CENTER FOR RURL DEVELOPMENT
COLLEGE OF DEVELOPMENT STUDIES

# ADOPTION OF IMPROVED SOYBEAN VARIETIES AND THE IMPACT ON PRODUCTIVITY AND INCOME OF SMALLHOLDER FARMERS IN PAWE DISTRICT, BENISHANGUL GUMUZ REGION, ETHIOPIA

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**JUNE, 2024**
**ADDIS ABABA,**
**ETHIOPIA**

ADDIS ABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

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**ADDIS ABABA UNIVERSTIY**

**COLLEGE OF DEVELOPMENTAL STUDIES**

**CENTER FOR RURAL DEVELOPMENT**

## DECLARTION

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As a major advisor of this thesis, I certify that I have read and evaluated the thesis by Yaregal Fekadu Semachew entitled 'Adoption of Improved Soybean Varieties and the Impact on Productivity and Income of Smallholder Farmers in Pawe District, Benishangul Gumuz Region, Ethiopia' and recommended for open defense as fulfilling the requirements for the degree of Master of Art in Rural Livelihoods and development.

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As a member of examining board of this thesis open defense, we certify that we have read and evaluated the thesis prepared by Yaregal Fekadu Semachew entitled 'Analysis of Adoption Intensity, Impacts, and Determinants of Improved Soybean Varieties On Productivity and Income of Smallholder Farmers In Pawe Distrct, Benishngul Gumuz Region, Ethiopia' and recommend that it is acceptable as a thesis required for the degree of Master of Art in Rural Livelihoods and development.

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# DEDICATION

This thesis is dedicated to my beloved mother, Enkouahanech Amare; my father, Fekadu Semachew; my wife, Netsanet Ayele; my sons, Entons and Meqars Yaregal; my brother, Asefaw Workeneh; Ferew Shawul and Teshger Akenaw; my sister, Kassaye Muluye; and my uncle, Abebw Amare, for their unlimited moral encouragement and financial support.

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# LIST OF ACRONYMS AND ABBREVIATION

| | |
|---|---|
| **ATT**: | Average Treatment Effect |
| **ATU** | Average Treatment Effect on Untreated |
| **BCE** | Before The Common Era |
| **CC** | Contingency Coefficient |
| **CDF** | Cumulative Distribution Function |
| **CLR** | Classical Linear Regression |
| **CSA** | Central Statistics Agency |
| **DH** | Double Hurdle |
| **DOI** | Theory of Innovation Diffusion |
| **ESRM** | Endogenous Switching Regression |
| **ETB** | Ethiopian Birr |
| **FGD**: | Focus Group Discussion |
| **FHH** | Female Household Head |
| **GDP**: | Growth Domestic Product |
| **ISVs** | Improved Soybean Varieties |
| **LR** | Log Likelihood Ratio |
| **ILRI**: | International Livestock Research Institute |
| **KII**: | Key Informant Interview |
| **MHH** | Meal Household Head |
| **OLS** | Center Ordinary Least Square |
| **PARC** | Pawe Agricultural Research |
| **PSM**: | Propensity Score Matching |
| **RESET** | Regression Specification Error Test |
| **SNNPRS** | Southern Nation Nationalities and People Region |
| **TLU**: | Total Livestock Unit |
| **VIF**: | Variable Inflation Factor |

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# ABSTRACT

*This study aims to identify the determinants of adoption of improved soybean varieties in Pawe district, and subsequently assess the factors influencing the intensity of adoption of the technology. About, 308-sample households were selected using systematic random sampling techniques. The data were obtained mainly from a survey of sampled soybean grower households' via structured interview, and was supported by key informant interviews. Descriptive statistics, Chi-square, t-test, One-way ANOVA, and Double-hurdle model were employed to analyze the data. Two sets of determinants were found out by the results of the double hurdle model. First-hurdle of the double hurdle model result revealed the determinants of the adoption decision of improved soybean varieties that included frequency of extension contact, agricultural training, field day participation and annul income having positive effects on the stated variables. On the other hand distances to the market and farm size were found to be determinants that have negative effects. The second-hurdle result also denoted determinants with positive effects on adoption intensity of improved soybean varieties that include credit access, soybean productivity and TLU. The research also explored the perceptions of farmers on the technologies assessed. In view of this, it was found out that farmers perceived high yielding potential, branching, drought resistance, resistant to shattering character, marketability, seed size and better prices are the key attributes of improved soybean varieties, whereas straw biomass and disease resistant were perceived as less importance attributes. Finally, the ESRM result shows that, adoption of improved soybean varieties significantly increased the adopters' average improved soybean productivity/ha by* 2.365 *quintal and 13897.07 ETB net incomes respectively. Therefore, to achieve sustainable production with high value addition and a viable value chain for soybeans, growers should be given access to enhanced soybean technology together with fully recommended packages, and relationships between actors should be strengthened.*

***Key words**: Adoption; Double-hurdle; Soybean, Pawe, Endogenous switching regression model*

# CHAPTER ONE:  INTRODUCTION

## 1.1. Background of the Study

Agriculture is the leading sector in terms of its contribution to the overall economic growth, development and employment. It supplies food for local consumption and raw materials for domestic manufacturing industries. It accounts for nearly 46% of GDP and account about 70% of the raw material requirements of local industries. It also serves as the main source of food and generates 90% of the foreign exchange earnings. Having all these importance, agriculture continues to face a number of challenges that include adverse climatic conditions, lack of appropriate land use system resulting in soil and other natural resource degradation, limited use of agricultural technologies and the predominance of subsistence agriculture practiced by smallholder farmers, etc (Agency, 2014).

Grain legumes are an important component of agricultural crops and contributing to smallholder farmers' regarding improving nutrition security and income generation all over the world (Kebede, 2020). Among them soybean is the major legume crops worldwide (Bezabeh et al., n.d.). Soybean is become one of the most important commodities in the global markets and most commonly planted and used legume crop due to its valuable seed composition (Jia et al., 2020; Shea et al., 2020). The crop is the major source of oil and protein in the world and its demand increasing rapidly in Africa due to the increasing demand of food and feed processing industries (Murithi et al., 2016; Pagano et al., 2020). Soybeans designed as a major legume crop to ensure sustainable food security both for the current and future generations in Africa (Siamabele, 2021). Its productivity is much lower than the world's average productivity due to use of poor-performing varieties and limited application of fertilizer and other agronomic practices (Khojely et al., 2018).

Currently, the 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. As part of this, producing and consuming more soybeans is believed to improve the situation 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, in addition to its nutrition rich potential, 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 (Sopov, 2011).

According to the research result of Pawe Agricultural Research Center (2010), soybean can grow in Woina Dega and Kola areas of the country. Depending on its varieties, the crop grows in an altitude ranging from 700-1800, and rain fall amount ranging from 450-1500 mm. The temperature requirement of this crop is also expected to be between 23-25 °C and is seen to be ideal for growing the crop. Potential areas for soybean are: Southern Nations Nationalities People region, Oromia region, Benshangul Gumuze region (Metekel, Kamashe and Asosa areas); Amahara region and Tigray region are expected to have potentials and are seen as appropriate for soybean production.

Although soybean is largely grown in Ethiopia, its national average yield is low (19.98 quintal per hectare) which is below the global average, 23.1 quintal per hectare (Bezabih, 2010). 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 PARC (2010).

Different agricultural technologies have been developed and supported by extension services to promote their proper adoption in the country. Despite such interventions, the adoption of agricultural technologies in the study areas has been inadequate (Markwei et al., 2008). For example, land improving technologies such as improved seed, fertilizer, improved agronomic practices and natural conservation measures are not widely adopted in Ethiopia (Tadesse, 2010).

Likewise, in Pawe district, a number of soybean production enhancing technologies and practices have been extended to smallholder farmers under the auspices of extension system and supports from non-governmental organizations. Despite this, however, the distribution and utilization of the technologies has not been significant. There is a need for location-specific empirical information on the adoption of improved soybean production technologies and the various factors affecting these interventions, and related policy actions to improve the production of the crop.

### 1.2. Statement of the Problem

Despite the district's strong potential for Soybean production (agro ecologically), a lot of farmers continue to use old varieties that were released more than two decades ago. These types are becoming increasingly susceptible to disease, and their production is declining (because to rust concerns). Agricultural production and productivity can be increased not just through the development of enhanced technologies, such as improved crop varieties, but also through farmers' use of existing technologies. On the one hand, the Pawe Agricultural Research Centre (PARC) and the Ethiopian Institute of Agricultural Research (EIAR) have developed various high yielding and disease resistant enhanced Soybean varieties. The agricultural office and other agricultural organizations have widely performed demonstrations and popularization of the improved Soybean varieties to farmers in Pawe district in order to boost Soybean productivity and to increase smallholder farmer's income. Despite its better yield than previously released soybean varieties, the majority of farmers in the research district do not use the improved Soybean varieties. The majority of farmers grow soybean types that were introduced several years ago and have a lower yield.

Although soybean is largely grown in Ethiopia, its national average yield is low (19.98 quintal per hectare) which is below the global average, 23.1 quintal per hectare (Bezabih, 2010). 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 PARC (2010).

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 are not widely accepted by farmers in different parts of the county as expected (Markwei et al., 2008).

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 recommended improved soybean production technologies are not yet well understood. The level of adoption of the recommended 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., 2009). Therefore, the main focus of this study was adoption of improved Soybean varieties and the impact on productivity and income of smallholder farmers in the study area.

## 1.3. Objectives of the Study

### 1.3.1. General Objective:

The overall objective of this study is Adoption of Improved Soybean Varieties and the Impact on Productivity and Income of Smallholder Farmers in Pawe District, Benishangul Gumuz Region, Ethiopia and to document information and recommendations for policy makers.

### 1.3.2. The specific objectives are:

1) Analyze adoption intensity determinants of improved Soybean varieties in the district
2) Examine determinants of adoption of improved Soybean varieties in the district
3) Explore farmers' perception of towards improved Soybean varieties
4) Analyze the impacts of improved Soybean varieties productivity and income of smallholder farmers in the district

### 1.4. Research question

- What is the current status of adoption of improved Soybean varieties in the study area?
- What are determinant of adoption of improved Soybean varieties in the district?
- What are determinant of adoption intensity of improved Soybean varieties in the district?
- What do farmers perceive towards attributes of improved soybean varieties?

### 1.5. Scope and delimitation of the study

The purpose of the study is to identify the factors that influence adoption of improved soybean varieties and its impacts on smallholder farmer's soybean productivity and income. As a result, the data generated will only be used within the district and will not be extrapolated to include nearby districts

### 1.6. Significance of the study

This study aims to assess the elements that smallholder farmers in the Pawe district consider when deciding whether to adopt new soybean technology. An in-depth knowledge of their adoption in a diverse environment is necessary to design effective strategies to capitalize on the potential benefits of improved varieties in target domains. The findings of this study can be used by researchers and extension workers involved in the development and transfer of production technology to set research and extension agendas. The evaluation is necessary in order to better inform policymakers about the contributions of soybean varieties. It contributes to the learning of good lessons about the effectiveness of existing approaches to development and poverty reduction, which improves the targeting of research programs. Smallholder soybean farmers benefit from the promotion of the adoption and introduction of new agricultural technologies. Other similar studies will benefit from the information produced by this investigation

# CHAPTER TWO: REVIEW OF RELATED LITERATURE

## 2.1. Operational Definition of Concepts

Soybean, (Glycine Max), also called Soybean, annual legume of the pea family (fabaceae) and its edible seed. The soybean is economically the most important bean in the world, providing vegetable proteins for millions of people and ingredients for hundreds of chemical products. The origins of soybean plant are obscure, but many botanists believe it was first domesticated in central china as early as 700 BCE. An ancient crop, the soybean has been used in china, japan, and Korea for thousands of years as a food and component of medicines. Soybeans were introduced in to the United States in 1804 and became particularly important in the south and Midwest in the mid -20th century. Brazil and Argentina is also major producer.

Soybean is one of the richest and cheapest sources of protein and is a staple in the diets of people and animals in numerous parts of the world. The seed contains 17 percent oil and 63 percent meal, 50 percent which is protein. Because soybean contains no starch, they are a good source of protein for diabetics. In East Asia the bean is extensively consumed in the form of soya milk, a whitish liquid suspension, and tofu, a crud somewhat resembling cottage cheese. Soybeans are also sprouted for use as a salad ingredient or as a vegetable and may be eaten roasted as a snack food. Young soybeans, known as edamame are commonly steamed or boiled and eaten directly from the pod. Soy sauce, a salt brown liquid, is produced from crushed soybeans and wheat that undergo yeast fermentation in salt water for six months to a year or more: it is a ubiquitous ingredient in Asian cooking.

## 2.2. Agricultural Technology Adoption

A diffusion of innovation with in a social system takes place through its adoption by individual or groups. Adoption is a decision to make full use of an innovation as the best course of action available. The decision to adopt an innovation, involves a process composed of learning, deciding, and acting over a period of time.

The adoption process, as a decision-making process goes through a number of mental stages before making a final decision to adopt an innovation. Decision - making is a process comprising a sequence of stages with a distinct type of activity occurring during each stage. The way in which an individual adopts an innovation is involves the following five steps namely, awareness stage, interest stage, evaluation stage, trial stage and adoption stage (Kedir et al., 2017).

The technology adoption lifecycle is a sociological model that describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups.

## 2.3. The Concepts of Adoption

The agricultural research centers focus is on developing new technology that enhances the production and productivity of the agricultural sector which consequently ensures poverty reduction and welfare of farming communities. The rapid adoption of agricultural innovations in developed and some developing countries has substantially increased agricultural production and productivity which contributed to overall economic growth, and reduced food insecurity and poverty.

Adoption is defined in different ways. Adoption commonly refers to the decision to use new technology or practice by the economic units on a regular basis. Thus, the adoption of innovation within a social system takes place through the usage of innovation by individuals or groups. (Feder et al., 1985) defined adoption as "the integration of innovation into farmers' normal farming activities over an extended period of time". The author also defined the adoption of new technology at the household level as "the degree of use of new technology in the long-run equilibrium when the farmer has full information about new technology".

The distinction between adoption and diffusion was conceptualized by (Rogers & Williams, 1983). According to his explanation diffusion (aggregate adoption) was defined as the process by which technology is communicated through certain channels over time among the members of the social system. The following four elements are recognized in this definition of diffusion.

These are, first the technology that represents the new idea, practice or object being diffused; second, communication channels which represent the means by which messages get from an individual (extension, technology supplier) to final users or adopters (farmers), third the time period over which a social system adopt a technology, and forth the social system. (Rogers & Williams, 1983), then defined adoption as the use or non-use of new technology by a farmer at a given time.

The authors also argue that adoption is a process that passes through several mental stages on which an individual passes after first hearing about an innovation to finally deciding to accept or reject it. The processes generally include five stages: awareness about innovation, interest about new technology/innovation, evaluation of weighing advantages and disadvantages of innovation, trial in small scale, and finally adopting and applying it to a larger scale if it fulfills their needs. Farmers are classified according to their tendency to adopt and accept innovation as innovators, early adopters, early majority, and late majority and the proportion of adoption category of individuals is 2.5%, 13.5%, 34%, and 16 % respectively (Feder et al., 1985).

According to (Ban & Hawkins, 1996), "adoption is defined as a decision to apply innovation and continue to use it over a reasonably long period of time." It is also further noted that adoption is not permanent behavior. For different social, institutional, Personal and technical reasons farmers can decide to quit the use of an innovation.

### 2.4. Models of Adoption

#### 2.4.1. Diffusion of innovation model

(Rogers, 1962), Theory of Innovation Diffusion (DOI), developed by E.M. in 1962 is one of the oldest theories in social science. It originated in communication to explain how, through a specific population or social system, an idea or product gains momentum and diffuses (or spreads) over time. The ultimate outcome of this diffusion is that people adopt a new idea, behavior, or product as part of a social system. Adoption means a person is doing something different from what they had before that is using new technology learning and practicing new behavior etc.

For Rogers (2003), adoption is a decision to use an innovation as the best course of action available and rejection is a decision not to adopt an innovation. Rogers defines diffusion as the process in which an innovation is communicated through certain channels over time among the members of social system. As expressed in this definition, innovation, communication channels, time, and social system are the four key components of the diffusion of innovation.

The first element of diffusion of an innovation process is innovation. Rogers defined innovation as an idea, practice, or project that is perceived as new by individual other unit of adoption (Rogers, 2003). The technology may have been invented long ago, but if it is viewed by individuals as new, it may still be the innovation for them. The novelty characteristic of an adoption is more related to the three steps of the innovation-decision process which are knowledge, persuasion and decision.

The second element of the diffusion of innovations process is communication channels. For Rogers (2003), communication is a process in which participants create and share information with one another in order to reach a mutual understanding. This communication occurs through channels between sources.

According to Rogers (2003), the time aspect is ignored in most behavioral research. He argues that including the time dimension in diffusion research illustrates one of its strengths. The innovation-diffusion process, adopter categorization, and rate of adoptions all include a time dimension.

The social system is the final element in the process of diffusion. Rogers (2003) defined the social system as "a set of interrelated units that work together to solve a problem to accomplish a common goal. Because diffusion of innovations is disseminated in the social system, it is influenced by the social system structure.

### 2.4.2. The innovation decision model

Rogers (2003) described the innovation-decision process as an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation. The innovation-decision process involves five steps: (1) knowledge, (2) persuasion, (3) decision, (4) implementation, and (5) confirmation. These stages typically follow each other in a time-ordered manner.

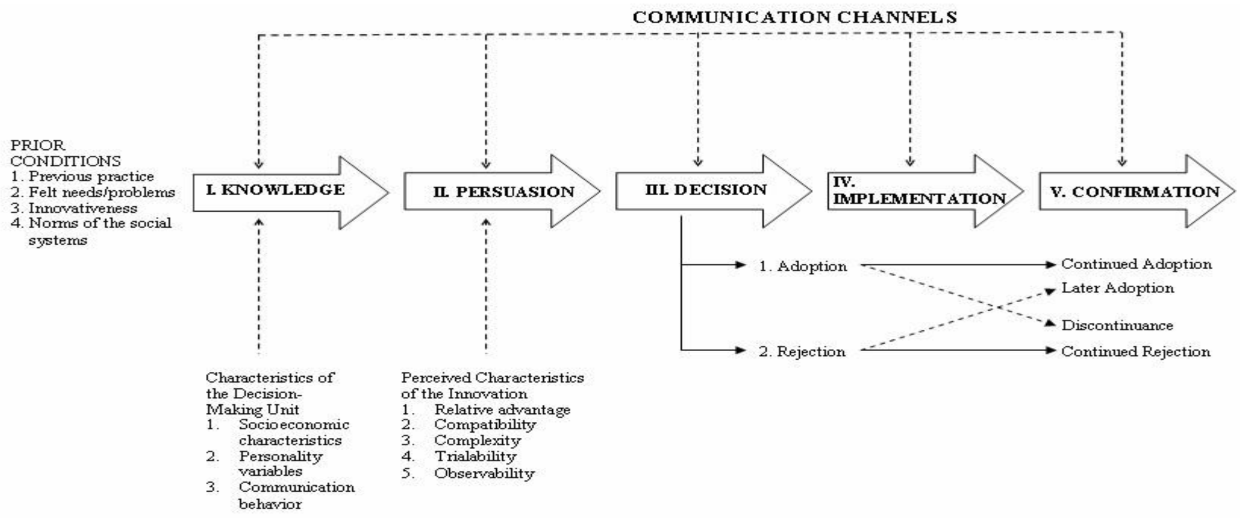


**Figure-1: Innovation decision model (Rogers 2003)**

### 2.4.3. Düvel's behavior analysis model

Independent variables appear behavior through intervening variables (Düvel, 1975). Düvel emphasizes the key role of intervening variables in a behavior model. Relevant intervening variables to found through research to influence behavior are needs, perception, and knowledge (Düvel, 1975). These variables are incorporated into a behavior in a cause effect relationship. The model represents a framework for problem conceptualization. In agricultural development, the problem is generally one of poor efficiency usually the result of some form of behavior (e.g., Practice adoption behavior). The model outlines two basic causal relationships poor or non-adoption of appropriate practices which result in poor efficiency and the hypothetical causes poor or non-adoption of any one practice that can be traced to the intervening variables of need perception and knowledge. The poor or non-adoption of a practice can be traced to two basic causes. The individual is unwilling or unable to adopt. Unwillingness can be linked to directly or indirectly to a lack of need, unfavorable perception and or lack of knowledge. Factor related to inability tends to be independent in nature, and fall mainly under the broad category of personal and environmental variables. They can also be grouped under one of the perception attributes, namely compatibility.

