearity problem. The result of VIF indicated that values for continuous variables were found to be small for all variables which are less than ten (Appendix table 3). This shows that there is no serious multicollinearity problem among continuous variables. Hence, all of them were included in the model. Similarly, contingency coefficients (CC) were computed in order to check the degree of association among dummy variables. The results of the analysis indicated that there was no serious multicollinearity problem of association among dummy variables which is less than 0.75(Appendix table 4). Also, the model goodness of fit was checked by chi-square test and the result indicated that the overall goodness of fit for Heckman selection model was statistically significant at a probability less than 1% level (Appendix table 5). This shows that jointly the independent variables included in the selection model regression explain the extent of adoption of soybean production technologies.

4.2.1. Determinants of adoption decision of soybean production technologies

In this sub-section results concerning demographic, socio-economic and other factors that determine the adoption of soybean technology production in soybean production behavior of household heads. The model output of heckman selection model; probit/ adoption equation shows that seven variables were affects the adoption decision of soybean production technologies out of fifteen explanatory variables. These variables are: education level of household head, total livestock holding, availability of improved seed, frequency of extension contact, distance from market, credit use and farm income. On the other hand, under this section since the coefficient cannot report directly, the marginal effect is calculated and used to report the adoption decision of soybean production technologies (Appendix table 6)

Education level of household head (EDLHH): Education level of household head was hypothesized to affect technology adoption positively since it increases the capacity of farm households to acquire information and knowledge of improved technologies and promote the decision to use it on his/her farm. In this study, as a prior expectation education level of household head was found to positively and significantly influence the probability of adoption of soybean production technologies at 1% (P = 0.001) level of significance. The result of this study indicated that, the increase in the number of years of formal schooling of the head of a household by one more schooling year would lead to increases the probability of soybean production technologies adoption of soybean production by 18.9%. This implies that, having education level of smallholder soybean production farmers will improve the ability to use information, process and interpret information concerning agricultural technology. The result of this study was consistent with the finding by Eba and Bashargo (2014), who stated that adoption of agricultural technology was positively associated with level of farmers' education. Consistent with the research results of Afework and Lemma (2015), Sisay (2016) and Abebe (2017) who stated that education, affect adoption of improved soybean technologies positively.

Livestock holding (TLUHH): Livestock holding was in line with the prior expectation and found to be statistically significant variable at 5% (P=0.015) level with positive relationship. The result implies that, the increase in livestock holding (in tropical livestock unit) of the head of household by one more TLU would lead to the increases in the adoption decision of soybean production technologies by 11.95%. This implies that, as livestock value increases the income of the smallholder farmers increases which leads to increases the purchasing power of soybean production technologies of the smallholder soybean farmer. Since the area is bordered by the Gibe river which means the availability of grass and water were high, both crop and livestock production are integrated and are connected to each other. On the other hand, this could be due to the fact that households with more number of livestock holding do minimize the capital constraints to purchase agricultural inputs as well as capacitate their risk taking behavior to use agricultural new technology like chemical fertilizer, soybean improved seed. This study was consistent with the research findings by Ketema and Bauer (2011), Yirga and Hassan (2013). Their results suggested that improving herd size (e.g. improving access to veterinary service) will have positive impact on raising adoption and expected use of soybean production technology. The result of the study also coherent with Debelo Duressa (2015) and Sisay Debebe (2016) also obtained similar result. However, Negera and Getachew (2014) and Berihun et al. (2014) reported that negative and significant relationship with the adoption.

Availability of Improved soybean seed (AIS): Availability of improved seed was in line with the prior expectation and found to be statistically significant variable at 10% (P=0.068) level with positive relationship. The result of the study indicated that, being improved seed availability of the head of household would leads to an increase in the adoption decision of soybean production technologies by 80%. From this result, it can be stated that those farmers who have obtain improved soybean seed are more probability of soybean production technology in soybean production than those not obtain improved soybean seed on time and closest place. In other words, farmers who have obtained improved soybean seed are more likely adopt soybean production technologies. Similar result was gained by Adunea (2016) shows Provision of improved wheat seed to farmers in required quantity and at the right time increases the probability of adoption of wheat row planting and the intensity of use of wheat row planting technology.

Frequency of extension contact (FEC): Frequency of contact with extension agent was a positively and statistically significant variable at 1% (P=0.004) level of significance in affecting the adoption of soybean production technologies. The result of the study revealed that, the increase in the frequency of extension agent contact with the head of household by one more day per month would lead to the increase in the probability of adoption of soybean production technologies by 27.57%. This result implies that frequency of contact with extension agent was enhanced the exposures of farmers on adoption practices, increases the probability of acquiring updated information on the new agricultural technologies. This study was consistent with research finding carried out by (Dereje et al., 2016). On the basis using the analytical method to analysis extension as a determinant in adoption of soybean production technology was proven to have positive and significant impact.

Distance from market (DFM): Distance from market was a negatively and statistically significant variable at 1% (P=0.000) level of significance in affecting the adoption decision of soybean production technologies. The result of the study indicated that, the increase in the distance from market of household by one more kilometer would lead to the decrease in the probability adoption of soybean production technologies by 35.99%. The result implies that since the farmer is far from market cannot obtain enough information about price, quality and have transportation problem. This is in line with previous studies by Debelo (2015), Sisay (2016) and musba (2017) who found that distance to nearest market influence adoption of new technologies negatively. According to Debelo (2015), Sisay (2016) and Musba (2017) distance to nearest market Quncho Teff in Wayu Tuqa District and maize technology in Jimma Zone and Adoption and Impact of Improved Soybean (belessa-95) Variety among Smallholder Farmers in Bambasi Woreda, Benishangul Gumuz Regional State negatively and respectively.

Use credit (UCRD): Use of credit was a positively and statistically significant variable at 10% (P=0.060) level in affecting the adoption of soybean production technologies. The result of the study indicated that, being user of input credit of the head of household would leads to an increase in the probability adoption of soybean production technologies by 56.3%. From this result, it can be stated that those farmers who have use formal credit are more probability of adoption of soybean production technologies than those not using formal credit. In other words, farmers who have use credit are more likely adopt soybean production technologies. Moreover, households who need and getting formal credit for purchasing of soybean production technologies was increase the probability growing of soybean than those not use. The result also indicated that credit is very helpful in relieving capital constraints faced by smallholder farmers for adopting soybean production technologies and other purchased input. The study result was consistent with Mekuria (2013). This indicated membership in cooperatives societies affect adoption positively and significantly.

Farm income (FRMICMHH): As prior hypothesized farm income was found to be positively and statistically significant at 1% (P=0.005) level of significance in influencing on the adoption decision of soybean production technologies. Accordingly, as farm income of the head of household increase by one ETB would lead to the increase in the probability of adoption decision of soybean production technologies by 0.001%. The result of the study implies that, smallholder farmers who got income from their annual agricultural production could invest his/her proportion of income to buy soybean improved seed as well as purchasing other agricultural inputs. Moreover, smallholder farmers with higher annual farm income tend to adopt soybean production technologies. The result is in line with the result found by mesfin (2017), both probability and intensity of technology adoption and musba (2017) positively significant on intensity of soybean improved varieties at his study area.

Table 9 : Parameter estimates of Heckman's first stage (Probit estimation) for adoption decision of soybean production technologies and its marginal effect.

Variables	Coef.	Std. Err.	P-Value	Marginal effect
Age of household head	-0.025	0.0173	0.162	-0.024
Sex of household head	0.638	0 .409	0.119	0.638
Adult equivalent labor	0.143	0.102	0.161	0.143
Education level of household head	0.189	0.057	0.001	0.189***
Livestock holding	0.119	0.049	0.015	0.119**
Total land holding size	0.0598	0.085	0.484	0.0598
Perception of household head toward soy bean	0.611	0.485	0.208	0.611
Availability of improved seed	0.800	0.438	0.068	0. 800*
Frequency of extension contact	0.276	0.097	0.004	0.276***
Off-farm income	-0.0001	0.0001	0.133	-0.0001
Distance from market	-0. 36	0.086	0.000	-0.36***
Member of cooperative society	0.045	0.30	0.883	0.045
Household field day participation	-0. 220	0.50	0.661	-0.220
Use of credit	0.563	0.302	0.063	0.563*
Farm income	0.0001	0.00003	0.005	0.0001***
Constant	-1.202	1.092	0.271	-1.202

Number of obs = 188 Wald chi2 (14) = 27.98 Prob>chi2 = 0.0000

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

Source: Own survey data result, 2018/2019.

4.2.2. Determinants of intensity of adoption of Soybean production technologies

The intensity of soybean production technology adoption has estimated according to the model put in the methodology party. Hence, the regression coefficients measure the unit of soybean production technology adoption change in soybean technologies adoption for a unit change in the explanatory variable. In this subsection the covariant that we used to analyze the adoption of soybean production technology are also used to identify the factors that affect the intensity of soybean production technology adoption. However, Heckman Model has been suggested that the covariates in the selection function should contain one or more variables related to the probability of selection equation, but excluded from outcome equation (Briggs, 2004). Accordingly, the variable improved seed availability to household head has been excluded from the intensity of soybean production technology adoption (outcome equation) and used only on corresponding adoption of soybean production technology (selection equation). The correlation of this variable with other variables in the intensity of adoption of soybean production technologies equation is tested and the test result revealed that this variable doesn't have correlation with any one variable in the intensity of soybean production technology adoption equation.

In outcome equation of the model, five (5) variables are found to be significant determinants of household head intensity of adoption of soybean production technologies. These are: age of household head, total land size holding, and distance from market, farm income and Inverse mill ratio (LAMBDA) (Table 10).

Inverse mill ratio (LAMBDA): According to the model output inverse mill ratio (Lambda) for the intensity of adoption of soybean production technologies was significant, indicating that selection bias would have been resulted if the intensity of soybean production technology had been calculated without taking into account the decision to adopt soybean production technologies. That is selection effects become important, the Inverse mill ratio is significant at 5% (P=0.010) level. Hence, this justifies the use of heckman's two-step procedure. The negative sign suggested that the error terms in the adoption equation and intensity of adoptions are negatively correlated. This shown that those unobserved factors that determine household adoption decision of soybean production technologies are likely to be negatively associated with household intensity of adoption of soybean production technologies.

Age of household head (AGHH): As hypothesized age of the household heads was found to be statistically significant variable in affecting intensity of adoption of soybean production technologies. The level of significant was at 10% (p=0.058). This implies that, the increase in age of sample respondents had a positive influence on intensity of adoption of soybean production technologies. The result of the study indicates that, the increase in the age of household head by one more year would leads to the increase in the intensity of adoption of soybean production technologies by 0.005units. This might be related to the reason that older farmers might gain knowledge and learnt though out their long life experience. Moreover, older farmers may accumulate more wealth than younger and so older ones may still be intensive in soybean production technologies adoption even as they grow older and again the implication is that the increase in farmer's age increases farmers' experience in farming and understanding more the benefits of the technology. Studies by Miruts (2016), Sisay (2016) and Abebe (2017) also obtained a similar result in their studies.

Total land size holding (TLSHH): As hypothesized expected total land size holding of household heads was found to be statistically significant variable at 1% (p=0.008) level with a positive relationship. This implies that, the increase in total land size holding of sample respondents had a positive influence on intensity of adoption of soybean production technologies. The result of the study indicates that, the increase in the total land size holding of household head by one more hectare would leads to the increase in the intensity of adoption of soybean production technologies by 0.044units.This result implies that having large farm size enhances the adoption of agricultural new technology at recommended rate. The result found by these researchers: Akubuilo (2013), Mohammed and Lakew (2013), Miruts (2016) was similar with this study.

Distance from market (DFM): Distance from market was a negatively and statistically significant variable at 10% (P=0.065) level of significance in affecting the intensity of adoption of soybean production technologies. The result of the study indicated that, the increase in the distance from market of household by one more kilometer would lead to the decrease in the intensity of soybean production technology adoption by 0.04 units. The result implies that since the farmer is far from market cannot obtain enough information about price, quality and transportation problem. This study result was similar with result of Adunea (2017) who state increase in distance (km) from the household residency to the nearest market will decrease the intensity of use of wheat row planting in his study. This means distance is negatively significant to the intensity of adoption of soybean production technologies.

Farm income (FARMINCMHH): As prior hypothesized farm income was found to be positively and statistically significant at 1% (P=0.005) level of significance in influencing on the intensity of adoption of soybean production technologies. Accordingly, as farm income of the head of household increase by one ETB would lead to the increase in the intensity of adoption of soybean production technologies by 0.00001 units. The result of the study implies that, smallholder farmers who got income from their annual agricultural production could invest his/her proportion of income to buy soybean production technologies such as purchasing agricultural inputs. Moreover, smallholder soybean farmers with higher annual farm income tend to adopt soybean production technologies. The study was in line with the result found by mesfin (2017) on chickpea technologies of adoption intensity positively and significantly and musba (2017) positively significant on intensity of adoption of soybean improved varieties at his study area.

Table 10: Parameter estimates of Heckman's two steps for the likelihood of intensity of adoption of soybean production technologies (OLS estimation).

Variables	Coef.	Std. Err.	P-Value
Age of household head	0.005*	0.003	0.058
Sex of household head	0.076	0 .087	0.382
Adult equivalent labor	-0.007	0.0175	0.690
Education level of household head	0.00023	0.0114	0.984
Livestock holding	-0.01	0.008	0.212
Land size holding	0.0445***	0.017	0.008
Perception of household head toward soy bean	0.027	0 .076	0.727
Frequency of extension contact	0.0002	0.015	0.991
Off-farm income	4.10e-06	0.00001	0.704
Distance from market	-0.0386*	0.021	0.065
Member of cooperative society	0.058	0.066	0.376
Household participation in field day	0.0142	0.077	0.855
credit use	0.037	0 .0596	0.538
Farm income	.00001** *	5.01e-06	0.013
Inverse mill ratio (Lambda)	-0.246**	0.095	0.010
Constant	-0.0566	0.22	0.797

Note: ***'and ** show the values of statistically significant at 1%, 5% and10% probability intensity of significance respectively.

Source: Own survey data result, 2018/2019.

4.3. Constraints Associated with smallholder farmers' soybean adoption

This subtopic required specially to know the negative factors that hinders smallholder farmers' soybean production. There are numerous constraints that hamper soybean productions among smallholder in Tiro Afeta District. Some of these constraints were identified and consolidated for the sake of this study. The constraints that were identified includes: High cost of inorganic fertilizer, lack of credit for input, High interest rate on credit, rain fall fluctuation, Poor quality of soybean seed , Lack of knowledge on soybean production, lack of oxen and poor transportation system. Under this subsection those constraints and their mean ranks and total weight score sum of ranks were presented in table 11 and appendix table 7 respectively.

The result of the Kendall's coefficient of concordance is presented (Table 11). The coefficient of concordance calculated was 0.670 (67%). The value indicates the degree of agreement in general to the rankings of the constraints. Hence, the Kendall's coefficient of concordance (W) analysis shows that 67% of the respondents were in agreement with each other on the ranking of the constraints in the study area. The result in table11 also shows that there is agreement among the ranking and it is fairly high; since Kendall's coefficient of concordance (W) is 0.670 (67%). The result was asymptotically significant at 1% level of significance and had a chi-square value of 881.285. Thus, the null hypothesis (Ho) was rejected, which states that there was no agreement among the respondents over them ranking of the constraints of adoption and intensity of soybean production technologies adoption. Hence, H1 was accepted and there was agreement among the respondents on the ranking of the constraints. Therefore, the main constraints put into the following categories based on the identification and rankings by the sampled respondents.

High cost of inorganic fertilizer: High cost of inorganic fertilizer was found to be the most important constraint to adoption and intensity of adoption of soybean production technologies adoption in soybean production according to the ranking of respondents. Despite the high cost of inorganic fertilizer, the smallholder soybean farmers in the study area tend to produce soybean without using inorganic fertilizer or using less than the recommended rate. These ways of production practice of smallholder soybean farmers have a negative consequence for the incremental of soybean production and the constraint was ranked at first by sampled respondents.

Lack of credit for input: Lack of credit for input use was found to be the second ranked most constraint by sampled respondents in the study area. Credit has its own influence on soybean production. Lack of credit for input like for inorganic fertilizer and improved seed has a negative influence on the increases of soybean productions. In the study area many farmers' were complained of not having opportunities to access credit of any kind to enhance their farming activities. This makes the production and productivity of crops in the area too low.