### 2.5. The Concepts of Perception

Technology adoption is a complex and dynamic process that is determined by many factors such as perceived attributes of the technology, farmers' socio-economic characteristics, and institutional factors. The adopter perception model suggests that the perceived characteristics of technology influence negatively or positively the adoption decision of end-users (Adesina & Zinnah, 1993).

Thus, adoption depends on users' judgment of the value of technology in relation to their prevailing socio-economic and cultural conditions. The end users may reflect the utility and effectiveness of the technology as determining factors for their decisions. Users will reject the technology that is not relevant to their needs, not suited to their working environment and interfere with other activities which they consider important. These subjective judgments of technology attributes have shown to significantly condition technology adoption decisions (Farrington, 1989).

Pickens (2005), explained perception as the process that organizes and interprets by our sensory in order to give meaning about the environment. It is the set of the process through which an individual becomes aware of and interpret information about the environment. People interpret the stimuli based on their past experiences into meaningful conclusion but their interpretation may differ from the fact or reality. (Ban & Hawkins, 1996) defined perception as "a process by which we receive information or stimuli from our environment and transform it into psychological awareness". The fact that all innovation does not diffuse at the same rate lies in the perception of end-users of technology in different ways. Thus, the perception of a specific technology could affect the adoption decision of farmers either positively or negatively as indicated above.

Rogers & Williams (1983) have classified characteristics that may describe an innovation and individuals' perception and, predict their rate of adoption. These characteristics of innovations are a relative advantage to the current tool or procedure, compatibility with the pre-existing system, complexity or difficulty, trial ability (testability) and observability of its effects. These qualities interact and judged as a whole by technology users.

## 2.6. Empirical Studies on Technology Adoption

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

Kassa et al. (2013) studied on Determinants of adoption of improved maize varieties for male headed and female headed households in West Harerghe zone. The study was based on cross sectional data of 148 of maize producing farmers. The study used the logistic regression model applied to assist in estimating the probability of adoption of improved maize verities. Of the total sampled households, 148 (115 MHH and 33 FHH), 56 (44.3% of MHH and 15.2% of FHH) farmers used improved maize varieties and 92 (55.7% of MHH and 84.8% of FHH) farmers did not use during the main cropping season. Correctly predicted figures for adopters were about 84.3% and 93.9%; while correctly predicted sample size for non-adopters were 89.1% and 80% for MHH and FHH, respectively. Cultivated farm size, number of Tropical Livestock Units (TLU), Extension contacts affects positively and significantly while Age and Distance to the nearest input market affects a negatively and significant the probability of adoption of improved maize varieties.

Hagos & Zemedu (2015) conducted study on the determinants of improved rice varieties adoption in Fogera district of Ethiopia. The study was based on cross sectional data of 151 of rice producing farmers. The study used Univariate Probit model in order to address factors that influence the decision to participate in improved rice varieties adoption. Out of the total randomly selected households, 86 (57%) were adopters and 65 (43%) were non-adopters of improved rice seed. Household size, education of the household head, land, rice farming experience, access to new cultivars of rice, off-farm income and institutions affect positively and significantly while distance to the nearest village market, access to main market, distance to access agricultural extension office affect negatively and significantly the probability of participation in improved rice cultivation.

Teferi et al. (2015) studied the impact of improved maize varieties adoption on smallholder Farmers marketed maize surplus in Oromia regional state, Ethiopia. The study was based on cross sectional data of 300 maize producing farmers. The study used the Logit model to deal with the determinants of adoption. Out of 300 households, about 26% were adopters while74% are non-adopters. Age, family size, marital status, adult-literacy, average livestock holding, access to output markets, access to credit for new verities affects positively and significantly while access to credit for other input and distance to main market affects a negatively and significantly adoption of improved maize verities.

Teferi, (2013), conducted a study on adoption of improved sorghum varieties and farmers' varietal trait preference in kobo district, north Wolo zone, Ethiopia. The study was based on cross sectional data of 150 sorghum producing farmers. The study used Tobit to trace the important determinants of adoption and intensity of use of improved sorghum varieties among the sample households. Out of 150 households about 53(35.3%) households were adopters while 97(64.7%) are non-adopters. Tropical Livestock Unit, participation in off-farm, perception on taste quality of improved sorghum, irrigated farm size (ha), striga infested land (ha) and perception on yield capacity of improved sorghum affects positively and significantly while farm size (ha) proportion of sorghum area from total crop land, distance from FTC to home and active labor ratio affects a negatively and significantly adoption of improved maize varieties.

Kebede & Tadesse (2015a) conducted a study on the determinants affecting adoption of malt-barley technology: Evidence from North Gondar Ethiopia. The study was based on cross sectional data of 120 malt-barley producing farmers. The study used probit model for estimating the probability of adoption. Out of 120 households about 39(32.5%) households were adopters' while 81 (67.5%) are non-adopters. Educational statuses, access of improved seed varieties and training affects positively and significantly while social status of the household head affects a negatively and significantly adoption of improved malt barley technology.

Aweke, (2013) identified factors influencing adoption of improved maize varieties in Gorogutu Woreda of Eastern Hararghe, Ethiopia. The study was based on cross sectional data of130improved maize producers. The study used Tobit model to analyses factors affecting probability and intensity of adoption of improved maize seed. Out of 130 households about 43.8% households were adopters while56.2 % are non-adopters. Educational level of household head, size of own cultivated land, off-farm employment, access to credit, contact with extension agent, membership in cooperative, income from chat, land size and affects positively and significantly while cosmopolitan affect negatively and significantly adoption of improved maize varieties.

Berihun, (2014) studied adoption and impact of agricultural technologies on farm income: evidence from southern Tigray, northern Ethiopia. The study was based on cross sectional data of 270 randomly selected smallholder farmers. The study used probit model. About 27% and 34% of the sample respondents were respectively chemical fertilizer and hybrid variety adopters while 73% and 66% of the sample respondents were respectively chemical fertilizer and hybrid variety non-adopters. Age, landownership, irrigation use and access to credit affects positively and significantly while distance to the nearest market and Tropical Livestock Unit (TLU) affects negatively and significantly agricultural technology adoption.

Mulugeta, (2011) studied on factors affecting adoption of improved haricot bean varieties and associated agronomic practices in Dale Woreda, SNNPRS. The study was based on cross sectional data of 150 farm household head from identified haricot bean growers. The study used Tobit model. Out of 150 farmers 17% are non-adopters while 4%,54% and 25% are low, medium and high adopters respectively. Sex of house hold head, access to improved haricot bean seed credit, participation in field day, membership of seed multiplication, participation in training and conducting demonstration affect positively and significantly while output and input market distance affect negatively and significantly adoption of haricot bean production package.

Asfaw et al. (2011) studied on Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. The study was based on cross sectional data of 700 chickpea producing farmers. The study employed the Double-Hurdle (DH) model. About 32% are adopters and 68 are non-adopters. Family labor force, per capita asset (farm size and non-oxen livestock), previous year knowledge about improved varieties and perception of farmers about the technology attribute affect positively and significantly while the district dummies affect negatively and significantly the level of adoption of improved chickpea varieties.

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

Tura et al. (2010) studied on Adoption and continued use of improved maize seeds: Case study of Central Ethiopia. The study was based on cross sectional data of 120 farm household head from identified maize growers. The study used bivariate probit model. Out of 120 farmers 7.5% of the sample households have never grown improved maize varieties. About 63% of the sample households have been using the improved seeds since they first adopted them, whereas the remaining 37% have dis adopted the improved seeds. Adult equivalent, Access to credit, member of a cooperative, Access to extension, Experience affects positively and significantly while education negatively and significantly influence likelihood of adopting improved maize.

Duressa, (2015) studied on Analysis of Factors Influencing Adoption of Quncho Tef: The Case of Wayu Tuqa District. The study was based on cross sectional data of 355 sample households. The study used Logit model. Out of 355 farmers 125 farmers are adopters while 250 were non adopters. The result shows that distance from market center, farmers owning the oxen and age of the household were found to influence adoption negatively while family labor in-terms of man equivalent and participation of farmers in agricultural trainings, education, livestock holding in-terms of tropical livestock unit, farmer's ability of meeting the family food consumption and frequency of extension contact were found to affect adoption positively.

Ndemo & Hadush (2015) studied on factors affecting adoption of upland rice and its implication on system innovation: the case of Tselemti district, North Western zone of Tigray, Ethiopia. The study was based on cross sectional data of 150 sample households. Binary logistic regression model was employed to identify the factors affecting adoption of rice technology. Of the total sample respondents interviewed, 41% were adopters and 59% were non-adopters. The level of education, perception on rice yield, access to credit service, participation in off-farm activities, participation on field day and participation in training were found positively and significantly influence in the adoption of rice technology. However, perception in the cost of inputs was negatively and significantly influences the adoption of rice technology.

Beshir et al. (2012) studied on determinants of chemical fertilizer technology adoption in North Eastern highlands of Ethiopia: the double hurdle approach. The study was based on cross sectional data of randomly selected 252 farmers. This study used a double hurdle model to identify factors affecting the probability of adoption and intensity of use of inorganic fertilizers.

About 45(3%) are adopters and 207(97%) are non-adopters. Extension service access, DA distance, credit service influence significantly and positively while distance to market, distance to input supply, credit distance influence significantly and negatively the probability adoption of chemical fertilizer technology. Sex, age, education, adult equivalent, total cultivated land, livestock owned, off/non-farm income, extension service access, influence significantly and positively while Active labor force, distance to market, distance to road, number of plots, distance to input supply, DA distance, credit service, credit distance influence significantly and negatively the intensity adoption of chemical fertilizer technology.

Eba & Bashargo (2014) identified factors affecting adoption of chemical fertilizer by smallholder farmers in Guto Gida district, Oromia Regional State, Ethiopia. The study was based on cross sectional data of randomly selected 350 farmers. This study used a Probit and Tobit model. About 130(37%) are adopters and 220(63%) are non-adopters. Education, family size, extension contact, access to information, access to credit, farm income and off-farm activity were positively influenced the adoption of fertilizer whereas distance to market and livestock are negatively influenced adoption of fertilizer use at standard significant levels. On the other hand, off-farm activity, access to information, land holding size and farming experience are positively affected the intensity use of fertilizer while family size and lives stocks are negatively determined the extent use of fertilizer.

### 2.7. Impact of Adoption of Agricultural Technologies

For a country like Ethiopia, where the agricultural sector drives the whole economy, studying the effects of the adoption of agricultural technology has significant advantages. A country's economic prosperity is positively impacted by agricultural technology advancement and acceptance. Improved varieties and other additional technologies have a favorable impact on food security, income improvement, household expenditure, poverty, and the welfare of farm households overall, according to research on the effects of adopting agricultural technologies. The adoption of agricultural technologies and household welfare are positively correlated, as confirmed by the symmetric assessments of literature that follow.

The study on role of adoption of agricultural technology on market participation among rural households by (Asfaw et al., 2011) found that increased production from improved agricultural technologies leads to greater output market integration. This study used a treatment effect model and propensity score matching approaches to quantify the potential impact of adoption while accounting for heterogeneity in the decision-making process and unobservable features of farmers and their farms.

Amare et al. (2012) conducted similar studies on the welfare impact of maize pigeon pea intensification in Tanzania, and their findings demonstrated a positive and significant impact of using new agricultural technologies. The study used propensity score matching and switching regression approaches to determine the causal influence of technology adoption on household welfare. Both estimations confirm that improved maize and pigeon pea intensification have a positive impact on consumption expenditure per capita, even if the PSM result for maize is not significant, highlighting the importance of controlling for unobserved heterogeneities when establishing causality. The results broadly corroborate the potential impact of technology adoption in enhancing rural household livelihoods, since better revenues from improved agricultural technologies translate into lower poverty, higher food security and greater ability to with stand risk.

Similarly, (Bezu et al., 2014) reported on the outcomes of a study that used three years of panel data to analyze the influence of enhanced maize on household welfare in Malawi. The study used household per capita maize available for consumption from own production, household per capita income, and household per capita asset holdings to measure welfare. A fixed-effects model was used to examine the connection between adopting enhanced maize technology and household welfare. An instrumental variable was employed to control the endogeneity issue. The model output reveals that better maize planting has positive and significant effects on farm households' welfare. The increase in improved maize plants was positively correlated with their own maize consumption, both male and female-headed households. Poor and better-off households had benefited from improved maize planting, with higher elasticity for the poorest households.

Dontsop Nguezet et al. (2011) conducted studies in Nigeria on the impacts of improved rice technology (NERICA varieties) on income and poverty among rice farming households, and the results show that adoption has a positive effect on farm household income and poverty reduction. The instrumental variable method was used in this study to determine the local average treatment effect of NERICA on income and poverty reduction. The empirical findings of this study show that adopting improved varieties increased farmers' income and per capita spending, boosting their chances of escaping poverty. This reinforces the commonly held belief that productivity-enhancing agricultural technologies can help to increase farm household incomes, alleviate poverty, and ensure food security in developing countries.

Degye Goshu et al. (2013) found a positive and significant relationship between adoption and food security among smallholders in rural Ethiopia. Three agricultural technologies and two food security measures were evaluated using a simulated maximum likelihood multivariate Probit model to assess the relationship between agricultural technology adoption and food security indicators and to find the underlying causes. The findings suggest that a concerted effort is necessary to improve family food security in rural Ethiopia through the rapid deployment and diffusion of appropriate agricultural technologies.

Similarly, (Mulugeta & Hundie, 2012) study on the impact of wheat technology adoption on household food consumption in southeastern Ethiopia (Lode Hetosa district, Oromia regional state) confirms the positive relationship between agricultural technology adoption and food security. The propensity score-matching approach of impact evaluation was used to examine the impact of adopting improved wheat technology on farm households' food consumption. Adoption of better varieties of wheat planted in spacing has a positive relationship with household food consumption levels. Despite the poor acceptance rate of improved wheat technologies, those households who did employ them were able to increase their food consumption. Scaling up the best practices of the adopters to other farmers was suggested as one option to enhance food security in the area, while introducing new practices and technologies was another option.

Zeng et al. (2014) conducted a similar study in rural Ethiopia on the adoption of improved maize varieties and their impact on child nutrition using instrumental variables and quantile instrumental variable regressions. The findings show that the adoption of improved technologies has a positive impact on the overall well-being of rural households, including the nutrition of children. According to the study, improving the lowest nutrition outcomes can reduce child malnutrition; hence adoption should be promoted among the poor.

Hailu et al. (2014) study on the adoption and impact of agricultural technologies on farm income in southern Tigray, Ethiopia, showed similar results. The ordinary least squares regression results showed that agricultural technology adoption has a positive influence on farm income, with adopters outperforming non-adopters. The study suggests that in order to increase the likelihood of adopting modern agricultural technologies and achieve the expected impact, credit market failures and irrigation problems must be addressed through the implementation of drip and pipe irrigations, farm households' land ownership must be secured, and female-headed households be empowered.

Kassie et al. (2014) showed a positive impact of the intensity of maize varieties adoption on household food security in rural Tanzania using the non-parametric continuous treatment effect estimating methodology known as generalized propensity-score matching. In addition to conventional per capita food consumption, farm households' subjective assessments of their food security were employed to assess their food security position. According to the findings of this model, maize technology adoption has a modest but considerable positive influence on food security, which varies according on the adoption level. Finally, the study indicated that adopting agricultural technology has helped to reduce rural food insecurity in Tanzania.

The previously mentioned research has shown that agricultural technologies have a significant and positive impact on the overall welfare of farm households. Nevertheless, the vast majority of research focuses on crops with economic or political significance. Regardless of the level of adoption, the majority of studies looked into the effects of adopting new technologies. The recent impact evaluation literature recommends against performing effect assessments based solely on farm households' productivity and net income, as this may not provide reliable information about the extent to which the technology has actually contributed to the impact under examination. Furthermore, the preceding work does not account for intra-household variability when analyzing the effects. Therefore, it is critical to evaluate the impact of soybean productivity and net income of smallholder farmers and account for variations among households.

### 2.8. Conceptual Framework of the Study

Agricultural technology adoption and diffusion patterns often vary from location to location. In general, the variations in adoption patterns proceed from the presence of disparity in agro ecology, institutional and social factors. Moreover, farmers' adoption behavior, especially in low-income countries, can be influenced by a different set of socio-economic, demographic, technical, institutional and biophysical factors. Farmer's decision to adopt new technologies can also be influenced by factors related to their objectives and constraints. These factors include farmer's resource endowments as measured by size of family labors, farm size and livestock ownership, farmers socio–economic circumstance (age, and formal education) and institutional support system available for inputs (Program et al., 1993).

In many developing countries, it has become apparent that generating new technology alone has(Program et al., 1993) not provided solution to help poor farmers increase agricultural productivity and achieve higher standards of living. In spite of the efforts of National and International development organizations, the problem of technology adoption and hence low agricultural productivity is still a major concern (Program et al., 1993).

In this study efforts were made to figure out adoption, intensity of adoption and impact of improved soybean according to farmers' personal characteristics, accessibilities to different services such as credit, extension, and psychological factors.

Figure 2. depicts the effect of demographic, behavioral, economic, situational, communication, institutional, farm characteristics and social factors on adoption of improved soybean. In this study the mentioned factors were hypothesized and fifteen variables are addressed these are age, sex of household head, education level, family size, farming experience, number of oxen, participation in training, cooperative member of household head, distance to nearest market

distance to nearest road, dependency ration, frequency of visit and participation in demonstration are included in the study.