High interest rate on credit: High interest rate on the credit was the third ranked most constraint by sampled respondents in the study area. The sample respondents of the study area was raised the interest rate on credit was high. Due to this most of the smallholder soybean farmers were reluctant to use of input credit. This implies high interest rate on credit has a negative influence on the soybean production technologies which leads to adopt without input like fertilizer technology consequently low income and low profit.

Poor quality of soybean seed: Poor quality of soybean seed was forth ranked constraint by sampled respondents and the most constraint that faced the smallholder farmers of the study area. The sampled respondents of the study area raise this constraint accordingly; the seed provided is face germination problem and sometimes unknown varieties FGD raised also the problem of seed germination as a problem. This makes the soybean farmers of the study area loss their production. Because of this study area farmers fear to take improved seed or bought seed from the market.

Rain fall fluctuations: Lack of uniform rain fall distribution was the fifth ranked constraint by sampled respondents and the most constraint that faced the smallholder farmers of the study area. The sample respondents of the study area raise this constraint accordingly; the rain was started late and stopped early or sometimes started early and stopped late in the area since the last five-year ago. This constraint makes the smallholder soybean farmers of the study area loss of their product. Due to that, some of the smallholder soybean production technology farmers of the study area reluctant to soybean production because of, they lost their production.

Lack of knowledge on soybean technology use, lack of oxen and poor transportation facilities was ranked at 6^{th}, 7^{th} and 8^{th} respectively by sampled respondents. These constraints are low level of influences on the adoption and intensity of adoption of soybean production technologies;

according to the rankings by respondents. In general, the result of this study was consistent with research finding (Tirfu, 2011; Basha, 2016; Joseph, 2016).

Table 11: Rankings of constrains of soybean production in the study area

Constraints	Mean Rank	Overall rank
High cost of inorganic fertilizer	1.68	1st
Lack of credit for input	2.27	2nd
High interest rate on credit	3.72	3rd
Poor quality of soybean seed	4.10	4th
Rain fall fluctuation	4.35	5th
Lack of knowledge on soybean production technologies	6.09	6th
Lack of oxen	6.47	7th
Poor transportation system	7.33	8th

Note: Kendall's W=0.670, M=188, n=8, $\chi 2$ =885.285, Asympt.sign=0.000, df=7

Source: Own survey result of 2018/2019

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusion

This study aimed at the Assessing Factors affecting adoption of soybean production technologies in Tiro Afeta districts, Jimma zone of Oromia region, Ethiopia with the specific objectives of the assess the level of adoption of soybean production technologies of smallholder farmers, analyzing factors affecting adoption decision and intensity of adoption of soybean production technologies and to explore the constraints that hinder the soybean production in the study areas.

The data were generated from both primary and secondary sources of data. The primary data were generated from individual interview using pre-tested semi-structured questionnaire. In this study the total sample respondents interviewed for primary data for this study were collected from 188 randomly selected households from three kebeles of Tiro Afeta District.

Data analyses were done with the help of descriptive and econometric methods using SPSS version 20 and STATA version 13computer software. Chi-square test and t-test were used to test the variation among farmers across the non-adopters and adopters group. Heckman two step model was used to analysis factor affecting adoption decision and intensity adoption of soybean production technologies. Result of descriptive statistics indicated a total of 91 (48.40%) of respondents have adopted the soybean production technologies, the rest 97(51.6%) were non-adopters. The levels of adoption of soybean production technologies were 18.08, 17.02% and 13.3% of the sample respondents were classified in to low, medium and high rate of intensity of adoption soybean technologies respectively.

Result from the Heckman two-step model indicated that out of the fifteen explanatory variables seven had shown significant relationship with adoption and intensity of adoption soybean production technologies. Accordingly, education of level of house hold , total livestock holding, improved seed availability, frequency of extension contact, credit use , farm income positively and significantly were as market distance do negatively and significantly affect adoption of soybean production technologies. Age, land holding size, and farm income determine adoption intensity of adoption of soybean production technologies positively and significantly whereas distance from market affect negatively and significantly. Hence, adoption and intensity of adoption of soybean production technologies can be observed as results of different set of factors. The constraints of soybean production technologies were also identified and ranked by the respondents in the study area and there are serious constraints. Hence, concerted efforts should be made to promote the adoption soybean production technologies at recommended rate in soybean production to enhance soybean productivity and profit through overcoming the factors and constraints. These require strengthening the institutional support provided to this sector, such as credit service, cooperative union, research and extension service.

5.2. Recommendations

On the basis of the outcomes of this study, the following recommendations are suggested as to be considered in the future intervention strategies which are aimed at promotion of soybean production technologies.

- Age of household head had a significant positive influence intensity of adoption of soybean production technologies. Older farmers adopt soybean production technologies than younger farmers. Hence, the local government should arrange experience sharing and provision of short term training programs in each *kebeles* so as to share the rich knowledge of old farmers to young and in experienced farmers.

- Education level of household head had a significant positive influence on adoption of soybean production technologies by smallholder farmers. Hence, appropriate policies should be designed to provide adequate and effective basic educational opportunity to rural farmers in general and to the study areas. In this regard, the regional bureau of education and woreda and zonal office of education need to strengthen the existing provision of formal and informal education through facilitating all necessary materials.

- The size of livestock holding had a significant positive impact on adoption of soybean production technologies. So, the farmers and woreda livestock production office should have to play their party in strengthening the existing livestock production system through providing improved health services, better livestock feed (forage), using high yielding breeds and disseminating artificial insemination in the areas.

- Frequency of extension agent contact with household head had a significant positive impact on adoption of soybean production technologies. Hence, it is necessary to strengthen farmers training centers for enabling them to properly demonstrate available technologies and at the same time to capacitate farmers on technology utilization through provision of training for the smallholder farmers and strengthening the existing extension services.
- Availability of improved soybean seed was positively determines the adoption decision of soybean production technologies. Therefore, the existing improved soybean seed supplier institutions at zonal/district level or the delivery system should be strengthen and has to be distributed on time with required quantity through easy channel at fair price directly to the farmers unlike to the current condition not reach at the peak sowing season.
- The negative influence of distance to the nearest market center on the adoption decision and intensity of adoption of soybean production technologies call for concerning bodies to invest on improving rural road infrastructure and market access through development and maintenances of rural road networking that provide services all year round. Alternatively, emphasis should be given to strengthen the existing rural-urban infrastructure development to improve farmer's access to input and output markets.
- Land holding was also an important variable which positively and significantly influenced intensity of adoption of soybean production technologies. This would indicate that, farmers with increasing land holding are more likely to adopt soybean production technologies. Thus, research and extension organizations should give attention in solving farmers' problem especially by improving the contribution of soybean production technologies to enhance productivity per unit of area.
- Use of input credit had a significant positive influence on adoption decision of soybean production technologies. Therefore, due attention is required from the Oromia Agriculture and Natural Resources Bureau, Oromia Cooperative Bureau and Oromia credit and saving institution through collaboration work in extending use of input credit

for all farmers rather than selective way and revising the existing interest rate of input credit.

- Farm income had a significant positive influence on adoption decision and intensity of adoption of soybean production technologies. So, the smallholder farmers of the study area should have to increases their crop and livestock productivity through using agricultural new technologies which leads to increases their farm income. Also, the attention is required from Oromia Agriculture and Natural Resources Bureau, Oromia Trade and Market Development Bureau and Oromia Cooperative Bureau through provision of awareness creation on agricultural new technology and facilitating the market strategy that enhances farm income.

- In the study area, the constraints of adoption and intensity of adoption soybean production were identified and ranked by the respondents. Accordingly, High cost of inorganic fertilizer, lack of credit for input, High interest rate on credit, Poor quality of soybean seed, rain fall fluctuation, Lack of knowledge on soybean production, lack of oxen and poor transportation system, were ranked in order of their influences. So, the smallholder farmers, District Agriculture and Natural Resources Office, District Cooperative Office and National Bank should have to play their party to overcome those constraints.

- The study was limited to smallholder farmers in three *kebeles* of Tiro Afeta District on adoption and intensity of adoption of soybean production technologies. Therefore, further study recommended that in the future should look at the adoption and intensity of adoption of soybean production technologies for other *kebeles* and crops in the district.

6. REFERENCE

Abebe Galmesa (2017). Adoption of Improved Soyabean Varieties: The Buno Bedele and East Wollega Zones of Oromia Region, Ethiopia (Doctoral dissertation, Haramaya University).

Abebe, A., Hagos, A., Alebachew, H. and Faji, M., (2018).Determinants of adoption of improved forages in selected districts of Benishangul-Gumuz, Western Ethiopia. *Tropical Grasslands-ForrajesTropicales*, *6*(2), pp.104-110.

Adeniji, O.B. (2002): Adoption of Improved Technologies for Cotton Production by Farmers in Kaduna State, Nigeria. Unpublished Ph.D Thesis, Department of Agricultural Economics and Rural Sociology, Ahmadu Bello University, Zaria, Nigeria.

Adesina, A.A.andZinnah, M.M..(1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leon, Agricultural Economics, 9(1993) 297-311.Elsevier Science Publishers B.V., Amsterdam

Afework, H, H. and Lemma, Z., (2015). Determinants of improved rice varieties adoption in Fogera district of Ethiopia. *Science, Technology and Arts Research Journal*, *4*(1), pp.221-228.Agrekon,40(3).

Alemitu, M., (2011).Factors Affecting Adoption of Improved Haricot Bean Varieties and Associated Agronomic Practice in Dale District*, SNNPS* (Doctoral dissertation, M. Sc. Thesis. Presented to Hawassa University).

Aman Tufa and TewodrosTefera. (2016). Determinants of improved barley adoption intensity in Malga district of Sidama Zone, Ethiopia. *International Journal of Agricultural Economics,* 1(3): 78-83.

Alene A.D., A. Menkir, S.O. Ajala, A.S. Badu-Apraku, V. Olanrewaju, M. Manyong, and A. Ndiaye (2009). The economic and poverty impacts of maize research in West and Central Africa. *Agricultural Economics,* 40: 535-550. 305-314.

Alexandratos, N., &Bruinsma, J. (2012).*World agriculture towards 2030/2050: The 2012 Revision* (ESA Working Paper No. 12-03). Rome: Food and Agriculture Organization of the United Nations (FAO), Agricultural Development Economics Division.

Amemiya, T. (1985).*Advanced Econometrics*.T.J press, Padstow Ltd. Great Britain Basingstoke. Rogers, E.M.1983. Diffusion of innovations: New York: The Free Press. *Pp 1-5.*

Atupokile, M. (2016). Adoption of improved maize varieties in northern and Eastern zones of Tanzania (Doctoral dissertation, Sokoine University of Agriculture).

Bezabih Emana (2000). The Role of New Varieties and Chemical Fertilizer Under Risk: The case of Mana and KersaWoredas. MSc Thesis. Alemaya University. Ethiopia. Case of Small Holders in Eastern Oromia, Ethiopia.PhD Dissertation, University of Hannover, Shaker Verlung. Germany.

Bezabih, Tariku, (2012). Study On the Intensity and Adoption of Improved Wheat Varieties and Associated Agronomic Practices In Kaffa Zone, The Case Of GeshaWoreda (Doctoral dissertation, St. Mary's University).

Bewket, W. 2007. Soil and Water Conservation Intervention with Conventional Technologies in Northwestern Highlands of Ethiopia: Acceptance and Adoption by Farmers. Land use Policy, 24:404-416.

Biftu, A., Diriba, B., Bayisa, T., and Getachew, F. (2016). Participatory Demonstration and Evaluation of Bread Wheat Technologies: The experience of FRG approach in Bale and West Arsi zones of Oromia national regional state, Ethiopia. Scientific Journal of Crop Science, 5(3): 90-103.

Burstin J, Gallerdo K, Mir RR, Varshney RK, Due G(2011), *Improving protein content and nutritional quality*. In: A Pratap, J Kumar (eds) biology and breeding of food legumes, chapter 20.

CSA (Central Statistical Agency) (2016). Agricultural sample survey 2015/16 (2008E.C): volume v- report on area, production and farm management practice of belg season crops for private peasant holdings. Statistical Bulletin, Central Statistical Agency, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency) 2018. Agricultural sample survey 2017/18 (2010E.C): volume I- report on area and production on major crops of meher season for private peasant holdings. Statistical Bulletin, Central Statistical Agency, Addis Ababa, Ethiopia.

DataStar, (2008). What Every Researcher Should Know About Statistical Significance.http://www.surveystar.com/news/oct2008.htm

Degnet Abebaw, Belay Kassa, AregayWaktola (2001). Adoption of high-yielding maize varieties in Jimma Zone: Evidence from farmers' level data. Ethiopia. *J. of Agri. Economics.* 5 (1&2): 4162, Feb.2001.

Demel Teketay (1999). History, Botany and Ecological Requirement of Coffee.The Ethiopian Wildlife and Natural History. No. 20: 28-50.

Dereje Derso, Edo Elemo and Yenesaw Sawnet, (2016). Determinants of the utilization of agricultural inputs and transfer of agricultural technologies. *Journal of Agricultural Research and Development* Vol. **6(2).** pp. 030-033, August, 2016

Deressa, Temesgen, Rashid M. Hassan, Tekie Alemu, Mahmud Yesuf, and Claudia R. (2008).Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia. Intl Food Policy Res Inst.

Düvel, G.H, (1991). Towards a model for the promotion of complex innovations through programmed extension. S. Afr. J. Agric. Extension. 20: Pp 70-86.

Duvel, G.H. and Botha, A.J., (1999). Human Constraints to Sustainable Agriculture in the Arid Regions of South Africa. The journal of Agricultural Education and Extension, 6(1): 47-60.

Fabiyi, and Hamidu, B.M., (2011). Adoption of improved technologies in soybean processing and utilization in Tafawa Balewa LGA of Bauchi State, Nigeria.*African J. Food, Agric., Nut. Dev*, *11*, pp.4460-4475.

Endrias Geta (2003). Adoption of improved sweet potato varieties in Boloso Sore woreda, south Ethiopia, M.Sc. Thesis, Alemaya University, Ethiopia.

Enters, T., (1996). Adoption: Section review. In Soil Conservation Extension from concepts to Adoption. Soil and Water Conservation Society of Thailand. 399 – 403. Ethiopia.

EPA (2008). United States Environmental Protection Agency Determination Upon Review of Amended Florida Administrative Code Chapter 62-303 Identification of Impaired Surface Waters. Appendix A. Binomial Statistical Test. February 13, 2008. https://archive.epa.gov/pesticides/region4/water/wqs/web/pdf/epa_iwr_decdoc_2-19-08.pdf

Feder, L., R.E., Just and O., Zilberman, (1985). Adoption of Agricultural Innovation, in Developing Countries: A Survey, Economic Development and Cultural Change, 32(2): 255- 298.

Fenta, M., (2017).Adoption of improved chickpea technologies in North Gondar zone of Ethiopia: The case of Gondar Zuria District (Doctoral dissertation, University of Gondar).

Fliegel, F.C., (1984). Extension Communication and the Adoption Process. In: FAO. A reference manual, 2nd ed. Rome.

Getahun Degu (2004). Assessment of Factors Affecting Adoption of Wheat Technologies and Its Impact: The Case of Hula Woreda, Ethiopia. MSc. Thesis (Unpublished) Presented to School of Graduate Studies of Alemaya University.

Giger, M.linger, H.P.Critchley, W,.(1999). Use of direct incentives and profitability of Soil and Water conservation in Eastern and Southern Africa. Preliminary analysis of WOCAT data, New Delhi.Gockowski, J. and Ndoumbe, M., 2004.The Adoption of Intensive Mono-Crop Horticulture Gujarati, D.N. (1995).Basic Econometrics. Third Edition. International Editors.

Gurmu, F. (2010).Overview of Soybean Research in Ethiopia. Hawassa: SARI

Habtemariam Abate (2004). The comparative Influence of Intervening variable in the adoption of Maize and Dairy Farmers in Shashemene and Debrezieit, Ethiopia.PhD Thesis, University of Pretoria.

Hailu Beyene (2008). Adoption of Improved *Teff* and Wheat Production Technologies in Crop Livestock Mixed Systems in Northern and Western Shewa Zones of Ethiopia. University of Pretoria, Faculty of Natural and Agricultural Science.