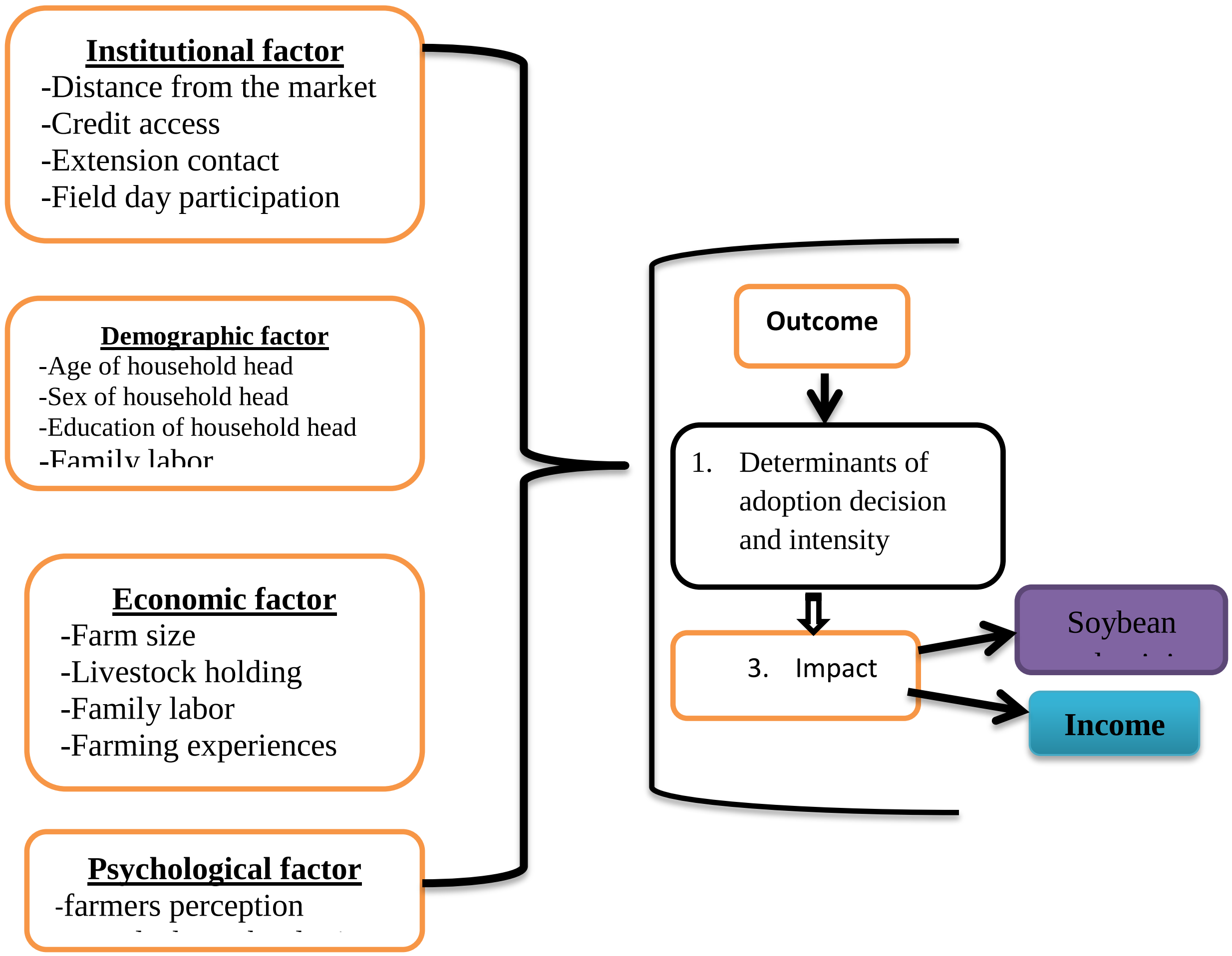


Figure 2. Conceptual frame work of the study

# CHAPTER THREE: RESEARCH METHODOLOGEY

## 3.1. Description of the Study Area

### 3.1.1. Location

This research was carried out in Pawe district which is one of the seven districts of Metekel Zone of Benshangul Gumuz Regional State, bordered by Dangure district in West, Mandura district in South and Jawi district of Amhara Region in North and Eastern par. It is found at 575km distance from Addis Ababa between 36° 20'-36° 32'- longitude and 11° 12'-11° 21'north latitude. The district has 20 kebles and the climate of the area is hot humid and characterized by unimodal rainfall pattern with high and torrential rainfall that exceeds from May to October. The area receives mean annual rainfall of 1586.32 mm and it has an altitude of 1120 m(Yemam, 2013).

### 3.1.2. Population and area coverage

Pawe district comprises 20 kebele administrative. According to the DOA, the district has 67,862 total populations out of which 35,407 are men and 32,445 are women. The total household in the district is 10,899. In the study district about 9% of the population is urban dwellers and the rest 84% are rural dwellers. About 87.9% of the population is engaged in agriculture, 8% are engaged in different merchandise sectors, and 4% are engaged in civil service (Pawi district agricultural office, 2019).

### 3.1.3. Soil types

The soil types in Pawi district are Vertisol 45%, Nitosols 35% red, and the rest 20% constitutes clay, loam, and sandy soils. The soils of the study district are believed to be comparatively fertile and farmers can harvest substantial yield during good rains (Pawi district agricultural office, 2019).

### 3.1.4. Land use type and vegetation coverage

The total area of the district is 63,400 hectares of land of which 50.4% of land is suitable for cultivation of crops and 73.9% of the land which is suitable for cultivation of crops is under cultivation of different crops. The farming system in the area is dominated by mixed crop livestock production, which accounts 96% of the population and 3.8% involved only in livestock production. Types of crops grown in the area includes cereals (maize, sorghum and finger millet), oil crops (sesame and groundnuts), vegetables, fruits (mainly mango and papaya), pulses (mainly haricot bean and soybeans). Soybean is the main pulse crop in Pawi district (Pawi district agricultural office, 2019).

### 3.1.5. Livestock production

Livestock rearing plays a major role in mixed farming system of the study district. Livestock types kept by the farmers include cattle, sheep, mules, donkey, goats and poultry. Livestock contributes to crop production as draft power for plowing, milk production for family consumption and sale, cash generation, and transporting agricultural inputs and products. Manure is also used to improve farm fertility for increasing yield of crops. The feed sources commonly used for livestock include natural grazing and crop residues (Pawi district agricultural office, 2019).

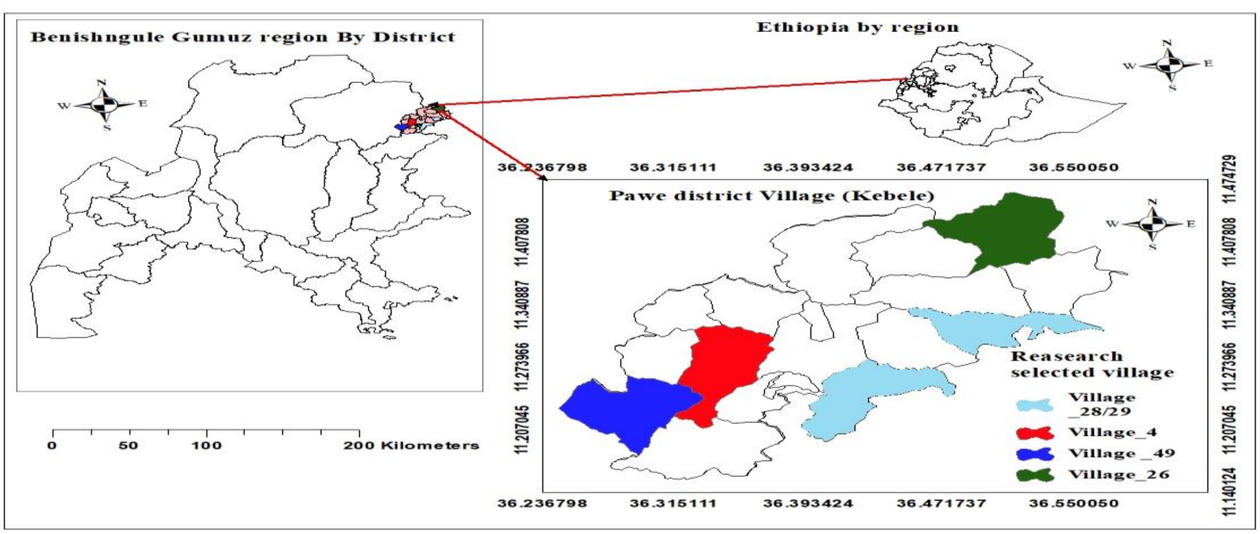


**Figure-3: Map of the Study Area (Pawi Districts)**

### 3.2. Research Design

Primary data were collected using a household survey design. This was preferred because it allows collection of primary data where the population is large. The study used descriptive survey design and the design was preferred because it allows analysis of both quantitative and qualitative data. Descriptive survey also helps to describe characteristics of targeted individuals or groups.

#### 3.2.1. Sampling procedure and sample size determination

In order to conduct the study in a representative way and to increase its reliability and validity three-stage sampling techniques was employed to select the sample respondents. The first stage of the sampling procedure was the purposive selection of the Pawe district. This district was selected purposively for its wider coverage of soybean and its production potential. There has been also demonstrations and pre-scaling up activities carried out by PARC in collaboration with district agricultural office on different improved soybean varieties. Improved soybean varieties was also demonstrated and popularized by pawe agricultural research center. The second stages was a random selection of soybean growing kebeles of the district, followed by the selection of sample households in order to give equal chance for all observations. The kebeles were first stratified as first soybean potential and soybean growing, and those without the potential of soybean production. Identification was made through reviewing secondary data on the production potential of soybean and dissemination of the improved soybean technologies and area coverage of the crop. Then from potential soybean growing kebeles, four kebeles were selected for sampling randomly. In the third stage, total sample respondents were selected in four kebeles using a systematic random sampling technique based on probability proportional to size for the interview purpose.

In principle, accurate information about a given population parameter is obtained from the census survey. The sample size for the study were determined by the formula of Yamane,1967 cited in Israel (1992) to minimize the availability of error and bias during sample determination selection for the study. The formula for sample determination at 5% level of precision is described as follows:

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size for the study, N is the total households of the study area, e is the maximum variability or margin of error which is 0.05 in this study. 0.05% margin of error was used because the population under the study is less heterogeneous. 1 is the probability of the event occurring.

The sample size from each kebeles was determined based on their proportion to the total share of households residing in each kebeles. According to the above formula from 10,899 household populations 308 households were taken as the sample in total from selected kebeles. The sample sizes for each kebeles were calculated proportionally to their population size. After calculating the sample household according to the above explanation 5% of the samples for each kebele were added to compensate if there are untouched population parts (Israel, 1992).

**Table-1: Sample size and households of the selected kebeles.**

| No | Name of the kebeles | Total number of HH in the sampled kebeles | Sample household selected |
|---|---|---|---|
| 1 | Mender, 49 | 351 | 81 |
| 2 | Mendir, 4 | 252 | 58 |
| 3 | Mender, 28/29 | 362 | 83 |
| 4 | Mender, 26 | 372 | 86 |
| | **Total** | **1337** | **308** |

Source: Own survey, 2024.

### 3.2.2. Data type, source and method of data collection

To achieve the stated objectives, primary and secondary data were utilized in this research. The main source of data for this study was primary data collected from the sampled respondents on different issues such as household characteristics, social, institutional, economic, demographic and all other variables hypothesized to influence adoption decision and intensities of improved soybean varieties as well as perception of farmers on technology attributes which were primarily obtained by field survey using semi-structured interview schedule.

Cross-sectional data of the 2023/2024 production season was used. Before the administration of the interview schedules, the respondents were informed about the objectives of the survey. Data collections were made with locally trained enumerators. The local enumerators were recruited and trained to administer the interview under the close supervision of the researcher.

Secondary data were those which were considered relevant to the study such as area coverage of crops in the study district and productivity of improved varieties which were obtained from reports of the district agricultural offices, previous findings, CSA, published and unpublished materials such as proceedings and progress reports in research centers, journals, books, scientific research works, and office records.

Focus group discussion were conducted to generate in-depth information on some of the survey findings and perceptions of farmers that were not seen or not adequately captured by semi-structured questionnaire interview about the adoption of improved Soybean varieties to substantiate information. One focus group containing eight members of active household heads in each selected kebeles were conducted. This was useful to explore what is known or thought about the research problem that the questions would cover, and then verify, confirm and add depth to the results of the household survey. Various open-ended questions regarding the adoption of improved Soybean production and perceptions on the varieties and other related factors were used during focus group discussions to express their perceptions and responses. In addition to focus group discussion, key informant interview will be employed to collect primary qualitative data. Accordingly, an in-depth interview will be made with 8 key informants from four selected kebeles on their personal experiences on improved Soybean varieties adoption. The participants of key informant interview are extension workers from respective kebele office of agriculture.

### 3.2.3. Ethical consideration

The researcher makes every effort to avoid unnecessary biases and ensures the objective analysis and interpretation of the collected data. Therefore, the researcher gave due respect to the rights, needs, values and desires of the respondents in the course of conducting this study. Moreover, the researcher assures that the information obtained from the respondents used for research purpose only. Finally, anonymity and confidentiality of the respondents respected.

### 3.3. Method of Data Analysis

The data collected were analyzed using descriptive statistics and application of econometric model.

#### 3.3.1. Descriptive analysis

Descriptive statistics such as mean, standard deviation, frequency distributions, and percentage were employed to have a clear picture of the socio-economic, institutional and demographic characteristics of sample households. Chi-square test and an independent sample t-test were employed to identify variables that vary significantly between adopters and non- adopters. The chi-square test will be conducted to compare some qualitative characteristics of adopters and non-adopters.  The t -test were used to observe if there was a statistically significant difference between the mean of the respective adopter and non-adopter categories for continuous variables.

#### 3.3.2. Measurement of perception

Likert scale and Likert-type scale are considered to measure perceptions and opinions of people on agricultural technology in extension research. The choice of scales is based on the type of series of questions offered to respondents. If Likert questions are unique and stand- alone Likert-type scale is used for analysis. If a series of questions when combined measure a particular trait, a Likert scale is used (Boone Jr & Boone, 2012).

The Likert-type scale uses frequency scales which have a fixed choice of response format and are designed to measure opinions or attitudes. Levels of agreements and disagreements on attitudes of different topics indicated in the format are measured by the ordinal scales (Bowling & Gabriel, 2004). The Liker-type scale assumes that the strength of understanding or experience is linear that is from strongly disagree to strongly agree, and considers that attitudes can be measured. The respondents may be offered a choice of five to seven or even nine pre-coded responses, the neutral point is neither agreed nor disagreed. There is no assumption that there are equal intervals between the points on the scale; however, they may indicate the relative ordering of the response of an individual to an item (Oppenheim, 2000).

While multiple questions may be used in a research instrument, there is no attempt by the researcher to combine the responses from the items into a composite scale in the case of Likert-type data. The appropriate analytical tools of descriptive statistics such as mode median and frequencies are used. Additional analysis procedures appropriate for ordinal scale items which include chi-square measures of the association are also applied (Boone Jr & Boone, 2012).

The Likert scale is used for measuring attitudes of people by asking them to reply to a series of statements that are constructed about a certain topic. The respondents are required to answer in terms of the extent to which they agree or disagree, and so the cognitive and affective components of behavior can be exploited (Krosnick et al., 2018).

Data on the Likert scale are analyzed at the measurement interval scale. By calculating a composite score (sum or mean) from four or more Likert-type items, Likert scale items are created; therefore, the composite score for Likert scales is analyzed at the interval measurement scale. The items are used in combination to provide a quantitative measure of personality trait or character. Likert scale data can apply descriptive statistics recommended for interval scale items which include the mean for central tendency and standard deviations for variability as well as additional data analysis procedures appropriate for interval scale items which include the Pearson's r, t-test, ANOVA, and regression procedures (Boone Jr & Boone, 2012). From two types of perception measurements, the Likert scale will be used to analyze perception levels of farmers towards the positive and negative attributes of improved soybean varieties in the study area because the researcher were interested to show a combined measure of traits rather than individual items that make up the scale.

### 3.3.3. Descriptive and inferential statistics

Descriptive statistics such as mean, standard deviation, percentage, and frequency distribution table were used to describe socio-economics, institutional, and demographic characteristics of the respondents. Furthermore, inferential statistics were used to compare mean (i.e., t-test, and one-way ANOVA) and show interdependency (i.e., Chi-square test) between adoption categories. There are two different types of Chi-square tests: the Chi-square for goodness of fit and the Chi-square test for dependence. The latter used to determine whether two categorical variables are related or not. Hence, independent Chi-square test was used to test whether there is a statistically significant association between two categorical variables (2x2, 2x3, 2x4, 3x3 etc.) or not (Lyman and Michael, 2016). Pearson correlation also employed to show the correlation (strength and direction) between continuous variables and adoption intensity of improved soybean varieties production. On the other hand, Mann-Whitney U test was used to test do categorical variables differ in terms of their adoption intensity of improved soybean varieties production or not. For instance, do males and females differ in terms of their adoption intensity? Instead of comparing means of the two groups, as in the case of the t-test, the Mann-Whitney U test actually compares medians (Julie, 2005).

To detect the degree of relationships between some quantifiable explanatory variables measured and the dependent variable, the Double-hurdle econometric model were employed. Farmers' decision to adopt improved soybean varieties is contingent upon the farmer or farm-specific attributes; therefore, their adoption is a self-selection process instead of a random-assignment process.

Let $U_{iA}$ and $U_{iN}$ be the farmer I's utilities from the adoption and non-adoption of the improved varieties, respectively. Farmers will decide to adopt the improved varieties when $U_i^* = U_{iA-}U_{iN} > 0$. However, farmers' utility from the adoption of improved varieties is unobserved. As suggested by (Asfaw et al., 2011), (Abdulai & Huffman, 2014) and (Kassie et al., 2014), the adoption decision can be modeled using a random utility framework and expressed as a function of the observed variables as follows:

$U_i^* = \beta x_i + \varepsilon_i$ ……………………………………………………………………………………..1

$U_i = 1\ if\ U_i > o\ \&\ Ui = 0U_i^* < 0$

Where $U_i^*$ is a latent variable representing farmer i's adoption of the improved Soybean varieties; it equals 1 if the farmer adopts and 0 otherwise. $X_i$ is the vector of observed variables that affect the probability of adoption.

In our sample data, there are both adopters and non-adopters of the improved varieties, while the adopters have different intensities of adoption. In other words, the adoption variable equals zero when the farmers do not adopt the improved Soybean varieties, but this variable takes a positive continuous value when the farmers adopt these improved Soybean varieties. In this case, the Tobit or the double-hurdle model may be appropriate (Mason & Smale, 2013). The adoption of the improved Soybean varieties may entail a two-stage decision-making process, including whether to adopt and then how much to adopt. These decisions can be simultaneously or separately determined. The Tobit model may be applied when these decisions are simultaneously determined. Meanwhile, the double-hurdle model may be more appropriate when these adoption decisions are made separately (Tambo & Abdoulaye, 2013). The double hurdle model is considered as a generalized and improved form of the Tobit model. The model is expressed using Eq. (2) for the first stage (decision on whether to adopt or the probability of adoption) and the following function for the second stage (decision on how much to adopt or the intensity of adoption):

$Y_i = \beta Z_i + \varepsilon_i$

$Y_i = \begin{cases} Y_i^*\ if\ Y_i^* > 0 \\ 0\ otherwise \end{cases}$ …………………………………………………………………….2

$Y_i^*$ is the latent variable that denotes the farmer i's actual intensity of adoption and is measured, in this research, using the proportion of the area of land devoted to the improved Soybean varieties cultivars. $Z_i$ is a vector of observed variables that explain the intensity of adoption. In the first stage of the model, the Probit or Logit estimation may be employed to estimate the probability of adoption (Langyintuo & Mungoma, 2008). In the second stage, several estimation techniques are suggested to estimate the intensity of adoption, including Truncated regression

(Detre et al., 2011; Ricker-Gilbert et al., 2011) OLS regression (Cragg, 1971), or Tobit (1958). His article applies the Probit and Truncated regressions to examine the farmers' adoption decisions in the first and second stages of the double-hurdle model, respectively (Cragg, 1971).

Both the Double-hurdle and Tobit's model output were presented in this article for a comparison to determine which model best fits the data used for analysis. The likelihood ratio (LR) test was applied to investigate whether farmers make two-stage decisions simultaneously or separately. The LR test makes comparisons of the log-likelihood values from the double-hurdle model and Tobit models. The LR test will be conducted using the following equation:

$$\lambda = -2(LL_T - LL_P - LL_{TR}) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .. 3$$

Where,$LL_T$, $LL_P$ and $LL_{TR}$ denote the log-likelihood values for the Tobit, Probit, and Truncated models, respectively. $\lambda$ is an LR statistic value with Chi-square distribution with degrees of freedom equal to the number of independent variables. $\lambda$ is estimated under the null hypothesis that the Tobit model is more appropriate than the double-hurdle model. Consequently, the rejection of the null hypothesis means that the double hurdle model is a better alternative to it the data.

**Intensity of adoption of improved soybean technology package**

For multiple practices (packages), there are two methods of measuring intensity of adoption. The first one is adoption index. This type of measurement measures the extent of adoption at the time of the survey. The second measurement is adoption quotient. This measures the degree or extent of use with reference to the maximum possible without considering time (Ilesanmi & Afolabi, 2020) and (Mihretie et al., 2022) . In this study, the first option was employed.

In order to know the intensity of adoption of soybean production technology, first listed the main components of the technology packages based on soybean production manual, which prepared by PARC in 2019. For package study, give equal weights for each package not acceptable by many researchers because some components are easy to implement, while others are difficult to implement. In addition, all components have not equal contributions for a specific crop production. Many scholars such as (Kebede & Tadesse, 2015), (Ogunya et al., 2017), (Ilesanmi

& Afolabi, 2020), (Mihretie et al., 2022) were gives weight for each packages to obtain intensity of adoption of a given technology. Therefore, this study gave different weight for each packages of soybean production technology (see Table 2). Based on the weight, soybean grower farmer's adoption intensity was calculated. Accordingly, adoption index of the technology was calculated as follow:

$\boldsymbol{AIi} = \boldsymbol{ATi}\ \boldsymbol{RTi}\ \boldsymbol{xISi}$ ………………………………………………………... Equation 4

Where; ATi is the level or amount of packages (plowing frequency, seed type, crop rotation, fertilizer rate, seed rate, sowing method, and weeding frequency) of the ith farmer actually applied. RTi is the recommended level or amount of packages farmers ought to apply, ISi is the proportion of score (weight) for each package. AIi is adoption index of ith farmer.

As already explained above, researches conducted on agricultural technology adoption had been using weight to calculate adoption intensity. For instance, (Mihretie et al., 2022) used weight to calculate the intensity of adoption of tef production technology packages. The researcher was compute weight from district agricultural experts and model farmers. (Kebede & Tadesse, 2015) were gave proportion score to calculate adoption intensity of malt-barley. Research conducted by (Ogunya et al., 2017) was used weight for each package to calculate adoption intensity and level of Nerica rice varieties in Ogun, Nigeria. (Ilesanmi & Afolabi, 2020) also gave weight for each technology packages to calculate intensity of adoption of cocoa production technology packages in Ekiti State, Nigeria. They calculated weight from sample respondents. Hence, this study was computed proportion score (weights) of soybean production technology packages from district agricultural officers, kebele agricultural experts, development group leaders, and model farmers based on the contribution and necessities of the package for soybean production.

**Table-2: Weights and methods of rating to calculate intensity of adoption improved soybean**

| $N^0$ | Packages | Recommendation | weights | Methods of rating |
|---|---|---|---|---|
| 1 | Seed type | Improved seed | 0.35 | Ratio of area covered by improved seed to total area covered by *soybean* |
| 3 | Plowing Frequency | 3 and above $ha^{-1}$ | 0.125 | Ratio of average plowing frequency $plot^{-1}$ to recommendation frequency |
| 4 | Seed rate | Row= 60Kg $ha^{-1}$ | 0.125 | Ratio of recommendation seed rate $ha^{-1}$ to farmers‟ actual application of seed $ha^{-1}$ |
| 5 | Fertilizer | NPS 100 Kg $ha^{-1}$ | 0.225 | Ratio of actual application of recommendation amount NPS of $ha^{-1}$ |
| 7 | Weeding | Manual weeding 2 and above $ha^{-1}$ | 0.175 | Ratio of average weeding frequency $plot^{-1}$ to recommendation weeding frequency $plot^{-1}$ |
| Total | | | 1.00 | |

Source: Computed from woreda and kebele agricultural experts, development group leaders, and model farmers, 2024.

### 3.3.4. Econometrics model

## Model specification

The specification of econometrics model depends on the nature of a data, and purpose and objective of the study (Wooldridge, 2020). There are three alternative models to achieve the two objectives (adoption decision and intensity of improved soybean varieties) of this study such as Tobit, double hurdle, Heckman two-stage and OLS (when all respondents are adopter).

To identify the model that best identifies the determinants of adoption decision or intensity of adoption of improved soybean varieties, a series of model specification test were carried out in the following sequences. First, the independent double hurdle model was tested against the Tobit specification. Second, the double hurdle model was tested against Heckman model.

**Double hurdle Vs Tobit model**

For dichotomous dependent (outcome) variable, Tobit and logit models are common. Tobit model is employ to analyze the determinants of decision and intensity of adoption of new technology. However, this model is very restrictive. For instance, the Tobit model has been revealed to be inadequate to the determinants in bread wheat technology: the adoption decision and the intensity of adoption. Any variable, which determines the probability of adopter also must determine the intensity of adoption, which is not always true (Gebremariam & Hagos, 2018). Even though the explanatory variables, which determine the decision of adoption and intensity of adoption, may be in the same direction, the magnitudes and statistical significance level for these two processes could be quite different. For instance, distance to farmers' training center may not be influence adoption intensity of bread wheat technology.

The double hurdle model proposed by Cragg (1971) is more flexible than the Tobit model because it accounts for possible that factors determine the decision to use the technology and intensity of adoption may be different in variable, magnitude, and significance level. That is why recent empirical studies have shown the inadequacy of the Tobit model in cross-sectional data structure and stressing the relevance of alternative approaches (*i.e.*, double hurdle and Heckman two-stage). Double hurdle model assumes farmers faced with two hurdles in any agricultural decision making processes.

To select appropriate model between double hurdle and Tobit, first estimate the truncated regression model, the Tobit model, and the probit model separately. The Tobit log-likelihood is the sum of the log-likelihoods for the truncated regression and probit models (Wooldridge, 2020). The likelihood ratio statistic was computed as follow:

$LR = -2[lnL_T - (\ln L_P + \ln L_{TR})]$……………………………………… Equation 5

Where: $LR$ = Likelihood Ratio; $lnL_P$= maximized log likelihood for the probit model;

$lnL_T$= maximized log likelihood for the Tobit model

$lnL_{TR}$= maximized log likelihood for the truncated regression model

The null hypothesis ($H_0$) is that the standard Tobit model is appropriate specification. If the calculated likelihood ratio statistic exceeds the critical Chi square (LR >$\chi k2$) value, the Tobit will be rejected in favor of the double hurdle model (Wooldridge, 2020).

The LR test of the double hurdle model against the Tobit model strongly rejects the latter specification. The result shows that the calculated value 510.36 is greater than the tabulated or critical value of chi-square at (0.05, 15) = 25. Therefore, there is enough evidence to reject null hypothesis (see appendix table 10). This is an indication of the existence of two separate decision-making stages in which individuals make independent decision regarding to adoption decision and intensity of adoption.

**Double hurdle Vs Heckman two-stage model**

The final quarter of $20^{th}$ century saw important advances in econometric models for analyzing limited dependent variables. The 2000 Economics Nobel Prize award winner James Heckman was developed tools for handling sample selection. Sample selection bias occurs when the availability of data influenced by a selection process related to the value of the dependent variable (Stock & Watson, 2020).

To select appropriate model between double hurdle and Heckman two-stage use the Chi-square statistic to test selection bias ($\hat{\lambda} i$). Under H0, there is no selection bias. If there is no evidence of sample selection, there is no reason to use Heckman-two stage. In this case double hurdle model is appropriate (Wooldridge, 2020).

Results of the double hurdle vs Heckman two-stage selection (inverse mills ratio or lambda Prob>chi2 = 0.730) is insignificant at 10%. This shows that there is no selection bias. Hence, there is no enough evidence to reject H0 (see appendix Table 11). Therefore, in this study the determinants of adoption decision and intensity of improved soybean varieties adoption was estimated by independent double hurdle model. The rejection of Hackman selection model disproves the claims that the zero level of adoption in the data is the result of adoption decision alone.

Eventually, it can be conclude that both Heckman and standard Tobit specification are inadequate to model the adoption decision and intensity of adoption of improved soybean varieties. The test reveals that the decision to adopting and the amount of use of soybean technology packages follow two independent decision paths. Therefore, the double-hurdle model was the appropriate model to identify factors that affecting both stages. Many scholars used double hurdle model to estimate adoption decision and intensity of crop technology adoption such as (Gedefa, 2016), (Solomon et al., 2014), (Abebe & Debebe, 2019), (Teshome, 2017) and (Mihretie et al., 2022).

Double-hurdle model estimation procedure involves running a probit model regression to identify factors affecting the decision to adopt using all sample population in the first stage and truncated regression model on the adopter households to analyze the intensity of adoption in the second stage. In this study, apply the first stage of double hurdle model to examine the factors affecting the decision to adopt soybean technology by using probit regression and the second stage of the double hurdle model to examine the factors affecting the intensity of adoption by using truncated regression. In the double hurdle model, there is no restriction regarding the element of explanatory variables in each decision. This implies that it is possible separately analyze the determinants of adoption decision and the intensity of improved soybean technology adoption. The first stage in the double-hurdle model is the decision to adopt ($\gamma_i$)improved soybean varieties expressed as follow:

$$\left.\begin{array}{l} \boldsymbol{\gamma_i* = \alpha\chi_i + \varepsilon_i} \\ \boldsymbol{\gamma_i = 1 if \gamma_i* > 0} \\ \boldsymbol{\gamma_i = 0 if \gamma_i* \leq 0} \end{array}\right\} \text{.................................... Equation 1}$$

Where: $\gamma_i*$ is the latent (unobserved) variable and $\gamma_i$is the observed variable that takes the value of 1 if a household grow improved soybean varieties ($\gamma_i* > 0$) and 0 otherwise (if$\gamma_i* \leq 0$). $\chi_i$ a vector of household variables such as socio-economic, demographic and institutional variables influencing the adoption of the technology and $\alpha$ a vector of parameters. $\varepsilon_i$ is the combination of unobserved variables of first hurdle. The second stage of double-hurdle model was expressed as follow:

$$\left.\begin{array}{l} t_i^* = \beta Z_i + \nu_i \text{ and } \gamma_i^* = \alpha \chi_i + \varepsilon_i \\ \mathbf{t_i^* = 0 \text{ if } \boldsymbol{\gamma}_i^* = 0} \\ \mathbf{t_i = t_i^* \text{ if } \boldsymbol{\gamma}_i^* = 1} \\ \mathbf{t_i = 0 \text{ if } \boldsymbol{\gamma}_i^* = 0} \end{array}\right\} \quad \text{.......................... Equation 2}$$

Where: $t_i^*$ is the latent variable describing the intensity of adoption of improved soybean varieties and $t_i$ observed variable. $Z_i$ is a vector of variables influencing how much the households use the technology and $\beta$ is a vector parameter. $\nu_i$ is the combination of unobserved variables of the second hurdle. This study assumed that the two error terms in Equation 6 and 7 are independent and normally distributed.

The log-likelihood function of Cragg's (independent double hurdle) model is the sum of the log-likelihood function from a probit and a truncated regression. Letting $\Phi$ denote a standard normal Cumulative Distribution Function (CDF) and $\phi$ denotes a standard normal density function.

$$\boldsymbol{L} = \left\{ \prod_0 \left\{ \mathbf{1} - \boldsymbol{\Phi\alpha' z}, \frac{\boldsymbol{\beta' x}}{\boldsymbol{\sigma}} \right\} \right\} \boldsymbol{\rho} \prod_+ \left\{ \boldsymbol{\Phi} \left\{ \frac{\boldsymbol{\alpha' z} + \frac{\boldsymbol{\rho}}{\boldsymbol{\sigma}}(\boldsymbol{\gamma} - \boldsymbol{\beta' x})}{\sqrt{\mathbf{1} - \boldsymbol{\rho}^2}} \right\} \frac{\mathbf{1}}{\boldsymbol{\sigma}} \boldsymbol{\phi} \left\{ \frac{\boldsymbol{\gamma} - \boldsymbol{\beta' x}}{\boldsymbol{\sigma}} \right\} \right\} \text{............ Equation 3}$$

**Diagnostic test for econometrics problems**

If there is an econometrics problem in a variable, it reduces the precision of other regressors. Therefore, this step is done before analyzing the data; it is referred to as a priori (before the fact) reasoning (Heckman, 1979). Hence, in this study before doing anything in the econometrics model, econometrics problems (*i.e.*, heteroscedasticity, multicollinearity, omitted variable bias and normality) were detected and remedy mechanism was taken.

**Multicollinearity**

An important CLR assumption is that the independent variables are not perfectly multicollinearity. One explanatory variable should not be a linear function of another (Wooldridge, 2020). In this study, multicollinearity was tested using Variance Inflation Factor for continuous variables and Contingency Coefficient for categorical variables. The value of Variance Inflation Factor (VIF) computed using Equation 9.

$\boldsymbol{VIF(Xi) = \frac{1}{1-R^2}}$…………………………………………………….. Equation 4

Where, $R^2$ stands for square multiple correlation coefficients between Xi and other explanatory variable. In practice, there is no variable, which not correlated with other explanatory variables. The issue is, it is serious problem or not. If the VIF values exceed 10, the problem is serious. When the VIF value greater than ten, standard error may be inflated (Green, 2018). Contingency Coefficient (CC) was computed using the following formula:

$\boldsymbol{CC = \sqrt{\frac{\chi^2}{n+\chi^2}}}$ ………………………………………………………….. Equation 5

Where, $\chi^2$stands for chi-square and $n$ stands for sample size. If CC value exceeds 0.75, the correlation is serious problem (Green, 2018). In this study, VIF and CC were computed, separately for first and second hurdle because there is a variable difference between the two steps. Both CC and VIF were computed using STATA 15.1.

In the first hurdle (probit) and second hurdle (truncated) multicollinearity for continuous variables were detected separately using VIF after regression. The maximum and mean VIF value for first hurdle model (probit) was 2.276 and 1.564, respectively (see appendix Table 5). On the other hand, 2.276 and 1.564 were the maximum and average VIF value of the second hurdle model (see appendix Table 7). In both case the VIF value was below the threshold value (>10 or 1/VIF < 0.10). Therefore, there was no serious multicollinearity problem between continuous variables in double hurdle model.

On the other hand, collinearity problem for categorical variables was identified by using correlation matrix for probit (first hurdle) and truncated regression (second hurdle), separately. The maximum pair wise correlation value of categorical variables in the first hurdle were 0.355 (see appendix Table 8). On the other hand, 0.355 was the maximum correlation value of the second hurdle (see appendix Table 9). Therefore, there was no serious collinearity problem (< 0.75) between categorical variables in the double hurdle model.

**Heteroscedasticity**

One of the major assumptions of Classical Linear Regression (CLR) is the variance $(\sigma^2)$of the error term is constant (homoscedasticity). If the variance is not constant, there is heteroscedasticity. If the regression error is heteroskedastic, those standard errors are not a reliable basis for hypothesis tests and confidence intervals. Heteroskedasticity-robust standard errors are provided as a solution in modern software packages for homoscedasticity problem (Mark et al., 2020). In this study, the homoscedasticity problem was tested only for second hurdle using Bruch pagan test. For the first hurdle, variance is a function of the mean. It is never constant; there is no assumption of homoscedasticity, so no need for test. When the dependent variable is a binary, the model must contain heteroscedasticity, unless all of the slope parameters are zero (Wooldridge, 2020).

This study was used Breush-pagan test to detect heteroscedasticity for truncated regression. The null hypothesis is that residuals are homogeneous. However the Breush-pagan test result (Prob > chi2 = 0.0013) shows there was an evidence to reject null hypothesis at 99% confidence level (see appendix Table 6). Therefore, there was heteroscedasticity in double hurdle model. The problem with this is that may have the wrong estimates of the standard errors for the coefficients and their t-values. As a result, this study was used robust standard error to fix homoscedasticity problem.

**Omitted variable test**

Insert an irrelevant variables and excluding the relevant variables to regression equation leads to misspecification of the model. The most widely used general specification test is Ramsey's Regression Specification Error Test (RESET) (Green, 2018). The null hypothesis is that the model does not have omitted variables bias. According to Ramsey RESET test result (Prob > F = 0.64) there is no enough evidence to reject the null hypothesis (see appendix Table 4). Therefore, there is no omitted variable bias in double hurdle model.

**Marginal effect after probit regression**

In most econometrics analysis, once parameters estimates from the probit, logit, and Tobit regression are obtained, a natural next step is to consider the marginal effects. Regression analysis usually aims at estimating the marginal effect of an explanatory variable on the dependent variable, controlling for the influence of other explanatory variables. In the linear regression analysis (*i.e.*, truncated regression), the estimated parameters can be interpreted as marginal effects. In non-linear regression models or the binary regression models (*i.e.* probit), parameter estimates cannot be interpreted as marginal effects. The marginal effect of an explanatory variable is obtained by calculated the derivation of the outcome probability with respect to an explanatory variable (Green, 2018).

**3.3.5 Endogenous Switching Regression Model Specification**

Selecting appropriate counterfactual and hence selection bias is a common challenge in estimating impact. For this study, an endogenous switching regression technique was employed to correct the selection bias and control unobserved household characteristics.

Following (Becerril & Abdulai, 2010) and (Khonje et al., 2015),the households' decision to adopt improved soybean varieties using a random utility framework modeled as follow. Let Ai represent the difference between the utility from the adoption of improved soybean varieties ($U_{i1}$) and the utility from the conventional seeds ($U_{i0}$). The farmer chooses to adopt improved soybean varieties if the utility from adoption is greater than the utility of the conventional seeds; $U_{i1} - U_{i0} > 0$. However, the two utilities are non-observable and the net benefit, Ai, which the farmer gains from adoption is a latent variable determined by observed and unobserved characteristics given in Equation (1)

$$A_i = Xi\beta + \varepsilon i \text{ With } Ai = \begin{cases} 1 & \text{if } A_i > 0 \\ 0 & \text{Otherwise} \end{cases} \text{.............................................. (eq.1)}$$

Where $A_i$ is a binary variable representing the adoption of improved soybean varieties; β is a vector of parameters to be estimated; X stands for a vector of households' socioeconomic and institutional characteristics that influence adoption of improved soybean verities and εi represents the random error term.