Haji Biru, (2003).Adoption of crossbred dairy cows in Aris Zone, The case of Tiyo and Lemu Bilbilo Woreds. M.Sc Thesis AU.

Hassen Beshir, Bezabih Emana, Belay Kassa and Jema Haji. 2012. Determinants of chemical fertilizer technology adoption in North Eastern highlands of Ethiopia: the double hurdle approach. *Journal of Research in Economics and International Finance,* 1(2): 39-49.

Heckman, J.J. (1979). Sample selection bias as a specification error. *Econometrica: Journal of the econometric society*, pp.153-161.

Heckman, J.J.(2008). Schools, skills, and synapses. *Economic inquiry*, *46*(3), pp.289-324.

IATP, (1995)."Coffee Hand Book" Manual prepared by International Agricultural Training Program and Coffee Improvement project, Addis Abeba Improved Dairy Technologies. Ethiopian Journal of Agricultural economics. 1: 11-17 in Southern Cameroon. Elsevier

B.V: Younde, Cameroon. Http://Www.Worldcocoafoundation.Org. IPMS, 2005 Dale Woreda Pilot Learning Site Diagnosis Survey Report.

IFC. (2013). *working with Smallholders: A hand for Firms Building Sustainable Supply Chains*. Washington D.C: International Finance Corporation, World Bank Group.

IITA (2009) International Institute of Tropical Agriculture, International Institute of Tropical Agriculture (IITA) 2009.lbadan. Nigeria. ISBN 978-131-333-1 Ijere, M.O, (1992) Leading Issues in Rural Development. Enugu Acena Publishers, Pp.1-8.

Itana Ayana (1985). An analysis of factors affecting the adoptions of packages of agricultural technologies in subsistence agriculture.A case study in two Extension Districts of Ethiopia. MSc. Thesis. Alemaya University. Ethiopia.

Jaleta, Moti, Chilot Yirga, Menale Kassie, Hugo De Groote, and Bekele Shiferaw (2013).Knowledge, adoption and use intensity of improved maize technologies in Ethiopia (No. 309-2016-5268).

Johnston, J. And Dinardo, J. (1997).Econometrics Methods. Fourth Edition. The McGraw-Hill Companies, Inc, New York.

Kansana, H.S., Sharma, R.P., and Sharma, S.K., (1996). Knowledge and Adoption of Wheat Technologies among Contact and Non-Contact Farmers. Agricultural Science, Digest Karnal, 16:154-156.

Kedir Bati (1998). The Role of SG2000 Project Credit System in The Adoption of Wheat Technologies By Smallholder Farmers in Ethiopia. The case of Hetosa Disrict.M. Sc. Thesis, Sokoine Agricultural University, Morongono, Tanzania.

Musba Kedir (2017). Adoption and Impact of Improved Soybean (Belessa-95) Variety among Smallholder Farmers in Bambasi Woreda, Benishangul Gumuz Regional State (Doctoral dissertation, Haramaya University)

Kidane Gebremariam (2001). Factors influencing the adoption of new maize varieties in Tigray, Ethiopia. The case of Hawzien Woreda. MSc Thesis. Alemaya University. Ethiopia.

Lakew Wondimu and Mohammed Edris (2013). Are fertilizers and improved seeds complimentary or substitute in the process of adoption: case study of northern Ethiopia.Wudpecker journal of agricultural research. Vol.2 (11), pp.286-293.

Leathers, H.D., and M.Smale, (1991).Abyssinian approach to explaining sequential adoption of components of a technological package. American Journal of Agricultural Economics, 73(3):734 – 742.

Legesse Daddi. (1998). Adoption and Diffusion of Agricultural Technologies: The case of East and West Shoa Zones, Ethiopia, A Thesis Submitted to the University of Manchester for the degree of Doctor of Philosophy in the Faculty of Economics and Social Studies, School of Economic Studies.

Legesse Dadi (2004). Agricultural Research and Technology Development in Ethiopia.

Legesse Dadi. (1992). Analysis of factors influencing adoption and the impact of wheat and maize technologies in Arsi Negelle Area, Ethiopia. MSc Thesis. Alemaya Agricultural University.

Lelissa Chalchissa and Mulat Demeke (2002).The Determinants of Adoption and Intensity of fertilizer use in Ejere District, West Shoa Zone, Ethiopia, Institute of Development Research (IDR), Addis Ababa.

Lelissa Chalichissa (1998). The Determinants of Adoption, Intensity and profitability of fertilizer Use. The Case of Ejere district, West Shoa Zone. M.Sc. Thesis. Addis Ababa University.

Loevisohn, M., Sumberg, J. and Diagne, A. (2012). Under what circumstances and conditions does adoption of technology result in increased Agriculture productivity? London: EPPI Center, Social Science Research Unit, Institute of Education, University of London.

Louw, G. and Duvel, G.H., (1993). The Adoption of Old man Saltbush (Atriplex Nummularia) Influenced by an Extension Programme. South African Journal of Agricultural Extension, 29-37.

MEDAC (1999).Survey of the Ethiopian Economy. Review of the post reform development (1992/93 – 1997/98). Addis Ababa, Ethiopia.

Melaku Gorfu (2005). Adoption and Profitability of Kenyan Top Bar Hive Beekeeping Technology. Study in Ambasal Woreda of Ethiopia. Msc. Thesis (Unpublished) Presented to School of Graduate Studies of Alemaya University.

Meseret Wondimu (1998). The Genetic Diversity of Ethiopian Coffee. Kaffa Coffee: 25-30. Addis Ababa, Ethiopia.

Mesfin Astatkie (2005). Analysis of factors Influencing Adoption of Triticale and its Impact. The Case Farta Wereda.Msc. Thesis (Unpublished) Presented to School of Graduate Studies of Alemaya University.

Million Tadesse and Belay Kassa (2004). Determinants of Fertilizer Use in Gununo Area, Ethiopia. Proceedings of the workshop held to discuss the socio-economic research results of 1998-2002. August 6-8, 2002, Addis Ababa, Ethiopia. Pp 30.EARO, 2004.

Miruts Fitsum (2016). "Analysis of the Factors Affecting Adoption of Soybean Production Technology in Pawe District, Metekele Zone of Benshangul Gumuz Regional State, Ethiopia." World Scientific News **53**(3): 122-137.

Misari, S. M. and Idowu A. A. (1995) “Soya bean in Nigerian Agriculture and strategies for sustainable production”, A paper presented at the 16th Annual Conference of Nigeria Soya bean Association.

MOA (1974) changed by Belay, 1999 cited in Trends and Determinants of Fertilizer Use in Gozamin Woreda, Amhara Region MSc. Thesis in Agricultural Economics by Teferi Wondale, April 2003.

Mulugeta Enki, Belay Kassa and Legesse Dadi (2001).Determinants of Adoption of Soil Conservation Measures in Central Highlands of Ethiopia. The Case of Three Districts of North Shoa.

Mulugeta Mekuria (1994). An Economic Analysis of Smallholder Wheat Production and Technology Adoption in the South Eastern Highlands of Ethiopia.PhD. Thesis, Michigan State University.

Mulugeta Alemitu (2011). Factors affecting adoption of improved Haricot bean varieties and associated agronomic practices in *Dale woreda, SNNPRS* (Doctoral dissertation, Hawassa University).

Mustapha, S. B., Makinta, A. A., Zongoma, B. A. and Iwan, A. S. (2012): “Socio-Economic Factors Affecting Adoption of Soya Bean Production Technologies in Takum Local Government Area of Taraba State, Nigeria”, Asian Journal Agriculture and Rural Development, Vol. 2, No. 2, pp. 276-281.

Nkonya, E. T Schroeder and D. Norman (1997). Factors Affecting Adoption of Improved Seed and Fertilizer In Northern Tanzania. Journal of Agricultural Economics.4: 1- 12.

Okereke, H.E. (1983): The role of extension technology development and transfer. Proceedings of a training workshop on rural agricultural extension.NRCRI, Umudike, Nigeria.Pp 79 – 82

Oxfam International (2002).Crisis in the Birthplace of Coffee. Oxfam International Research Paper. September 2002. Addis Ababa.

Presser, H. A., (1969).Measuring Innovativeness rather than Adoption. Rural Sociology, 34 (4): 510-527.

Proceedings of the workshop held to discuss the socio-economic research results of 1998- 2002. August 6-8, 2002, Addis Ababa, Ethiopia. EARO, 2004.

RAO (2007) (Regional Agricultural Office) Report 2006/2007 Awassa, Ethiopia

Ren'e Coste, 1992.Coffee the Plant and The Product. The Macmillan press Ltd, London and Rogers, E.M., 1995. Diffusion of Innovations, New York: Free Press.

Samuel, D., Asfaw, E B. and Anteneh, M., (2017).Factors affecting adoption and degree of adoption of soybean in Ilu-Ababora Zone; Southwestern Ethiopia. *Agricultural Science Research Journal*, *7*(1), pp.15-26.

Samuel., H. De Groote, et al. (2016). Effect of nutritional information and sensory quality on the willingness to pay for quality protein maize-results of a field experiment in Jimma zone, Ethiopia.2016 AAAE Fifth International Conference, September 23-26, 2016, Addis Ababa, Ethiopia, African Association of Agricultural Economists (AAAE). Southern Africa. University of Stellenbosch, Southern Africa, 14-18 September 1998.

Shiferaw, B., Okello, J., and Reddy, R. 2009. Adoption and Adaptation of Natural Resource Management Innovations in Smallholder Agriculture: Reflections on key Lessons and Best Practices. Environ Dev Sustain, 11:601-619.

Simtowe F., Solomon Asfaw, and Tsedeke Abate (2016). Determinants of Agricultural Technology Adoption under Partial Population Awareness: The Case of Pigeonpea in Malawi. *Agricultural and Food Economic*, 4:7.

Sisay Debebe. 2016. Agricultural technology adoption, crop diversification and efficiency of maize-dominated smallholder farming system in Jimma Zone, South-Western Ethiopia. PhD Dissertation, Haramaya University, Ethiopia.

Solomon Asfaw and Bekele Shiferaw. (2010). Agricultural technology adoption and rural poverty: Application of Endogenous Switching regression for selected East African countries. Poster Presented at the joint 3rd African Association of Agricultural Economics (AAAE): 19-23.

Swanson, B.E. (1996): Strengthen research extension farmers linkage: In Adekoya, A.E. and Tologbonse, E.B. edition. Agricultural Extension in Nigeria. Published by Agricultural and Rural Development Training Institute (ARMTI), Ilorin, Kwara State, Nigeria. 28 – 35.

Tegegne, Y.I.T.B.A.R.E.K., (2017). Factors affecting adoption of legume technologies and its impact on income of farmers: The case of Sinana and Ginir Woredas of Bale Zone (Doctoral dissertation, Haramaya University).

Tesfaye Zegeye, Girma Taye, D.Tanner, H.Verkuijl, Aklilu Agidie, W. Mwangi (2001).Adoption of Improved Bread Wheat Varieties and Inorganic Fertilizer by mall-scale Farmers in Yelmana Densa and Farta Diatricts of Northwestern Ethiopia. Mexico, D.F.: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improvement Center (CIMMYT).

Tewodaj, M., Cohen, M. J., Birner, R., Lemma, M., Randriamamonjy, J., Tadesse Fanaye and Paulos Zelekawork. 2009. *Agricultural extension in Ethiopia through a gender and governance lens*. *Ethiopia Strategy Support Program 2 (ESSP2*).Discussion Paper No.

Tolesa Alemu, Bezabih Emana, Jema Haji, and Belaineh Legesse (2014).Impact of Wheat Row Planting on Yield of Smallholders in Selected Highland and Lowland Areas of Ethiopia. An Agricultural Marketing Project (AAMP). *International Journal of Agriculture and Forestry*, 4(5): 386 – 393.

Tolesa Alemu. 2014. Socio-economic and Institutional Factors Limiting Adoption of Wheat Row Planting in Ethiopia. Ethiopian Institute of Agricultural Research, Kulumsa Agricultural research Center.

UNDP (United Nations Development Program), OECD (Organization for Economic Cooperation and Development) and AFDB (African Development Bank) (2016).*African Economic Outlook, Ethiopia*.Report.

UNDP (United Nations Development Program). 2015. *Ethiopia: Key economic and social indicators*. Report No. 2, 2015, UNDP Ethiopia, Addis Ababa, P.O.Box 5580.

Uwagboe, E. O., Akinbile, L. A. and Oduwole, O. O. 2012. Socio-economic factors and integrated pest management utilization among Cocoa farmers in Edo State. *Academic Journal of Plant Sciences*, 5: 07-11.

Van Den Ban, A.W. and Hawkins (1998).Agricultural Extension (2nd Ed.).Black well Science.The Netherlands. pp249.

Wondimagegn Mesfin. Bekabil Fufa, and Jema Haji. 2011. Pattern, Trend and Determinants of Crop Diversification: Empirical Evidence from Smallholders in Eastern Ethiopia. *Journal of Economics and Sustainable Development,* 2(8).

Yamane, T. (1967).*Statistics: An Introductory Analysis, 2nd Ed*. New York: Haper and Row.

Yenealem Kassa, Ranjan S. Kakrippai and Belaineh Legesse. 2013. Determinants of adoption of improved maize varieties for male headed and female headed households in West Harerghe Zone, Ethiopia. *International Journal of Economic Behaviour and Organization,* 1(4): 33-38.

Yishak Gecho and Punjabi N.(2011).Determinants of Adoption of Improved Maize Technology in Damot Gale, Wolaita, Ethiopia.

Yu, B., Nin-Pratt, A., Funes, J., and Asrat, S. 2010. Cereal Production and Technology in Ethiopia.Discussion Paper 12. Washington, D.C. International Food Policy Research Institute.

Zinaw D, Seltene A, Addisu G (2013). Genetic variability and heritability of soybean (*Glycinemax*(L.) Merrill) genotypes in Pawe district, Metekel zone, Benishangul Gumuz regional state, northwestern Ethiopia. Wudpecker J. Agric. Res., 2(9): 240-245.

7. APPENDICES

Appendix Tables

Appendix Table 1: Conversion Factor used to calculate Adult Equivalent (AE)

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

source: Storck, et al. (1991)

Appendix Table 2: Conversion Factor for Tropical Livestock Unit (TLU)

Animal category	Tropical Livestock Unit (TLU)
Ox/Cow	1.0
Weaned	0.34
Calf	0.2
Heifer	0.75
Horse/mule	1.1
Donkey	0.7
Poultry	0.02
Goat/sheep	0.13

Source: Storck, et al. (1991)

Appendix Table 3: Variance inflation factor for continuous explanatory variables

Variable	VIF	1/VIF
EDHH	1.39	0.719213
TLUHH	1.35	0.739694
CWEA	1.28	0.781262
ADLE	1.27	0.785053
FMICMHH	1.22	0.818271
AGHH	1.19	0.837353
DFM	1.14	0.879820
OFFMINC	1.13	0.885857
TLSHH	1.11	0.900000
Mean VIF	1.23	

Source: survey data model output

Appendix Table 4: Contingency coefficient for dummy variables

correlate SHH PHH ISA MCPS HPIFD UFCRD

(obs=188)

Variables	SHH	PHH	ISA	MCPS	HPIFD	UFCRD
SHH	1.0000					
PHH	0.0257	1.0000				
ISA	0.1118	0.1604	1.0000			
MCPS	-0.0963	0.0336	-0.0042	1.0000		
HPIFD	-0.0571	0.6073	0.2917	0.1996	1.0000	
UFCRD	0.0011	-0.1338	-0.1199	0.0244	-0.2413	1.0000

Source: survey data model output

Apendix Table 5: Heckman selection model -- two-step estimates (regression model with sample selection)

Heckman selection model -- two-step estimates Number of obs =188 Uncensored obs =97