The relationship between the adoption of improved soybean varieties and its impact on soybean productivity and household net income can be modeled, along with a vector of explanatory variables (Z) as follows:

$$Y_i^* = Z_i \partial + \theta A_i + u_i \text{............................................................................................. (eqn.2)}$$

Where $Y_i^*$represents the improved soybean productivity and net income $Z_i$ stands for a vector of explanatory variables, $A_i$ stands for the adoption of improved soybean varieties, $\partial$ and θ are vectors of parameters to be estimated, and $u_i$ is an error term. The impact of the adoption of improved soybean varieties on the productivity and net income is therefore measured by the estimations of the parameter θ if farmers are randomly assigned to adopter or non-adopter groups (Faltermeier & Abdulai, 2009; Khonje et al., 2015).

However, since farmers themselves decide to adopt the technology based on the information they have, adopters and non-adopters may not be randomly distributed to the two groups as they may be systematically different (Amare M.*et al*., 2012). In this case the mean outcome of the two groups differs even in the absence of the treatment. Hence, this initial bias has to be solved. To do so, we used ESR technique (Khonje *et al*. 2015).

A number of recent empirical analyses that measured the impact of agricultural technologies (*e.g*. (Khonje et al., 2015) also indicated the significance of unobservable factors under impact evaluation. Hence, to implement ESR to control for unobservable variables that affects both the adoption and outcome variables. The ESR framework follows two stages. The first stage is estimation of the selection equation, the decision to adopt improved soybean varieties. Following (Khonje et al., 2015), the selection equation for the adoption of improved soybean varieties is specified as:

$A_i^* = X_i\beta + u_i$ With $A_i = \begin{cases} 1 \text{ if } A_i^* > 0 \\ 0 \text{ Otherwise} \end{cases}$ ............................................. (eq.3)

Where $A_i^*$ the latent variable for the adoption of improved soybean varieties and $A_i$ is its observable counterpart, $X_i$are vectors of observed characteristics determining the adoption of improved soybean varieties and ui is the error term. This stage of the ESR framework is estimated using a logit model. For the ESR model to be identified, it is important to include selection instruments that affect the adoption decision but not the soybean productivity and net income variable (Shiferaw *et al*. 2014). Accordingly, we included, distance from cooperatives as selection instruments by conducting a Simple falsification test following (Khonje et al., 2015).

The test results show that the identified instruments are jointly significant in explaining adoption [chi2 = 91.01 (p = 0.0000)] but are not jointly significant in the outcome equation [F = 3.07 (0.2155)] (see appendix Table 1&2).

In the second stage the two outcome regression equations faced by the farmers: to adopt (regimes 1) and not to adopt (regimes 2) conditional on adoption can be expressed as:

Regime 1 (Adopters): $Y1i = \beta 1x_i + \delta 1\varepsilon\lambda 1i + \eta 1_i$ if $A_i$= 1, (4a)

Regime 2 (non- adopters): $Y_{2I} = \beta_2 x_i + \delta_2\varepsilon\lambda 2i + \eta_{2i}$ if $A_i$ =0, (4b)

Where,

$Y_i$-is the soybean productivity and income in each regime

$Z_i$ -represents a vector of exogenous variables expected to affect soybean productivity and net income and Where $\lambda 1i = \frac{\phi(Z\iota\alpha)}{\phi(Z\iota\alpha)}$ and $\lambda 2i = \frac{\phi(Z\iota\alpha)}{1-\phi(Z\iota\alpha)}$ are the invers mill's ratio (IMRs) computed from the logit model of the selection equation to correct the selection bias in the second stage estimation $\beta$and $\sigma$ are the parameter to estimated and $\eta$ is an independently and identical distributed error term with mean zero and constant variance.

Following the two regimes of the outcome equations, 4(a) and 4(b) the actual and the counter factual welfare outcomes (productivity and income) is defined as follows;

The average treatment effect of the treated, (ATT), and of the untreated, (ATU), can be obtained from the above ESR framework by using comparison the expected values of the outcomes of adopters and non-adopters in actual and counterfactual scenarios. Following (Di Falco et al., 2011) and (Asfaw et al., 2012), the expected values of the outcomes of adopters and non-adopters in actual and counterfactual scenarios are computed as follows:

$E\,[Y_{i1} A_I = 1;\ x] = X_{i1}\beta + \sigma\varepsilon 1\lambda i1.$ (5a) Adopters with adoption (observed in the sample)

$E\,[Y_{i2} A_I = 0;\ x] = X_{i2}\,\beta + \sigma\varepsilon 2\lambda i2.$(5b) Non-adopters without adoption (observed in the sample)

$E\,[Y_{i2} A_I = 1;\ x] = X_{i1}\,\beta + \sigma\varepsilon 2\lambda i1.$ (5c) Adopters had they decided not to adopt (counterfactual)

$E\,[Y_{i1} A_I = 0;\ x] = X_{i2}\,\beta + \sigma\varepsilon 1\lambda i2.$(5d) Non-adopters had they decided to adopt (counterfactual)

Then ATT, which represents the effect of improved soybean varieties on the productivity and income of the farm households that actually adopted the technology, is calculated as the difference between (5a) and (5c);

$$ATT = E\,[Y_{i1}|A_i = 1;\ X] - E\,[Y_{i2}|A_i = 1;\ X] = X_{i1}\,\beta + \sigma\varepsilon 1\lambda i1\ X_{i2}\beta + \sigma\varepsilon 2\lambda i2.$$

Similarly, we can calculate the ATU for the farm households that actually did not adopt improved soybean varieties as the difference between (5d) and (5b) gives ATU;

$$ATU = E\,[Y_{i1}|A_i = 0;\ X] - E\,[Y_{i2}|A_i = 0;\ X] = Xi1\,\beta + \sigma\varepsilon 1\lambda i1 - Xi2\,\beta + \sigma\varepsilon 2\lambda i2$$

### 3.4. Definition of Variables and Hypotheses

### 3.4.1. Dependent Variables

**Adoption decision:** There is no universal agreed definition and length of time to say households as adopters or non-adopters. In the improved technology, the variety forms are the central part (used as a vehicle) then includes improved practices involving the use of fertilizers, appropriate land preparation, sowing method, seed rate, and weed control, management of pests, timely harvesting, and the like (Kebebew & Solomon, 2018). In this study, adopters are farmers who used improved soybean varieties in 2023/2024 production season, while non-adopters are farmers who not used improved soybean varieties.

**Intensity of adoption:** It refers to farmers" intensity of use of multiple practices from the recommended improved soybean technology. Hence, intensity of adoption is a continuous variable measured in adoption index. It ranges from 0 (non-adopter) to 1 (full adopter).

### 3.4.2. Explanatory Variables

The explanatory variables of this study listed and selected based on review of related literature, technology adoption theories, and from the experience of the farming system of the study area. The Theory of Diffusion Innovation, which is proposed by Rogers (1995), revealed that adoption decision, rejection decision, and confirmation of technologies determined by characteristics of decision-making unit (i.e., socio-economic characteristics, personality variables, and communication variables) and perceived characteristics of the innovation (relative advantage, compatibility, complexity, trialability, and observability). The list of variables to be included in the model (double hurdle) was finalized after detecting econometrics problems.

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

**Age of the household head:** It is a continuous explanatory variable, which is measured in number of year from birth. The ability to hear fast and make a decision on certain key issues and act as favorable to certain information dependents on age of the farmers. Older farmers may have experience and resource that could allow them more possibilities for trying a new technology. On the other hand, younger farmers are more likely to adopt new technology and apply technology packages because they have more schooling than the older. According to (Bayissa Gedefa Weyessa, 2014) and (Bannor et al., 2020) age was influenced positively the intensity of adoption of improved tef and rice technologies, respectively. Contrary, (Kebede, 2020) age of the household head negatively influences the adoption decision and intensity of improved wheat technologies. Therefore, age is hypothesized that influence positively or negatively the adoption intensity of soybean varieties.

**Education level of the household:** It is a categorical variable measured in terms of the level of education (illiterate, read and write, Elementary completed, secondary completed and college/university) a farmer was attended. 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. Education is expected to be positively and significantly influencing adoption of new technologies (Hagos & Zemedu, 2015). Education thus is expected to have a positive effect on the decision to adopt new technology.

**Frequency of extension agents:** It is a dummy variable, which takes a value of 1 if the household received extension contact and 0, otherwise. The frequency of contact between the extension agent and the farmers is hypothesized to be the potential force, which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to adopt new crop technologies. According to (Asmelash, 2014), contact with extension agents has positively influenced the adoption of improved upland rice varieties. A similar study of (Beshir et al., 2012) indicated that, more contacts with extension agents will increase farmers' adoption of technologies. It is hypothesized that contact with extension workers will increase a farmer's likelihood of adopting new technologies.

**Farm size:** It is a continuous variable measured in hectares. Farm size is an indicator of wealth and social status and influence within a community. This means that farmers who have relatively large farm size will be more initiated to adopt 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 (Asfaw et al., 2011; Kassa et al., 2013). Therefore, it is expected to be positively associated with the decision to adopt the improved soybean technology.

**Total annual income:** It is a continuous variable measured in Birr. The farm income refers to the total annual earnings of the family from the sale of agricultural produce such as sale of crop, livestock and livestock products after meeting family requirements. Total annual income positively and significantly affect adoption of new technology (Eba & Bashargo, 2014).

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

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

**Family labor force:** It is a continuous variable measured in terms of adult equivalent of persons living together in the household. Adoption of soybean requires adequate labor supply to carry out the production processes. It is obvious that large families may have adequate labor that would enhance the adoption of technologies. The labor availability is positively related with the adoption of improved new technologies (Duressa, 2015). Hence, it is hypothesized that availability of labor has positively influenced the adoption of soybean technology.

**Market distance:** It is a continuous variable measured in kilometers. Market distance is one of the determining factors in the adoption of technology. Better access to the market can influence the use of output and input markets, and the availability of information. It is expected that farmers living near the market would easily access market for their farm produce hence readily adopt new technology (Hagos & Zemedu, 2015). Therefore, it is hypothesized that market distance is inversely related to adoption of soybean technology.

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

**Farming experience**: It is a continuous variable measured in years of soybean production. It is expected that farmers who have adequate soybean production and its rate more likely to adopt soybean technologies than those who lack it. (Hagos & Zemedu, 2015) indicated that farm experience affect adoption of improved varieties. Therefore, it is expected that the availability of off-farm income is positively related to adoption of soybean. Therefore, it is expected that farm experience is positively related to adoption of soybean.

**Participation in field days**: Farmers participating in field days can acquire new understanding and methods on newly introduced technology to know how these technologies or methods can be practically applied on their farm. Participating in field days, therefore, enables farmers to readily implement agricultural technologies (Katengeza et al., 2012). It was measured whether the sample household head was participated in field days or not in the last three consecutive years. It was treated as a dummy variable assigning 1, for the farmers' participated on field day and 0, otherwise. It was hypothesized that it would influence the adoption of soybean variety positively.

**Participation in training:** Training is one of the means by which farmers acquire new knowledge and skills. Hence, participation in training is the determining factor for farmers' adoption behavior (Bekele, 2015). It was measured as a dummy variable and treated as 1, for farmers participated in the training of improved soybean variety 0, otherwise. Hence it was hypothesized that it would affect the adoption positively.

**Cooperative membership**: A farmer who is membership of multi-purpose farmers' cooperative in rural kebeles and different cooperatives are more likely to be aware of new practices as they are easily exposed to information. Cooperative membership may enable farmers to get credit access and enhancing saving behaviors. According to (Ilesanmi & Afolabi, 2020), membership on farmers" cooperative had positive association on adoption of improved cocoa technologies. Therefore, it is expected that farmers" cooperative membership influence positively the adoption of decision of improved soybean variety. It is a dummy variable taken 1 if household are member of farmers" cooperative and 0 otherwise.

**Table-3: The independent variables and their definitions**

| Definition variables | Categories | measurement | Expected Sign |
|---|---|---|---|
| **Dependent variable** | | | |
| Adoption of decision | Dummy | 1= Adopter 0= non-adopter | |
| Adoption intensity | Continuous | Adoption index | |
| **Independent variables** | | | |
| Age of household head | Continuous | Years | +/- |
| Sex of the household head | Dummy | Male/female | Positive(+) |
| Education level of household head | Continuous | Formal schooling in years | Positive(+) |
| Farming experience | Continuous | Year | Positive(+) |
| Family labor force | Continuous | Man equivalent | Positive (+) |
| Farm size | Continuous | Cultivated area in ha | Positive(+) |
| Productivity | Continuous | Quintal in ha | Positive(+) |
| Number of livestock owned | Continuous | TLU | Negative(+) |
| Total annual income | Continuous | In birr(ETB) | Positive(+) |
| Distance to market center | Continuous | Minutes (min) | Negative (-) |
| Credit access | Dummy | Yes/no | Positive(+) |
| Participation in field days | Dummy | Yes/no | Positive(+) |
| Participation in training | Dummy | Yes/no | Positive(+) |
| Frequency of Extension contact | Continuous | No of days per year | Positive(+) |
| Perception | Continuous | 9 Items rated from 1 (Stron gly disagree) to 5 (Strongly agree) Scoring: mean score for each respondent (minimum : 1; maximum 5) | Positive(+) |

# CHAPTER 4: RESULTS AND DISCUSSION

This chapter of the thesis presents the results of the statistical analyses and the discussions based on the collected data generated through formal and informal surveys.  In view of this, the chapter deals with analysis of the seriocomic and demographic variables, i.e., descriptive analysis as well as econometric and supportive qualitative data and respective discussion of results as provided below.

## 4.1. Descriptive results

Descriptive statistics, in this sub section deals with, analysis of the selected demographic and socioeconomic characteristics of sample households is crucial elements of the analysis, as it would help to frame the econometric analysis. Chi-square and T- statistic tests were also employed to compare improved soybean varieties adoption taking the comparative view between adopter and non- adopter groups with respect to some explanatory variables. Accordingly, t-test is used to test the significance of the mean values of continuous variables while chi-square is used to test the significance of the values of the potential dummy variables, in comparison with the adopter and non-adopter households.

### 4.1.1. Demographic and socioeconomic characteristics of respondents

This sub-section described the demographic and socio-economic characteristics. Accordingly, a total of fifteen explanatory variables were identified and out of these variables twelve of them revealed significant association with the adoption and intensity of use of improved forage technology. Variables such TLU, total annual income, distance to the nearest market, frequency of extension contacts, family labor force and farming experience are continuous, whereas participation in field day visiting, training, sex of household, education level cooperative membership and credit access are dummy variables that show statistically significant at 1% , 5% and10 % significant level with the adoption decision. Differently, market distance and off farm income, had not statistically significant relation with the adoption decision. Summary of the overall descriptive results of this study is presented in table 4 and 5 below.

**Participation in field day visiting (PARTFILDVIST): -** The majority of the respondents, 54.9%, had participated in demonstration visits, while 45.1% of the respondents did not participate in demonstration visits. From the total respondents, 85.8% were improved soybean adopters, and 14.2% were non-adopters, as they had participated in demonstration visits. On the other hand, 84.3% of respondents were improved soybean adopters, and 15.7% of respondents were non-adopters, as they did not participate in demonstration visits. The chi-square result showed that there is a statistically significant difference (p = 0.000) between improved soybean adopters and non-adopters with respect to participation in demonstration visits. Participation in demonstration visits can give respondents the chance to evaluate different varieties demonstrated and decide to try them on their farm by selecting crop varieties that match others by different attributes using their judgment. As households participate in demonstration visits, they can develop improved soybean technology.

**Cooperative membership (COOPMEM): -** The result of this study showed that majority, 54.22% of the respondents had cooperative membership while the remaining 45.78% was not cooperative membership. From the total respondents, 83.83% of respondents were improved soybean adopter and 16.17% of respondents who were non adopter reported as they had cooperative membership. On the other hand, 40.42% of respondents were improved soybean adopter and 59.58% of respondents were non-adopter reported as they are not cooperative membership. The chi-square result showed that there is statistically significance difference (p=0.000) between improved soybean adopter and non-adopter with respect to cooperative membership. This implies that being a member of cooperatives are important than use improved soybean technology than non-adopter.

**Training (TRAINSOY):** The result of this study showed that majority, 53.6% of the respondents have attended training while the remaining 46.4% have not attended training. From the total respondents, 83.63% of respondents were improved soybean adopter and 16.37% of respondents who were non adopter reported as they were attended training. On the other hand, 41.26% of respondents were improved soybean adopter and 58.74% of respondents were non-adopter reported as they are not attended training. The Chi-square test confirmed that the association between attained training and improved soybean adoption was significant (P=0.000). The finding is in similar with the findings of (Abebe et al., 2018) and (Tesfaye Tegegne, 2021) who reported those farmers with access to trainings have better chance to adopt improved forage.

**Sex of household (SEXHH):** The findings of this study revealed that 76.3% of respondents are male-headed, with the remaining 23.7% are female-headed. In terms of improved soybean adoption status among sample respondents, 67.23% were male household heads, with the remaining 53.42% were female. On the non-adopter household side, approximately 32.77% and 46.58% of all respondents were male and female, respectively. The Chi-square test indicated that having a male household head was associated with increased soybean adoption (P = 0.031). This results is in line with the study of (Mesfin et al., 2011), who noted that because of several socio-cultural beliefs and conventions, male have higher freedom of mobility and participation in various extension programs, resulting in better access to knowledge. Therefore, it is hypothesized that male farmers are more likely to adopt package.

**Credit access (ACCCREDIT):** According to Table 4 the study found that, approximately 84.3% and 15.7% of adopters and non-adapters have access to credit, whereas approximately 47.02% and 52.98% do not. The Chi-square test indicated a significant relationship between obtained training and improved soybean adoption (P = 0.000).

**Education level (EDUHH):** As shown in Table 4 below, 12.01% of improved soybean adopters completed secondary school education, compared to 3.8% of non-adopters. The mean difference between the two groups was determined to be statistically significant (P = 0.000). This suggests that there is a significant positive association between education and increased soybean adoption.