(Regression model with sample selection) Censored obs =91

	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval]
ISAT					
AGHH	.005318	.0028016	1.90	0.058	-.0001732 .0108091
SHH	.0761447	.087041	0.87	0.382	-.0944525 .2467419
ADLE	-.0069744	.0174729	-0.40	0.690	-.0412206 .0272717
EDHH	.0002286	.011385	0.02	0.984	-.0220856 .0225428
TLUHH	-.0099252	.0079576	-1.25	0.212	-.0255217 .0056713
TLSHH	.0444973	.0167468	2.66	0.008	.0116742 .0773205
PHH	.0266631	.0762285	0.35	0.727	-.1227419 .1760682
CWEA	.0001696	.0156781	0.01	0.991	-.030559 .0308982
OFFMINC	4.10e-06	.0000108	0.38	0.704	-.0000171 .0000253
DFM	-.0385729	.0208732	-1.85	0.065	-.0023377 .0794836
MCPS	-.0582081	.0658048	-0.88	0.376	-.1871832 .070767
HPIFD	.0141918	.0774075	0.18	0.855	-.1375241 .1659078
UFCRD	.0366493	.0595618	0.62	0.538	-.0800897 .1533883
FMICMHH	.0000124	5.01e-06	2.48	0.013	2.62e-06 .0000223
_cons	-.0565599	.2195632	-0.26	0.797	-.4868959 .373776
AST AGHH	-.024196	.0172996	-1.40	0.162	-.0581026 .0097106
SHH	.6378616	.4088926	1.56	0.119	-.1635533 1.439276
ADLE	.1429476	.1018701	1.40	0.161	-.0567142 .3426094
EDHH	.1891306	.0571105	3.31	0.001	.0771961 .3010651
TLUHH	.1194688	.0492304	2.43	0.015	.02297 .2159585
TLSHH	.0597716	.0853542	0.70	0.484	-.1075195 .2270627
PHH	.6107888	.4852935	1.26	0.208	-.3403689 1.561947
ISA	.800494	.4381265	1.83	0.068	-.0582182 1.659206
CWEA	.2757271	.096533	2.86	0.004	.0865259 .4649283
OFFMINC	-.0000974	.0000648	-1.50	0.133	-.0002243 .0000296
DFM	-.3599084	.0858427	-4.19	0.000	-.528157 -.1916597
MCPS	.0445802	.3022086	0.15	0.883	-.5477378 .6368981
HPIFD	-.2204094	.5029393	0.44	0.661	-1.206152 .7653334
UFCRD	.5629946	.3023582	1.86	0.063	-.0296167 1.155606
FMICMHH	.0000732	.0000262	2.80	0.005	.0000219 .0001245
_cons	-1.20237	1.092466	-1.10	0.271	-3.343564 .9388246
mills lambda	.2459296	.0949771	-2.59	0.010	-.4320813 -.0597778
rho -1.00000 sigma .24592956					

Source: survey data model output

Appendix Table 6: Average marginal effect margins,dydx(AGHH SHH ADLE EDHH TLUHH TLSHHPHH ISA CWEA OFFMINC DFM MCPS HPIFD UFCRD FMICMHH)expression(xb(AST))

Average marginal effects Number of obs = 188

Model VCE : Conventional

Expression : normal,(xb(AST))

dy/dx w.r.t. : AGHH SHH ADLE EDHH TLUHH TLSHH PHH CWEA OFFMINC DFM MCPS HPIFD UFCRD FMICMHH ISA

Variables	Delta-method				
	dy/dx	Std. Err.	Z	P>z	[95% Conf. Interval]
AGHH	-.024196	.0172996	-1.40	0.162	-.0581026 .0097106
SHH	.6378616	.4088927	1.56	0.119	-.1635533 1.439276
ADLE	.1429476	.1018701	1.40	0.161	-.0567142 .3426094
EDHH	.1891306	.0571105	3.31	0.001	.0771961 .3010651
TLUHH	.1194688	.0492304	2.43	0.015	.022979 .2159585
TLSHH	.0597716	.0853542	0.70	0.484	-.1075195 .2270627
PHH	.6107888	.4852935	1.26	0.208	-.3403689 1.561947
FEC	.2757271	.096533	2.86	0.004	.0865259 .4649283
OFFMINC	-.0000974	.0000648	-1.50	0.133	-.0002243 .0000296
DFM	-.3599084	.0858427	-4.19	0.000	-.528157 -.1916597
MCPS	.0445802	.3022086	0.15	0.883	-.5477378 .6368981
HPIFD	-.2204094	.5029393	-0.44	0.661	-1.206152 .7653334
UFCRD	.5629946	.3023582	1.86	0.063	-.0296167 1.155606
FMICMHH	.0000732	.0000262	2.80	0.005	.0000219 .0001245
ISA	.800494	.4381266	1.83	0.068	-.0582183 1.659206

Source: survey data model output

Appendix Table 7: Ranking of the constraints hinder adoption and intensity of soybean production adoption technologies by sampled respondents

List of constraints in soybean technology adoption	Rank	TWS	Rank scores of constraints							
			1	2	3	4	5	6	7	8
High cost of inorganic fertilizer	1	316	84	98	2	0	0	0	2	2
Lack of credit for input	2	427	82	64	16	6	2	0	8	10
High interest rate on credit	3	699	6	7	53	75	41	3	3	0
Poor quality of soybean seed	4	771	0	2	68	48	55	9	6	0
Rain fall fluctuation	5	817	3	5	18	76	78	1	6	1
Lack of knowledge on soybean production technologies	6	1145	0	1	5	4	6	128	34	10
Lack of oxen	7	1219	11	8	3	1	4	26	77	58
Poor transportation system	8	1378	2	2	0	2	1	18	53	110

Source: Own survey result of 2018/2019

Appendix: **The questionnaire used for the survey**

This survey questionnaire is prepared for the study entitled Factors affecting adoption of soybean production technologies by smallholder farmers in Tiro Afeta district, Oromia regional state of Ethiopia.

INTERVIEW SCHEDULE

TITLE: FACTORS AFFECTING ADOPTION OF SOYBEAN PRODUCTION TECHNOLOGY IN TIRO AFETA WOREDA, JIMMA ZONE OF OROMIA REGIONAL SATATE

1. GENERAL INFORMATION

1.1. Questionnaire Ser.No: _______ **1.2.** Date of interview (DD/MM/YYY): _________

1.3. Peasant Association (Kebele) ____

1.4. Name of respondent____

1.5. Name of Enumerator______________________________Signiture____________

2. HOUSEHOLD PERSONAL AND DEMOGRAPHIC CHARACTERISTICS

No	**Household Characteristics**	**Answer**
2.1	Name of household head	
2.2	Age of the household head in (yrs)	
2.3	Sex of the household head. (1,male 2, female)	
2.4	Education level of the household head (in grade)	
2.5	Family size in adult equivalent(AE)	

Demographic Characteristics

2.9. Number of family members by sex and age Composition

No	**By age category**	**By Sex category**	
		Male	**Female**
1	<10		
2	10-13		
3	14-16		
4	17-50		
5	>50		
	Total		

3. Socio economics Characteristics

3.1. Please fill the following table about land holdings during 2010/11E.C agricultural season in hectare

Land Ownership	Total area in Hectare	Cultivated Land area in hectare	Fallow land	Rented out Land area	Other Source
Own					
Rented out					
rented in					
Other					
Total					

3.2. From your total hectare of crop production, how many hectares you allocate for soybean crop production (improved seed)? ___________________ha

3.3 If you use improved seed technology for soybean production in 2010/11 E.C, how many hectares you allocate for soybean improved seed from total area of soybean?

Please specify it___________________ha.

3.4. What are the major crops you cultivate in your farm for 2010/11 cropping season? Please fill the requested information here below:

Crops grown	**Area coverage (ha)**	**Amount produced in** (qt.)	**Amount to be used for**			
			seed	Food	Sale	Price
Soybean						
Maize						
Sorghum						
coffee						
Ground nut						
Wheat						
Others(specify)						

3.5. Do you practice rearing livestock? 1. Yes 2. No

3.5. If yes, Q 3.5, fill the table bellow

Class of livestock	Number owned			Amount sold last year(2010 E.C)		Unit price		Total price
	Local	Improved	Total	Local	Improved	Local	Improved	
Cows								
Oxen								
Heifers								
Bulls								
Calves								
Sheep								
Goats								
Donkeys								
Horses								
Mules								
Poultry								

3.5.1. Could you get income from your agricultural production? 1. Yes 2.No

3.5.1.1. If the answer of question number 4 is yes, how much income did you get annually from your agricultural production? ________in birr

3.5.1.2. What is your annual expenditure from your agricultural production? _____in birr

3.6. Do you participate on work outside agriculture/off-farm activities in 2010/11 E.C? 1, Yes 2, No

3.6.1. If yes, who participates in off-farm activity? Specify name of participant and number of days spent in a year ___________days

3.6.2.If yes in question no3.6, how many birr do you get from off-farm income annually? ____

3.6.3 If "yes" questions #3.6.1, do you earn income from the activities? 1, Yes 2, No

3.6.4. If "yes" questions #3.6.2, for what purpose you use the income you earn from the Activities? 1) To buy agricultural inputs like fertilizers, improved seed 2) To purchase

Oxen 3) for household consumption 4) To construct house 5) To pay other debit 6) all 7) if other, please specify________________

3.6.5. If "yes" questions #3.6.2, what is/are your source of income outside agriculture/off-farm activities? 1, Paid daily labor 2, Petty trade 3, Handcraft 4, other, specify__________________

4. Institutional Factors

Membership participation

4.1 Do you participate as member in cooperative societies? 1) Yes 2) No

Credit use

4.3. Is credit service available in the area? 1) Yes 2) No

4.4. Have you used credit during 2010/11E.C cropping calendar? 1) Yes 2) no

4.5. If yesQ4.4, which category? 1) Cash 2) kind

4.6. From whom did you get credit? 1) Bank 2) NGO 3) Friends \relatives
4) Local organizations 5) Cooperative 6) saving and credit 7) others, specify

4.7. If yes Q4.4, what is the amount of credit you got? ______

4.8. Procedures/ Conditions for getting credit? 1) _________ 2) _________ 3)___________

15. If no to Q4.4, why? 1) I didn't need it/Self finance 2) it was inaccessible 3) no financial institutions

Extension contact

4.9. Did you get advisory services from extension agents in 2010/11 E.C? 1) Yes 2) No

4.10. If yes Q4.9, have you received advice in soya bean production? 1) Yes 2) no

4.11. If yes Q4.10, how many times were you visited by the extension workers with information on Soybean production during the 2010/11 farming seasons?
1) Once in a year 2) twice a year 3) Monthly 4)bi-weekly 5)Weekly 6) not at all

4.12. During which farm operation extension agent visit you?

1) Land preparation 2) During input provision 3) during sowing 4) Whenever disease/pest occur 5) during credit collection 6) any time 7) others, __

4.13. Did you visit extension agents by yourself? 1) Yes 2) No

Availability of improved soybean seed

4.14. When you did first hear of improved variety of soybean? _______year

4.15. Do you need improved soybean variety of technologies? 1, Yes 2, No

4.16. If yes Q4.15, is their availability of improved soybean seed with time and required quantity during cropping season in the district? 1, Yes 2, No

4.17. If yes Q4.16, do you have access in last years? 1, Yes 2, No

4.18. From where did you get improved soybean seed?

1, BOA _________ 2, Research centre ______ 3, Own source _________

4, Market ________ 5, Neighbors______ 6, NGO _______7, others, specify

4.19. Have you ever used improved soybean variety technology during 2010/11 E.C cropping season? 1, No 2, Yes

4.20. If you cultivate soya bean during 2010/11, frequency of weeding? _________

4.21. Did you face labor shortage in soybean production? 1) Yes 2) no

4.22. If yes, how do you solve labor shortage problem? 1) Hiring 2) Debo 3) assistance from relatives 4) other (specify)

4.23. If you face labor shortage, during which farm operation face labor shortage?

1. Land preparation 2) planting 3) weeding 4) harvest 5) storage 6) others (specify)

4.24. On which farm activities female family members participate? (in the order of importance)

1. _____________ 2. __________ 3. ___________

4.25. Do you have a plan to plant soybean in future? 1) Yes 2) no

4.26 If noQ4.25. why not?

1) Seed not available 2.) Lack of cash to buy seed 3) Low yielding variety

4) Lack of access to credit (seed) 5) other……

4.27. Is there production risk in soybean farming? 1) Yes 2) no

4.27. What are your problems in soybean farming? 1) ______________

2) _______________ 3) ______________

4.28. Do you think that there is risk regarding market value? 1) Yes 2) no

4.29. How do you perceive the production cost of soybean 1) low 2) moderate 3) high?

Market distance

4.30. Does your home near to the market center? 1, Yes 2, No

4.31. How many kilo maters is the market far from your home? _____________km

4.32. Do you get market information about prices and demand conditions of agricultural? inputs and out puts? 1, Yes 2, No

4.33. If yes Q4.32, what is your source of information

1, Development agent 2, Traders 3, Neighbor farmers 4, Friends 5, Other…………….

1. Did you sell soybean last year? 1) Yes 2) No

4.34. If yesQ4.32 what is the average market price of soybean? (Birr/kg) _________

Price at farm gate	Price at market	To whom did you sell at farm? 1)Wholesaler 2)Retailer 3)consumers 4)Middlemen 5)Rural assembler	To whom did you sell at market? 1)Wholesaler 2)Retailer 3)consumers 4)Middlemen 5)Rural assembler
__________**birr/kg**	__________**birr/kg**	_______	_________

4.35. How did you transport your output? 1) Carrying 2) donkey 3) cart 4) trucks

4.36. What is the trend in market price? 1) Decreasing 2) normal 3) increasing

4.37. Which months of the year had the higher price for soya bean? ___________

4.38. Compare price of soya bean with alternative crops that you can grow? 1) Motivated2) demotivated

4.39. How long do you store soybean? _______months

4. 40. Time taken to reach the main market? _____min,

Participation in farmers' field day

4.41. Have you participated in farmers' field day? 1) Yes 2) Broadcasting)

4.42. If yesQ4.41, how many times------------------and who arranged for you?

1) BoA 2) Research 3) NGO 4) Others, Specify

4.43. Do you implement the following improved technologies?

Practice used by farmers	1.yes	0. no
Frequency of land preparation (2-3 times)		
Planting time (1st June_ mid-June)		
Planting method (1.row planting)		
Weeding frequency (2-3 times)		
Rhizobium		

Intensity of adoption of improved soybean technologies in 2010/2011 E.C

Subject	**Name of soybean variety Grown**	**Area coverage in (ha)**	**Seed rate(kg)**	**Fertilizer rate(kg)**	
				NPS	**Other**
Total area					
Allocated for soybean improved seed	Clarck 63k				
	Sc1				
Allocated for other	Other				

Farmers' perception to soybean technologies

Comparison of improved soybean technologies with local and traditional practices?

Technology	Attributes of technologies	Likert scale measurement					Compiled perception		
		Strongly Agree	Agree	Neutral	Dis agree	Strongly Agree	+ve	Neutral	-ve
Variaties	What do you think comparing improved and local varieties by attribute [..], improved is ?								

2	When comparing the yield of improved ,higher than the local								
3	The pod per plant of improved soybean varieties are more than local								
4	The improved varieties of soybean technologies disease and pest resistant than the local one								
5	Improved varieties of soybean grain is marketable than the local								
6	Improved soybean color is more attractive than the local								

Which of the following problems do you encounter in soybean production?

Constraints	Rank
High cost of inorganic fertilizer	
Lack of credit for input	
High interest rate on credit	
Poor quality of soybean seed	
Rain fall fluctuation	
Lack of knowledge on soybean production technologies	
Lack of oxen	
Poor transportation system	
Other…..	

CHECKLIST USED FOR CONDUCTING FOCUSED GROUP DISCUSSION

- How do you compare the advantage of improved soybean production technology with local one?
- How do you evaluate your kebeles regarding transport facilities in relation to access the main market?
- Where did you sell your soybean production?
- The level of benefits from soybean production. eg. Price per kg?
- Which month is recorded the highest price?
- How do you see farmers' motivation regarding soybean production?
- What are the major problems of soybean cultivation?
- How do you see the labor requirement of soybean production?
- How do you see farmers' participation in Non/Off farm activities and their income from these activities?

Interview checklist for key informants

1. When the soybean production technology is introduced to your district?

2. What is current performance of the soybean production technology on soybean in your district?

3. What are common problems faced by farmers while practicing soybean production Technologies and what actions have been taken to solve the problems for the farmers in the district?

4. What kind of support does district agricultural office is providing to improve the Adoption level of soybean production technology by farmers?