**Table-4: Test statistic of demographic and socioeconomic characteristics for dummy variables (chi2 -test)**

| Variable | Categories | Adopter (N=197) | | Non-Adopter (N=111) | | Total value (N=308) | | $Chi^2$-value (probability) | p-value |
|---|---|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % | | |
| Sex | Male | 158 | 67.23 | 77 | 32.77 | 235 | 76.3 | 4.61 | 0.031* |
| | Female | 39 | 53.42 | 34 | 46.58 | 73 | 23.7 | | |
| Education | Illiterate | 37 | 12.01 | 51 | 16.56 | 88 | 28.57 | 33.23 | 0.000*** |
| | Red & write | 51 | 16.56 | 32 | 10.4 | 83 | 26.95 | | |
| | Primary school completed | 72 | 23.4 | 17 | 5.52 | 89 | 28.89 | | |
| | Secondary school completed | 37 | 12.01 | 11 | 3.8 | 48 | 15.59 | | |
| Training on soybean production | Yes | 138 | 83.63 | 27 | 16.37 | 165 | 53.6 | 59.68 | 0.000*** |
| | No | 59 | 41.26 | 84 | 58.74 | 143 | 46.4 | | |
| Field day | Yes | 145 | 85.8 | 24 | 14.2 | 169 | 54.9 | 77.47 | 0.000*** |
| | No | 52 | 37.41 | 87 | 62.59 | 139 | 45.1 | | |
| Cooperative | Yes | 140 | 83.83 | 27 | 16.17 | 167 | 54.22 | 62.49 | 0.000*** |
| | No | 57 | 40.42 | 84 | 59.58 | 141 | 45.78 | | |
| Credit | Yes | 118 | 84.3 | 22 | 15.7 | 140 | 45.45 | 46.00 | 0.000*** |
| | No | 79 | 47.02 | 89 | 52.98 | 168 | 54.55 | | |

Source: computed from own survey, 2024 *** $p<0.01$, ** $p<0.05$, * $p<0.1$ and ns $P>0.1$

**TLU:** Farm animals play a crucial part in rural livelihoods. They serve as a source of draft power to augment protein requirements, as well as status, currency, animal dung for organic fertilizer and fuel, a mode of transportation, and a hedge against general economic crises. Livestock found in the research region included cattle, sheep, goats, equines, and chickens. The mixed farming system (integrated crop and livestock production) is the primary agricultural activity in the study region. As a result, draft power is regarded as the primary source of production in the research area. Aside from that, it was discovered that livestock ownership has a major impact on the adoption of enhanced soybean technology. The average cattle ownership among adopters and non-adopters was 6.66 and 5.37, respectively. The p-value indicates a significant mean difference between the two groups (P = 0.000). As a result, adoptive households are more likely to own livestock than non-adopter families. This finding is consistent with a study by (Bayissa Gedefa Weyessa, 2014), who found that when cattle ownership increases, adoption and intensity of adoption are likely to rise and correlate positively.

**Annual income (ANUINC)** is an important factor that influences the adoption of improved soybean varieties in the study area. In comparison to improved soybean adoption, the average yearly income of adopter households was 41989 ETB, whereas the equivalent figure for non-adopter households was 13044.54 ETB. The mean difference between the two groups was determined to be statistically significant (P=0.000). This demonstrates that respondents with higher income levels are more likely to spend above their fundamental needs, allowing them to purchase improved soybeans and related services, whereas those with lower incomes spend the majority of their income on basic needs.

**Distance to the nearest market (DISMARK):** The time required to go from house to the nearest soybean market location where farmers sell their produce (soybean). Adopters and non-adopters take an average of 24.20 and 52.16 minutes to reach the nearest market. The mean difference between the two groups was found to be statistically significant (P = 0.000), implying that non-adopters take longer to reach the nearest market than adopters.

**The frequency of extension contact (FRQEXCONT)** is one of the key factors influencing the adoption of improved soybean varieties in the study area. In comparison to improved soybean adoption, the average contact of adopter household heads with extension agents was 72.69, while the comparable figure for non-adopters was 58.35. The mean difference between the two groups was determined to be statistically significant (P = 0.000). This shows that the frequency of extension contact has a positive and significant effect on the adoption of improved soybean varieties. The findings of this study are consistent with those reported by (Negash, 2007), (Asfaw et al., 2011), and (Dereje, 2019).

**Family labor force (FAMLABFORCE):** The average family labor force supply in men equivalents of the sampled households was 4.75 persons, whereas adopters had 4.93 persons and non-adopters had 4.43 persons. The mean difference between the two groups was determined to be statistically significant (P = 0.000). This indicates that large families, or man equivalents, may provide a comparatively larger labor force supply for agriculture tasks related with their utilization (for example, weeding and land preparation). A labor shortage may prevent a household from adopting improved soybean varieties. The study provides similar results to the current study by (Beshir et al., 2012), (Asfaw et al., 2011), and (Dereje, 2019).

**Farming experiences (FARMEXP):** The average years of agricultural production experience for all household heads, adopters, and non-adopters were 18.63 and 15.88 years, respectively. The mean difference between the two groups was determined to be statistically significant (P = 0.000). The results show that technology adoption and agricultural production experience are positively related.

**Table-5: Test statistics of demographic and socioeconomic characteristics for continuous variables (t-test)**

| Types of variable | Adopter (N=197) | | non-adopter (N=111) | | Combined (N=308) | | T- value | P-value |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. | Mean | Std. | Mean | Std. | | |
| AGHH | 45.06 | 0.64 | 44.63 | 0.9 | 44.90 | 0.51 | 0.655 | 0.689 |
| DISMARK | 24.20 | 0.96 | 52.16 | 3.97 | 34.3 | 1.73 | 0.000 | 0.000*** |
| FRQEXCONT | 72.69 | 0.65 | 58.35 | 1.19 | 67.52 | 0.72 | 1 | 0.000*** |
| FAMLABFORCE | 4.93 | 0.11 | 4.43 | 0.15 | 4.75 | 0.09 | 0.99 | 0.008** |
| FARMEXP | 18.63 | 0.68 | 15.88 | 0.76 | 17.64 | 0.47 | 0.99 | 0.005** |
| FARSIZ | 3.56 | 0.07 | 3.34 | 0.11 | 3.48 | 0.06 | 0.94 | 0.101 |
| TLU | 6.66 | 0.17 | 5.37 | 0.27 | 6.20 | 0.15 | 1 | 0.000*** |
| ANUINC | 41989 | 1489.31 | 13044.54 | 895 | 31558 | 1280 | 1 | 0.000*** |

Source: computed from own survey, 2024 *** p<0.01, ** p<0.05, * p<0.1 and ns P>0.1

## 4.2. Adoption status of improved soybean technologies

### 4.2.1. Current Status of Adoption and Intensity of soybean Technology packages

Improved soybean production technology packages contain different agronomic practices such as land preparation, crop rotation, improved seed, sowing method, plating date, seed rate, rate of fertilizer application, timing of fertilizer application, weeding frequency, disease prevention, pest prevention, harvesting time, threshing method, and storage system. However, not all packages were included in this study for calculating the adoption index because it is difficult to gate reliable data for some packages (i.e., sowing date and harvesting). Furthermore, one package is included in another package. For instance, the recommendations for disease and pest prevention are integrated management such as frequent plows, deep plows, crop rotation, and using improved seed. Therefore, those packages are included in crop rotation, improved seed, and plowing frequency. Eventually, this study will include plowing frequency, rate of fertilizer application, seed type, seed rate, and weeding frequency to know the adoption status and intensity of soybean production technology in the study area.

Adoption level of adopter sample households were categorized in to three groups namely: low adopter, medium adopter and high adopter using lower limit 0.01 and upper limit 1.00. The actual adoption categories were categorized in to four groups such as non-adopter, low adopter, medium adopter and high adopter based on adoption index. The index score 0.00, 0.01-0.33, 0.34-0.66, and 0.67-1.00 gives for none, low, medium, and high adopters, respectively. Similar studies, (Endeshaw, 2019), (Teshome, 2017) and (Mihretie et al., 2022) also categorized in similar way.

Finally, the aggregate intensity of adoption of soybean technology packages was calculated after multiplying each adoption quotient of the package by its weight. The weights of the package were computed by woreda agricultural officers, kebele agricultural experts, development group leader farmers, and model farmers. Various author such as (Arega, 2009), (Ogunya et al., 2017) (Ilesanmi & Afolabi, 2020) and (Mihretie et al., 2022) give weights for each packages of the technology to calculate adoption intensity of improved Coffee, new Rice varieties and Cacao technology packages, respectively.

According to Table 6, of the total sample households, 36.03%, 4.54%, 15.6%, and 43.83% were classified as low, medium, and high adopters of soybean production technology packages, respectively. The results also show that the average adoption index was 1.57, with a standard deviation of 0.045. This implies that farmers in the study area are categorized as higher adopters of soybean production technology, and as a result, efforts are expected from all actors in order to increase the adoption levels of the farmers. There is also a significant mean difference between adoption categories in the adoption index at less than 1% level of significance.

**Table-4: Farmers' adoption status in soybean technology packages.**

| Adoption category | N | Percent | Adoption index | | SD | F |
|---|---|---|---|---|---|---|
| | | | Range | Mean | | |
| Non-adopters | 111 | 36.03 | 0.00 | 0 | 0 | |
| Low Adopters | 14 | 4.54 | 0.01-0.33 | 0.22 | 0.02 | |
| Medium Adopters | 48 | 15.6 | 0.34-0.66 | 0.56 | 0.08 | |
| High Adopters | 135 | 43.83 | 0.67-1.00 | 0.79 | 0.08 | |
| Total | 308 | 100 | 1.00 | 1.57 | 0.045 | 3301.01*** |

Source: computed from own survey, 2024 *** p<0.01, ** p<0.05, * p<0.1 and ns P>0.1

### 4.2.2 Adoption rates and intensity of soybean technologies

Improved soybean varieties have been available for use for decades. As a result, the findings demonstrate how farmers in the study areas adopted and used this technology. In this study, soybean technology adopters are farmers who provided aside a parcel of land three decades ago to produce soybeans. As a result, of the 308 respondents, 111 (36.04%) were non-adopters, while the remaining 197 (63.96%) were adopters of improved soybean varieties in their districts. (Figure 4, below).

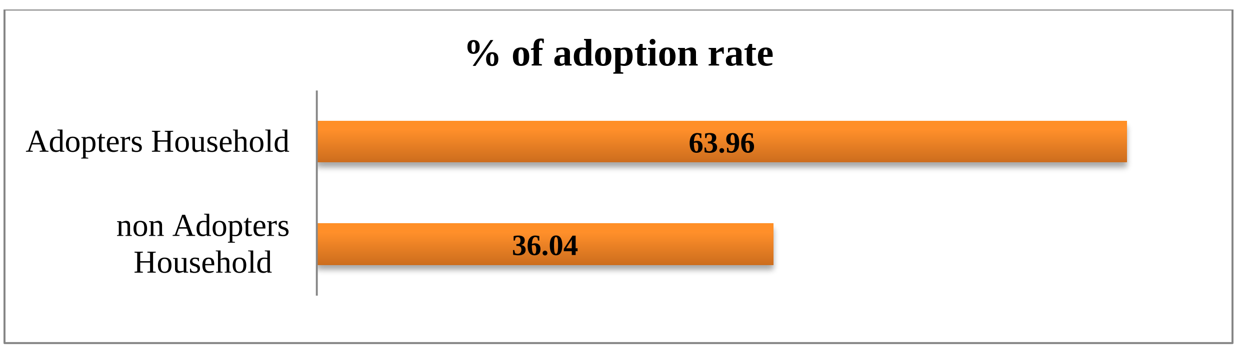


**Figure-4: Adoption rates of improved soybean technologies**
Source: Computed from own survey (2024)

Participants in the focus group discussion (FGD) from the four kebeles of the woreda indicated that the adoption status and rate of improved soybean varieties are increasing at a slower rate year after year. They stated that the low level of land allocation for enhanced soybeans is attributable to a lack of training

The survey results indicated in Figure 5 show that the respondents covered 340.58 hectares of land with soybeans during the 2023/24 production season. Adopters and non-adopters covered 227.81 and 112.77 hectares of land, respectively. This indicates that 66.90% of the land was covered by improved soybean varieties from the total lands cultivated by all the sample households.

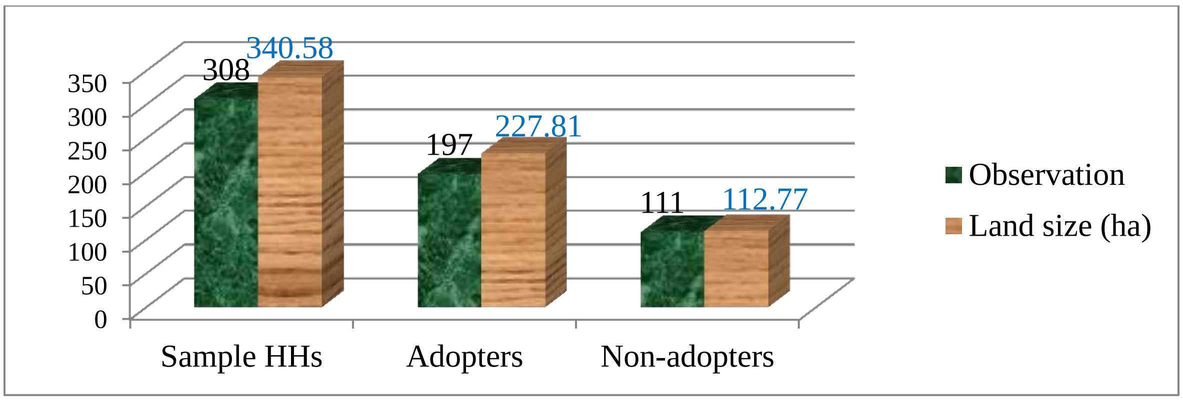


**Figure-5: Adoption intensities of improved soybean technologies.**

### 4.2.3. Varietal level adoption rates of improved soybean crops

Various stakeholders were engaged in the promotion of these soybean crops, such as the Office of Agriculture, the Agricultural Research Center, higher learning institutes, special purpose projects, and commercial growers. According to the findings of this study, the different varieties of soybean crops have varying levels of adoption rates. As presented in Table 7, the three major soybean crops that have relatively been expanded and grown in the study areas include local (36%), Pawe-1 (22.1%), Pawe-2 (19.2%), Belesa-95 (13.6%), and TGX (9.1%). On the other hand, Belesa-95 (13.6%) and TGX (9.1%) were the least adopted soybean crops in this particular study area. The major reasons behind the lower adoption rates of soybean crops are associated with limited access to improved soybean seeds, a shortage of farmlands, and the consequent interest of the farmers in giving priority to food crops (cereals) over soybean crops.

**Table-5: Varietal level adoption rates of improved soybean crops in the study area, 2024.**

| Soybean varieties adoption | Frequency | Adoption rates % N =308 |
|---|---|---|
| TGX | 28 | 9.1 |
| Pawe-1 | 68 | 22.1 |
| Pawe-2 | 59 | 19.2 |
| Belesa-95 | 42 | 13.6 |
| Local | 111 | 36 |
| **Total** | 308 | 100 |

Source: computed from own survey 2024

### 4.2.4. Productivity of soybean in the study area

At the national level, 2016 indicated that area, production, and yield of soybeans have become quick at a rate of 30.8%, 45.4%, and 11.2% per annum, respectively, and reached 38,166 ha of land to produce 812,420 quintals of soybeans with a national average yield of 21.3 quintals/ha (CSA, 2016). Table 8, shows survey respondents soybean production quintal/ha during the 2023/24 cropping season. According to the table, the average soybean production quintal/ha in the study area was 14.23 quintal/ha. As can be seen, adopters exceed 2.56 quintal/ha compared to non-adopters. Another notable result is that there is a significant production mean difference between adopters and non-adopters.

**Table-6: Production of soybean per hectare**

| Adopter Category | Obs | % | production ha-1 (Kg) | SD | Min | Max | T-test |
|---|---|---|---|---|---|---|---|
| Non-adopters | 111 | 36.04 | 12.95 | 2.849 | 7.5 | 26.52 | 3.024** |
| Adopter | 197 | 93.96 | 15.51 | 2.482 | 9 | 22.5 | |
| Total | 308 | 100 | 14.23 | 2.66 | 8.25 | 24.51 | |

Source: computed from own survey, 2024 *** $p<0.01$, ** $p<0.05$, * $p<0.1$ and ns $P>0.1$

### 4.2.5. Productivity performance of the varieties

According to the results shown in Table 9, adopters used TGX-1332644, Pawe-1, Pawe-2, and Belessa-95 improved soybean varieties. The Pawe Agricultural Research Center has verified these varieties and recommends that they be used in large-scale production. The results show that

9.10%, 22.40%, 18.83%, and 13.67% of adopters used TGX-1332644, Pawe-1, Pawe-2, and Belessa-95 varieties, respectively, while 36.00% of sampled households (non-adopters) used local variety seeds. Although the productivity of all improved varieties outperformed the native variety, the TGX-1332644 (16.11 Qt. ha-1) variety had the highest mean grain yield, followed by Pawe-2 (15.957 Qt. ha-1). Belessa-95 and Pawe-1 varieties had a mean grain yield of 15.335 and 14.928 quintals per hectare, respectively. The overall mean of improved seed users (adopters) was 15.633 quintals per hectare. The local variety produced the lowest mean grain yield, which is 12.945 quintals per hectare. The findings revealed that the TGX-1332644 variety had the highest yield advantage (3.366 quintal/ha) over the local variety, followed by Pawe-2 (3.012 quintal/ha). Belessa-95 and Pawe-1 varieties yielded 2.390 and 1.983 quintals per hectare, respectively, over the local seed users (non-adopters). Overall, the findings found that adopters of improved soybean varieties had a 2.688 quintal yield advantage per hectare over non-adopters.

**Table-7: Production of soybean varieties per hectare**

| Varieties | N | Percent | Mean grain yield (Qt. $ha^{-1}$ ) | SD | Yield increment over local variety (Qt. $ha^{-1}$ ) |
|---|---|---|---|---|---|
| TGX | 28 | 9.10 | 16.311 | 2.664 | 3.366 |
| Pawe-1 | 69 | 22.40 | 14.928 | 2.105 | 1.983 |
| Pawe-2 | 58 | 18.83 | 15.957 | 2.017 | 3.012 |
| Belesa-95 | 42 | 13.67 | 15.335 | 3.229 | 2.390 |
| Combined | 197 | 64.00 | 15.633 | 2.504 | 2.688 |
| Local | 111 | 36.00 | 12.945 | 2.848 | -- |
| Total | 308 | 100.00 | | | |

Source: own survey (2024).

### 4.3. Farmers Perception on improved soybean varieties attributes

Farmers‟ perception on use of improved soybean varieties is generally attached with the advantages of technology components. Farmers‟ examine the advantages from the point view of profitability and compatibility. Davis in (1989; pp. 26) suggested that the "degree to which a person believes that using a particular technology would enhance production" is a major factors that affecting the acceptance of a technology. Based on this farmer perception on improved soybean varieties have been included in this study. Accordingly, the rating such as strongly agree (5), agree (4), undecided (3), disagree (2) and strongly disagree (1) were used to measure the respondents perception to the technology. The value (5) indicates that how farmers perceived a technology as highly positive and value less than (3) shows how farmers perceived the technology as a negative or poor. According to Table 12, the grand mean (1.52) shows that the overall perception of the respondents based for the given attributes were positive. The result also shows that farmers‟ perception on straw biomass (2.51) and disease resistant (1.99) capacity were negative. Negative perception for straw biomass of improved soybean varieties could be due to farmers need high biomass straw for livestock feeding, but the qualities of improved seed straw is lower biomass. The reason for the lower perception of disease resistance was because of leaf blotch disease occurrence in soybean varieties as evidenced by focus group discussion and the key informant interviews. But farmers reported that the severity of the disease was not serious to cause substantial yield loss.

**Table-10: Farmers‟ perception on improved soybean varieties attributes**

| No | Attributes of the vriety | Distribution of respondents based on perception of improved soyben varieties (Frequency) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Stongly disagree | disagree | Undecieded | agree | strongly agree | Item mean | Std.dev |
| 1 | Yield | 0 | 4 | 8 | 11 | 285 | 1.13 | 0.49 |
| 2 | Branching | 0 | 5 | 12 | 5 | 286 | 1.14 | 0.54 |
| 3 | Drought resistant | 0 | 3 | 105 | 0 | 200 | 2.36 | 0.50 |
| 4 | Disease resistant | 0 | 11 | 16 | 239 | 42 | 1.99 | 0.57 |
| 5 | Resistant to shattering | 0 | 6 | 15 | 88 | 119 | 1.44 | 0.68 |
| 6 | Marketability | 0 | 0 | 0 | 0 | 308 | 1 | 0 |
| 7 | Bettre price | 0 | 0 | 0 | 0 | 308 | 1 | 0 |
| 8 | Seed size | 0 | 0 | 19 | 9 | 280 | 1.15 | 0.50 |
| 9 | Straw biomass | 0 | 48 | 90 | 142 | 28 | 2.51 | 0.86 |
| | Sum of mean | | | | | | 13.72 | 4.14 |
| | Grand mean | | | | | | 1.52 | |

Source: own survey 2024

### 4.4. Econometrics Analysis

#### 4.4.1. Determinants of adoption of improved soybean varieties

As shown in the model specification test, the log likelihood ratio (LR) value shows the reliability of the double hurdle model for this study. This implies that the factors that determine the adoption decision and intensity of improved soybean varieties production run in two- stages separately. The first hurdle indicates how given variables determine the likelihood of an adoption decision for improved soybean varieties production. The second hurdle indicates how variables affect the intensity of adoption of improved soybean varieties production. As shown in Table 11, the Wald chi-square value of 104.18 is statistically significant at the 1% level of significance, indicating that the explanatory variables in the model jointly explain both the probability of adoption and the intensity of adoption of improved soybean production.

**Distance to the nearest market (DISMARK):** it has a negative effect and statistical significance at 1% on the adoption decision of an improved soybean variety. When other variables were held constant, a 1-minute distance increase in the input market from the farmer's residence caused the adoption decision of the improved soybean varieties to decrease by 2.8%. This implies that the nearest farmers can get market information and agricultural inputs (fertilizer, certified improved seed, insecticide, and herbicide on time from the primary cooperative) more quickly than distant farmers. The result is consistent with previous studies by (Gedefaw, 2019) found that distant farmers from input provider centers were affect negatively the adoption decision and intensity of improved maize BH540.

**Training on soybean production (TRANSOY):** is significantly and positively influenced the adoption decision of improved soybean varieties at the 1% significance level. When all other variables are held constant, participating in farm training increases the probability of improved soybean varieties adoption decisions by 13.3%. This suggests that farm training may enable farmers to acquire sufficient knowledge and skills for improved soybean varieties adoption, increasing the likelihood that respondents will accept the technology. The result is harmony with the study by (Gedefa, 2010), (Daniel Masresha et al., 2017) and (Hagos & Girma, 2018).

**The frequency of extension contact (FREQEXCONT):** it has positively and significantly influenced the adoption decision of the improved soybean varieties at the 1% level of significance. The marginal effect shows that one more extension contact between farmers and agricultural extension experts increases the probability of improved soybean varieties adoption by 4.2%, ceteris paribus. This implies that frequent extension contact creates knowledge and updated information about improved soybean varieties. The result is harmony with the study by (Duressa, 2015) frequency extension contact between farmers and extension agents was positively and significantly influence on adoption decision Quncho tef in Wayu Tuqa district, respectively.

**Field day participation (PARTFILDVIST):** is positively and significantly influenced the adoption decision of improved soybean production at the 1% level of significance. All other variables held constant, participation in field day visits increases the probability of an improved soybean varieties adoption decision by 94.7%. This implies that the demonstration approach is one of the important approaches to transferring practical knowledge on agricultural production and technologies to farmers. When farmers conduct a new practice, they can weigh the advantages and disadvantages of the new technology, which can facilitate adoption and help them implement the new technology properly. This result shows that farmers who participate in demonstration activities are more likely to adopt new, improved technology than others. This suggests that wider demonstration would speed up the adoption of agricultural packages and hence calls for development of the existing limited demonstration practices. Similar results were reported by (Bezabih, 2012), (Kedir et al., 2017) and (Tesfaye Tegegne, 2021). These studies indicated that demonstration and dissemination of information through field day and demonstration activities might facilitate adoption of improved varieties.

**Farm size (FARSIZ):** is negatively and significantly influenced the adoption decision of improved soybean production at the 5% level of significance. All other variables were held constant, but the result was unexpected because, under many adoption studies, farmers who have more land were assumed to adopt better new technologies than their counterparts. In this study, however, the finding was the inverse. Thus, model output revealed that one ha of additional land owned by sample farmers decreased their adoption decision probability by 28.6%. This implies that smallholders who have lower landholdings are more likely to strive to adopt improved soybean varieties to compensate for the limitations of crop production due to land shortages than farmers who have more land. On the other hand, farmers who have large landholdings might be rented out because of a lack of finance or awareness of how to utilize their land. The result is contradicted with the work of (Khonje et al., 2015).

**Total annual income (ANUINC):** it has positive and statistical significance at 1% on the adoption decision of improved soybean varieties. When other variables were held constant, we found out that for every one unit increase in income, the adoption decision for improved soybean production increased by 2.1%. This implies that a farmer who has a better income will be more likely to adopt improved soybean varieties. This may be due to the resource-demanding nature of improved soybean production activity, particularly when the production purpose is beyond home consumption and for commercial purposes. Regarding the influence of farm income on adoption, many other studies have also found similar results. The result is in line with the finding of similar studies by (Gedefa, 2010) and (Beshir et al., 2012).

#### 4.4.2. Determinants of intensity of adoption of improved soybean varieties

This section focuses on factors that determine farmer's intensity of adoption of improved soybean production. As shown in the second hurdle (truncated regression), three predictor variables from 12 explanatory variables significantly determined the intensity of adoption of improved soybean production technology packages. (see Table 11).

**Access to credit (ACCCREDIT):** is significantly and positively influenced the adoption intensity of improved soybean varieties at the 10% significance level. When all other variables are held constant, access to credit increases the adoption intensity of improved soybean varieties by 4.5%. From this result, it can be stated that those farmers who have access to credit are in their district. The possible reason would be that all farmers who need cash for their farm activities do not take credit because of fear of the high interest rate that indebts them, as the focus group discussion revealed. Those who take credit are relatively in a better economic situation and can pay the credit back. Farmers who can take credit can buy improved seeds and other farm inputs, while cash-constrained farmers cannot. This finding is congruent with (Beshir, 2014), and (Eba & Bashargo, 2014).

**TLU:** The number of livestock holdings in terms of tropical livestock units has positively and significantly influenced the adoption intensity of improved soybean varieties at the 1% level of significance. When other variables were held constant, the result of the study revealed that as the livestock size (TLU) of a household increased by 1 unit, the intensity of improved soybean production would increase by a factor of 2%. This implies that a farmer who has more livestock will be more likely to influence the intensity of improved soybean varieties production. This may be due to the fact that having more livestock offers a means for a better propensity to buy improved soybean seed, and farmers who have a large number of livestock might consider their asset base as a mechanism for ensuring any risk associated with the adoption intensity of improved soybean production. The same results were reported by (Burke, 2009) and (Weyessa, 2014). This implies that livestock holding has an influence on the adoption of new technology in different areas.

**SOYPROD**: is significantly and positively influenced the adoption intensity of improved soybean varieties at the 1% significance level. When all other variables are held constant, increase in soybean output by one quintal increases the adoption intensity of improved soybean varieties by 2.8%. This was eventually expected since households that have greater production have more surpluses they can sell. The findings of this study are consistent with another study that households with a higher value of crop produced sell a higher proportion of their produce (Awotide et al., 2016; Mather et al., 2011).

**Table-11: Estimates of double hurdle model for adoption of improved soybean production**

| | | First hurdle (Tier1) | | First hurdle (Tier2) | | |
|---|---|---|---|---|---|---|
| Variables | Coef. | Marginal effect | Robust Std.Err | Variables | Coef. | Robust Std.Err |
| AGEHH | 0.028 | 0.007 | 0.021 | AGEHH | -0.003 | 0.003 |
| SEXHH | -0.413 | -0.089 | 0.321 | SEXHH | 0.037 | 0.035 |
| EDUHH | 0.168 | 0.040 | 0.126 | EDUHH | -0.012 | 0.011 |
| FAMLABFORCE | -0.081 | -0.019 | 0.151 | FAMLABFORCE | 0.011 | 0.013 |
| DISMARK | -0.028 | -0.007 | 0.005 | DISMARK | 0.001 | 0.001 |
| TRAINSOY | 1.133 | 0.282 | 0.277 | TRAINSOY | 0.031 | 0.027 |
| FRQEXCONT | 0.042 | 0.010 | 0.011 | PARTFILDVIST | 0.005 | 0.026 |
| PARTFILDVIST | 0.947 | 0.237 | 0.274 | COOPMEM | 0.002 | 0.027 |
| ACCCREDIT | 0.665 | 0.155 | 0.273 | ACCCREDIT | 0.045* | 0.023 |
| COOPMEM | 0.211 | 0.051 | 0.286 | TLU | 0.020*** | 0.004 |
| FARSIZ | -0.286 | -0.069 | 0.136 | FARMEXP | 0.001 | 0.003 |
| TLU | 0.021 | 0.005 | 0.066 | SOYPROD | 0.028*** | 0.006 |
| ANUINC | 0.021 | 0.005 | 0.004 | | | |
| _cons | -5.939 | | 1.303 | | 0.186 | 0.154 |
| sigma _cons | 0.148 | | 0.007 | | | |
| Number of obs = 308 Wald chi2(15) = 104.18<br>Prob > chi2 = 0.0000 Log pseudolikelihood = 45.009892 | | | | | | |

Source: own estimation result, 2024 *** p<0.01, ** p<0.05, * p<0.1

### 4.5. Endogenous Switching Regression Model Result

The full information and maximum likelihood estimates of the determinants of adoption of ISVs (selection equations) and impacts of the adoption on soybean yield and net crop income (outcome equations) in the ESR model are presented in Appendix 1 and Appendix 2, which present estimates of the selection equations for soybean yield and net crop income, respectively. The estimates of the selection equations show that variables representing sources of information about ISVs, such as access to extension contact, education, land sizes, and family size, are significantly associated with the decision to adopt ISVs.

The education level of the household head was found to have a positive and significant influence on soybean productivity for the adopters at the 1% level of significance. This means farming households with more education have the possibility of obtaining higher yields and improving their livelihood. Moreover, they engage themselves and their family members in various non-farm income-generating activities. (Urassa, 2010), argues that households with more education or other forms of human capital stand a better chance of engaging in nonfarm income or credit, and they, therefore, could be more able to afford inputs and thereby becomes more efficient in their farming practices. The result of this variable is consistent with the study done by (CHIROTAW, 2020).They reported that in rural areas, education improves agricultural productivity, leading to food security.

The frequency of extension contact positively and significantly influences improved soybean varieties productivity for adopters at the 5% level of significance, indicating that soybean growers who had access to extension are more likely to adopt ISVs compared to soybean growers who had no access to extension, which is in agreement with previous adoption studies by (Abdulai & Huffman, 2014) and (Tufa et al., 2019). Access to extension is expected to improve knowledge of soybean growers about the benefits related to ISVs.

Farm size has a positive and significant influence on improved soybean varieties productivity for adopters at the 1% level of significance, and this is also consistent with the findings of (Abdulai & Huffman, 2014). Land is the main production asset for farmers and an indicator of wealth.

Wealthier soybean growers are expected to gain more income than poorer households growing soybean.

The family labor force is positively and significantly correlated with income, and the correlation is significant at the 10% and 5% levels only for adopters and non-adopters. This suggests that larger households increase household income. Since they have more labor to manage inputs, they are able to produce and gain income. The argument was that larger households have the capacity to relax the labor constraints required during the introduction of new technologies. The result is consistent with (Seng, 2016), finding on Effects of market participation on farm households' food security.

### 4.5.1. Impacts of improved soybean varieties adoption on soybean productivity and income

This sub-section discusses the second stage of endogenous switching regression (ESR) model results using average treatment on the treated (ATT) and average treatment on the untreated (ATU). The primary outcome variable related with the adoption of enhanced soybean varieties is shown in Table 12. In this study, the average productivity of improved soybean varieties was calculated. According to the second stage ESR treatment impact model, adopters' (treated) average soybean productivity is 14.632 quintals higher than that of non-adopters, and their net income is 11064.24 ETB higher than their counterparts. However, if adopters had not adopted improved soybean varieties, their soybean productivity and net income would have declined by 0.723 quintal and 27531.02 earnings, respectively.

Similarly, if non-adopters had chosen to use improved soybean varieties, their net-income and productivity would have increased from 24698.19 to 13283.16 ETB and from 12.990 quintal to 13.476 quintal ha-1, respectively. Because farmers with improved soybean varieties adopters had higher differences in their net income and ha-1 productivity of soybeans between the treated (BH1T) and untreated (BH2T) groups, the transitional heterogeneity effect was also positive. That was 2218.92 ETB and 1.156 quintal ha-1 (Table 12).

**Table-12: Expected conditional and average treatment effect of ISV on soybean productivity and income**

| Outcome variables | Categories | Decision stage | | Adoption effect |
|---|---|---|---|---|
| | | ISV adopter | ISV non-adopter | |
| Soybean productivity | ATT | 15.355 | 14.632 | 0.723*** |
| | ATU | 12.990 | 13.476 | 0.486*** |
| | HE | BH1=2.365 | BH2=1.156 | 1.209 |
| Soybean income | ATT | 38595.26 | 11064.24 | 27531.02*** |
| | ATU | 24698.19 | 13283.16 | 11415.03*** |
| | HE | BH1=13897.07 | BH2=2218.92 | 11678.15 |

Source: computed from own survey, 2024 *** p<0.01, ** p<0.05, * p<0.1

# CHPTER FIVE: CONCLUSSIONS AND RECOMMENDATIONS

## 5.1. Conclusions

The research would like to conclude its observations on the level or intensity of adoption of improved soybean varieties, its determinants and impacts on productivity and income and as well as the perception of stallholder farmers that specialize on improved soybean production. Farmers that have soybean technology varieties were found to be those who participated in field days, receive agricultural training, and have frequent extension contacts. These actions also prevent income and credit access for improved soybean varieties. The results also show that the use of improved soybean production technology has intensified due to factors such as sex, annual income, TLU, and family labor force. The result additionally validates that the distance to the input market, household age, and seed cost represent significant obstacles to the widespread adoption of this technology.

An endogenous switching regression model was used to assess the effects of better soybean varieties adoption, correct selection bias, and guarantee that the results were consistent under multiple assumptions. The ESR model results showed that increased soybean varieties adoption significantly increases soybean productivity and household income. As a result, soybeans can help to fill seasonal gaps in household income diversification.

Farmer's perception towards the relative advantages of improved soybean varieties shows that high yield, branching drought resistant, resistant to shattering, marketability, seed size and better price were perceived by farmers as the most crucial attributes of improved soybean varieties, whereas straw biomass and disease resistant were perceived as the least importance of attributes of the technology.

## 5.2. Recommendations

This study's findings indicate recommendations for future research, policy, and development interventions to boost adoption of enhanced soybean technology and improve productivity and livelihoods for smallholder farmers. Given the key findings on the pertinent themes of the research on adoption, adoption intensity, determinants and impacts as well as perception of farmers, the following are recommended for further interventions by the actors in the study themes:-

- Currently, edible oil factories are being established at the country level with the goal of meeting domestic oil consumption by substituting imported oil, with soybeans serving as the primary crop for oil production. However, current output levels are quite low, and this is the primary threat to the factories. As a result, farmers, professionals, researchers, and other stakeholders must work tirelessly to improve soybean production in order to assure long-term domestic oil production.

- The existing improved soybean varieties are lower disease resistant as the farmer's perception. Therefore, Agricultural research centers are expected to work together to eliminate the bottleneck of soybean disease through hybridization. Post-harvest loss assessment procedures for soybean technologies may be future research objectives.

- Finally, to mitigate factors negatively associated with improved soybean varieties production, the research strongly recommended lifting seed cost as a barrier for farmers to use and recycled seed for 3–5 years and strengthening the farmer in community based seed multiplication system, revolving seed scheme by improving farmers‟ skills in seed multiplication can assist in increasing the supply of seed for improved soybean varieties both within communities.

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# APPENDIX

Appendix Table 1. Endogenous switching regression model results the impact of improved soybean varieties on soybean productivity

| Variables | Soybean productivity | | | | |
|---|---|---|---|---|---|
| | Non- adopter | | Variables | Adopter | |
| | Coefficient | St errs. | | Coefficient | St errs. |
| AGEHH | 0.003 | 0.005 | AGEHH | -0.003 | 0.003 |
| SEXHH | -0.054 | 0.035 | SEXHH | 0.080** | 0.026 |
| EDUHH | 0.041** | 0.018 | EDUHH | 0.015 | 0.011 |
| FAMLABFORCE | -0.018 | 0.017 | FAMLABFORCE | -0.010 | 0.012 |
| DISMARK | 0.000 | 0.000 | DISMARK | -0.001 | 0.001 |
| TRAINSOY | -0.029 | 0.038 | TRAINSOY | -0.022 | 0.023 |
| FRQEXCONT | 0.003** | 0.001 | FRQEXCONT | 0.002*** | 0.001 |
| PARTFILDVIST | 0.021 | 0.039 | PARTFILDVIST | -0.029 | 0.023 |
| ACCCREDIT | 0.019 | 0.043 | ACCCREDIT | -0.008 | 0.021 |
| COOPMEM | 0.002 | 0.037 | COOPMEM | -0.015 | 0.024 |
| FARSIZ | -0.083*** | 0.017 | FARSIZ | -0.024** | 0.011 |
| TLU | -0.000 | 0.007 | TLU | 0.007 | 0.005 |
| FARMEXP | 0.002 | 0.005 | FARMEXP | 0.006** | 0.002 |
| ANUINC | 0.001** | 0.000 | ANUINC | 0.001*** | 0.000 |
| _cons | 2.278 | 0.151 | _cons | 2.613 | 0.129 |
| | | | select | | |
| | | | SOYMARKPRI | 0.001 | 0.000 |
| Number of obs = 308<br>Wald chi2(15) = 107.84<br>Prob > chi2 = 0.0000<br>Log likelihood = -173.68173 | | | | | |

Source: own estimation result, 2024 *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 2: Endogenous switching regression model results the impact of improved soybean varieties on annul income.

| Variables | Net income(annul income) | | | | |
|---|---|---|---|---|---|
| | Non- adopter | | Variables | Adopter | |
| | Coefficient | St errs. | | Coefficient | St errs. |
| AGEHH | -0.038** | 0.019 | AGEHH | -0.009 | 0.009 |
| SEXHH | 0.127 | 0.139 | SEXHH | -0.027 | 0.094 |
| EDUHH | 0.039 | 0.075 | EDUHH | -0.042 | 0.036 |
| FAMLABFORCE | 0.147** | 0.066 | FAMLABFORCE | 0.063 | 0.038 |
| DISMARK | -0.000 | 0.002 | DISMARK | 0.000 | 0.003 |
| FRQEXCONT | -0.000 | 0.006 | FRQEXCONT | 0.000 | 0.004 |
| COOPMEM | -0.046 | 0.151 | COOPMEM | 0.056 | 0.083 |

| | | | | | |
|---|---|---|---|---|---|
| ACCCREDIT | -0.143 | 0.169 | ACCCREDIT | 0.115 | 0.071 |
| TRAINSOY | 0.010 | 0.153 | TRAINSOY | -0.021 | 0.077 |
| FARSIZ | 0.317*** | 0.066 | FARSIZ | 0.190*** | 0.033 |
| TLU | -0.009 | 0.028 | TLU | -0.033** | 0.014 |
| FARMEXP | 0.024 | 0.019 | FARMEXP | 0.001 | 0.008 |
| SOYPROD | 0.102*** | 0.026 | SOYPROD | 0.058*** | 0.015 |
| _cons | 7.661 | 0.638 | _cons | 9.338 | 0.450 |
| | | | select | | |
| | | | PARTFILDVIST | 1.379 | 0.167 |
| Number of obs = 308<br>Wald chi2(15) = 107.84<br>Prob > chi2 = 0.0000<br>Log likelihood = -173.68173 | | | | | |

Source: own estimation result, 2024 *** p<0.01, ** p<0.05, * p<0.1

Appendix Table 3. Topical livestock unit conversion factor (TLU)

| Livestock category | Conversion factors |
|---|---|
| Ox | 1.1 |
| Cow | 0.8 |
| Bull | 1.1 |
| Heifer | 0.5 |
| Calf | 0.2 |
| Sheep | 0.09 |
| Goat | 0.09 |
| Mule | 0.8 |
| Donkey | 0.36 |

Source: ILRI (International Livestock research Institute)

Appendix Table 4.Omitted variable test using Ramsey RESET for 2nd hurdle

| Hypothesis | Ramsey RESET result | Decision |
|---|---|---|
| **H0**: models has omitted variables | F(3, 290) = 0.54 | Reject **H0** |
| **H1:** models has no omitted variables | Prob > F = 0.64 | |

Source: Computed from own survey, 2024

Appendix Table 5. Multicollinearity Test using VIF for 1st hurdle (Probit) variables

| | VIF | 1/VIF |
|---|---|---|
| FARMEXP | 2.276 | .439 |
| FAMLABFORCE | 2.223 | .45 |
| SOYPROD | 1.146 | .872 |
| TLU | 1.116 | .896 |
| DISMARK | 1.057 | .946 |
| Mean VIF | 1.564 | . |

Source: Computed from own survey, 2024

Appendix Table 6. Breusch-Pagan/Cook-Weisberg test for heteroscedasticity for 2nd hurdle

| Hypothesis | Breusch-Pagan test result | Decision |
|---|---|---|
| **H0: Constant variance** | chi2(1) = 10.36 | There is no any evidence to reject **H0** |
| **Hl: No-constant variance** | Prob > chi2 = 0.0013 | |

Source: Computed from own survey, 2024

Appendix Table 7. Multicollinearity test using VIF for 2nd hurdle (Truncated) variables

| | VIF | 1/VIF |
|---|---|---|
| FARMEXP | 2.276 | .439 |
| FAMLABFORCE | 2.223 | .45 |
| SOYPROD | 1.146 | .872 |
| TLU | 1.116 | .896 |
| DISMARK | 1.057 | .946 |
| Mean VIF | 1.564 | . |

Source: Computed from own survey, 2024

Appendix Table 8. Collinearity test for 1st hurdle (Probit) categorical variables

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| (1) SEXHH | 1.000 | | | | | |
| (2) EDUHH | 0.124 | 1.000 | | | | |
| (3) TRAINSOY | 0.201 | 0.230 | 1.000 | | | |
| (4) PARTFILDVIST | 0.170 | 0.192 | 0.307 | 1.000 | | |
| (5) ACCCREDIT | 0.110 | 0.149 | 0.261 | 0.330 | 1.000 | |
| (6) COOPMEM | 0.254 | 0.201 | 0.308 | 0.319 | 0.355 | 1.000 |

Source: Computed from own survey, 2024

Appendix Table 9. Collinearity test for 2nd hurdle (Truncated) categorical variables

| Variables | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| (1) SEXHH | 1.000 | | | | | |
| (2) EDUHH | 0.124 | 1.000 | | | | |
| (3) TRAINSOY | 0.201 | 0.230 | 1.000 | | | |
| (4) PARTFILDVIST | 0.170 | 0.192 | 0.307 | 1.000 | | |
| (5) COOPMEM | 0.254 | 0.201 | 0.308 | 0.319 | 1.000 | |
| (6) ACCCREDIT | 0.110 | 0.149 | 0.261 | 0.330 | 0.355 | 1.000 |

Source: Computed from own survey, 2024

Appendix Table 10. Tobit model Vs. Double-Hurdle model

| | Probit | Truncated reg. | Tobit | Hypotheses | Tabulated value |
|---|---|---|---|---|---|
| No of observation | 308 | 308 | 308 | **H0**:Tobit model is appropriate<br>**H1:** DH model is appropriate | $\chi^2$ (0.05, 15)=25.00 |
| Wald $\chi^2$ (15) | 129.54 | | 334.85 | | |
| F (13,211) | | 38.27 | | | |
| Prob > chi2 | 0.000 | | 0.000 | | |
| Prob > F | | 0.000 | | | |
| Log Likelihood | -46.8 | 273.02 | -28.96 | | |
| Calculated value: LR= -2[lnLT- (lnLP+ lnLTR)] => 2[(-46.8) +( 273.02)- (-28.96)] = 510.36 | | | | | |
| Decision = Reject **H0** | | | | | |

Source: Own estimation result, 2024

Appendix Table 11. Independent double hurdle vs heckman two-stage model

| Model | Hypotheses | Test value | Decision |
|---|---|---|---|
| Heckman Vs DH | **H0:** there is no selection bias | [mills] lambda = 0 chi2 (1) =(0.730) | Fail to reject **H0** at 10% |
| | **H1**: there is selection bias | Prob > chi2 = 0.0000 | |

Source: Own estimation result, 2024

# Household Questionnaire

**Questionnaire ID** ____________________

**Checked by:**

Study on Analysis Of Belesa-95 Soybean Variety Adoption: Perceptions, Determinants And Impacts On Productivity And Income Of Smallholder In Pawe District, Benishngul Gumuz Region, Ethiopia Household Survey Questionnaire(2015/16 E.C Cropping Year)

**PART A: HOUSEHOLD AND VILLAGE IDENTIFICATION**

1. Region ________________________
2. Zone ________________________
3. District ________________________
4. Kebele __________________________
5. Village __________________
6. Date of interview __________/________/___________
7. Name of Enumerator _______________________________________
8. Name of household head (include grandfather name) ______________________________________
9. Name of respondent (if other from household head) ______________________________________
10. Sex of household head ☐ ( Male = 1; Female = 0)
11. Age of the Household head in years ☐
12. Number of years the household head has been living in this Kebele _________________
13. Level of education of household head in years completed________________
14. Religion of the household head

    1. Orthodox 2. Muslim 3. Protestant 4. Catholic 5. No religion/atheist

15. Farming experience in years_________________
16. Experience in growing soybean in years ________________

**PART B: FAMILY SIZE AND COMPOSITION**

1.Total family size _________________

| Age class | All | | | Dependents | | |
|---|---|---|---|---|---|---|
| | Male | Female | Total | Male | Female | Total |
| Up to 14 years | | | | | | |
| Between 15 and 65 inclusive | | | | | | |
| Above 65 years | | | | | | |
| Total | | | | | | |

**PART C: PHYSICAL, FINANCIAL, AND SOCIAL CAPITAL**

C.1 Main source of income for the family

1. From own agriculture product
2. Non/ Off farm business
3. Gift and remittance from GOV
4. Gift and remittance from NGO
5. Gift and remittance from household/individual (in the country or abroad)
6. Pension
7. Other , specify

C.2 Share of agriculture in total family income ________ (%)

C.3 Are you model farmer? __________ (1=Yes, 0=No)

C.4 Number of rooms in the main residence of household ______

C.5 Is household head a member of any community leadership? __________ (1=Yes, 0=No)

C.6 Is the household head a member of any organization or association? __________ (1=Yes, 0=No).

C.7 Do you know people planting/use any improved soybean variety in your village?______(1=Yes,0=No)

C.8 Do you have reliable sources for borrowing in times of need?_____ (1=Yes, 0=No)

C.9. If yes to C8, List sources 1. ________________ 2. _________________ 3.______________________

C.10.If yes to C.8, what is the maximum amount you can borrow from them? ________ ETB

C.11 If your crop fails, can you rely on government support (subsidies, food aid, etc.)? _____(1=Yes, 0=No)

C. 12Considering your own production & all income sources, how do you rate your family's food security?

1. Food secure, produce enough for family and able to sell significance portion of our production
2. Self-sufficient produce enough for the family
3. Face food shortage occasionally
4. Face severe food shortages for most months in a year

**C13: How many of the following assets do you have**

| Asset Category | Asset type | Does the household own (1=Yes; 0=No) | Number owned | Average current value of assets |
|---|---|---|---|---|
| Farm implements | Plow (set) | | | |
| | Spade or shovel | | | |
| | Knapsack | | | |
| | Water pump | | | |
| Transport | Animal Cart (any) | | | |
| | Bicycle | | | |
| | Motorbike | | | |
| | Bajaj | | | |
| | Car | | | |
| Communication and solar power | Radio | | | |
| | Mobile phone | | | |
| | Cassette or CD player | | | |
| | TV | | | |
| | Solar energy | | | |
| House | Thatched roof | | | |
| | Tin (corrugated) roof | | | |

**C14. How many of the following livestock do you have?**

| S. N. | Animal type | | Does the household own 0=No, 1=yes | Number owned |
|---|---|---|---|---|
| 1 | Indigenous cows | | | |
| 2 | Crossbred/exotic cows | | | |
| 3 | Oxen | | | |
| 4 | Bulls | | | |
| 5 | Heifers | | | |
| 6 | Calves | | | |
| 7 | Small livestock (goats + sheep) | | | |
| 8 | Donkeys | | | |
| 9 | Horse | | | |
| 10 | Mule | | | |
| 11 | Poultry (local chicken, improved chicken, | | | |
| 12 | Bee hives with colony | Modern and transition | | |
| | | Traditional | | |

**C15. Land ownership and tenure system in 2015/16 E.C.**

C15.1. Total land holding _______________ (ha)

| No | Type | Land area by tenure system (in ha) | | | | |
|---|---|---|---|---|---|---|
| | | Own land cultivated | Rented in | Rented out | Shared in | Shared out |
| **A** | **System** | | | | | |
| 1 | Rain fed | | | | | |
| 2 | Irrigable | | | | | |
| Total | | | | | | |
| **B** | **Crop** | | | | | |
| 1 | Soybean | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |
| 7 | | | | | | |
| Total | | | | | | |

**PART D: IMPROVED CROP VARIETY KNOWLEDGE AND ADOPTION/ DISADOPTION**

**D.1 Soybean variety knowledge, sources of information, seed, adoption and dis-adoption**

D.1.1 Have you grown local varieties of soybean? ______ (1. Yes 0=No)

D1.2 If yes, how certain are you about the origin and purity of the seed? 1. Very 2.Modest 3.Not sure

D1.3 Have you grown improved soybean varieties? ______(1. Yes 0=No)

D1.4 If yes, how certain are you about the origin and purity of the seed? 1. Very 2.Modest 3.Not sure

D1.5 How do you verify the origin and purity of seeds?

_____________________________________________

D 1.6 Which improved soybean variety are growing? _____________________

D1.7 What is the name of your most preferred soybean variety (that you know or heard about)?_______________

D1.8 Do you cultivate that variety? ______________ (1=Yes, 0=No)

D1.9 If No to D1.8, why not? ________

1. Seed not availability 2. Seed price 3. Access to credit 4. Susceptible to disease/pest
5. Low/poor yield 6. Taste in consumption 7. Other, specify______________

D1.10 If no to D1.8, how do you think can this problem be solved?

________________________________________

D1.11 In your opinion, what do you think is the most important problem related to varietal acquisition?

__________________________________________________________________________________

____

D1.11 Are you still growing improved soy bean variety?_____________(1=Yes 0=No)

D1.12 If no to D1.11

Why?____________________________________________________________________

D1.13 Have you heard of Bio-fertilizer?_____________(1=Yes 0=No)

D1.14 If yes, When (state the year)__________________

D1.15 Have you used Bio-fertilizer?_____________(1=Yes 0=No)

D1.16 If no to D1.15 Why?

_________________________________________________________________

**D2.Variety Attributes Influencing Adoption**

**D2.1Which attributes are important in your soybean variety selection decision**

[Provide ratings on 1to5 scales, 5 being most important and 1 being not important] **scoring main local variety first**

| **Characteristics** | **Improved Soybean varieties** | | | |
|---|---|---|---|---|
| **Production characteristics** | | | | |
| Yield | | | | |
| Yield stability | | | | |
| Vigoursity | | | | |
| Drought tolerance | | | | |
| Frost tolerance | | | | |
| Disease tolerance | | | | |
| Insect tolerance | | | | |
| Labor demand | | | | |
| Inputs demand (e.g., fertilizer) | | | | |
| **Market and economics** | | | | |
| Marketability (demand) | | | | |
| Better price (Birr /unit) | | | | |
| **Consumption characteristics** | | | | |
| Store ability | | | | |
| Taste | | | | |
| Other specify......... | | | | |
| **Overall rank for variety** | | | | |

| Characteristics | Improved Soybean varieties | | | |
|---|---|---|---|---|
| **Production characteristics** | | | | |
| Maximum amount you are willing to pay for the seed of the soybean variety of your best choice (ETB /kg) | | | | |
| **Straw for animal feed** | | | | |
| Other specify......... | | | | |

NOTE; Rates for Q D2.1

1. strongly disagree
2. disagree
3. undecided
4. agree
5. strongly agree (5),

## PART E: AGRICULTURE PRODUCTION

E1.Crop production and utilization in **2015/16**

| No | Name of crop | Area[1] (in ha) | Type of stress if any Code A | Amount produced in 2015/16 (Qt) | Amount carried over from 2014/15 (Qt) | Amount Purchased in 2015/16 (Qt) | Utilization in 2015/16 (A+B+C=D+E+F+G) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Sold (Qt) | Sales price (Birr/qt) | Consumed (Qt) | Other (Qt) | Amount carried to 2016/17 |
| 1 | Soybean | | | | | | | | | | |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | | | | | |
| 4 | | | | | | | | | | | |
| 5 | | | | | | | | | | | |
| 6 | | | | | | | | | | | |
| | Total | | | | | | | | | | |

**CODE A**

1. No Stress
2.Insects/pests
3.Disease
4.WaterLogging
5.Drought
6.Frost
7.Hailstorm
8.Animal trampling
9.Other, specify……………

[1] Refer area cultivated from table- C15

E2. Crop production for the last two years (**2014/15** and 2015/16)

| **Year** | **Name of crop** | **Type of variety Local=1 Improved=2 Both=3** | **Total area sown (ha)** | **Qty of seed applied (kg)** | **Unit price of seed (Birr/kg)** | **Qty of fertilizer applied (kg)** | **Unit price of fertilizer (Birr/kg)** | **Qty of chemical applied (lt/kg)** | **Unit price of chemical (Birr/kg/lt)** | **Total Output (Qt)** |
|---|---|---|---|---|---|---|---|---|---|---|
| 2014/15 | Soybean | Local | | | | | | | | |
| | | Improved | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| 2015/16 | Soybean | Local | | | | | | | | |
| | | improved | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
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**E3. AGRICULTURAL ACTIVITIES (2015/16)**

E3.1 Cropped land area with Soybean _____________ha

E3.2 Cost of production of Soybean

| No | Type of farm Activities | Unit | Amount involved | Cost per unit per day (Birr) | Total Cost (Birr) | Gender participation Code A |
|---|---|---|---|---|---|---|
| 1 | Land clearing human labor | Man day | | | | |
| | material | | | | | |
| 2 | Ploughing(include frequency) Oxen | Oxen day | | | | |
| | human labor | Man day | | | | |
| | material | | | | | |
| 3 | Planting and Fertilizer application Oxen | Oxen day | | | | |
| | human labor | Man day | | | | |
| 4 | Weeding(include frequency)human labor | Man day | | | | |
| | material | | | | | |
| 5 | Hoeing Oxen | Oxen day | | | | |
| | human labor | Man day | | | | |
| | Material | | | | | |
| 6 | Spraying chemicals human labor | Man day | | | | |
| 7 | Bird scaring human labor | Man day | | | | |
| 8 | Harvesting human labor | Man day | | | | |
| | Food and drink | | | | | |
| 9 | Dumping human labor | Man day | | | | |
| 10 | Threshing Oxen/animal | Oxen day | | | | |
| | human labor | Man day | | | | |
| | Food and drink | | | | | |
| 11 | Transaction cost of inputs (seed, | | | | | |

| No | Type of farm Activities | Unit | Amount involved | Cost per unit per day (Birr) | Total Cost (Birr) | Gender participation Code A |
|---|---|---|---|---|---|---|
| | fertilizer) purchased | | | | | |
| 12 | Transaction cost of outputs (grain, ..) sold | | | | | |
| | | | | | | |
| Total (Birr) | | | | | | |

| | | |
|---|---|---|
| **Code A**<br>1. Husband only<br>2. Wife only<br>3. Husband and wife equally | 4. Husband mostly<br>5. Wife mostly<br>6. Children only | 7. Wife and children<br>8. Hired labor only<br>9. Husband and children<br>10. All equally |

## PART F: ACCESS TO INCOME SOURCE

## F1. INCOME SOURCES IN 2015/19

| Sources | Did you receive income from the following items?(1=Yes, 0=No) | If yes, actual amount received (Birr) | If payment was in-kind, what is the estimated value? (in Birr) | Total income (ETB) |
|---|---|---|---|---|
| 1. Rented/share cropped out land | | | | |
| 2. Rented out trucks, tractors, etc. | | | | |
| 3. Salaried/wage employment | | | | |
| 4. Income from trade | | | | |
| 5. Pension income | | | | |
| 6. Drought/flood relief | | | | |
| 7.Government transfer | | | | |
| 8. Remittances | | | | |
| 9. Sales of animals and by products | | | | |
| 10. Sale of crop residues /hay | | | | |
| 11. Quarrying (mining, hunting and fishing) | | | | |
| 13. Other sources (specify) -------------------- | | | | |

**PART- G: ACCESS TO FINANCIAL CAPITAL, INFORMATION AND INSTITUTIONS**

## G1. Access to financial capital and sources during 2015/16 cropping year

| **Reason for credit** | **Needed credit? Code A** | **If Yes in column 2, then did you get it? Code A** | If **Yes** in column 3, then source of credit, **Code B** | **If NO in column 3, then why not? Rank 3 (Code C)** | | | If yes to column 3, how much did you get, Birr | Did you get amount you requested **Code A** | Annual interest rate charged **(%)** |
|---|---|---|---|---|---|---|---|---|---|
| | | | | **1st** | **2nd** | **3rd** | | | |
| **Buying seeds** | | | | | | | | | |
| **Buying fertilizer** | | | | | | | | | |
| **Buying herbicide** | | | | | | | | | |
| **Buying pesticide** | | | | | | | | | |
| **Consumption needs (health, education, travel, tax, etc.)** | | | | | | | | | |
| | | | | | | | | | |

| **Code A** | **Code B:** | | **Code C** | | |
|---|---|---|---|---|---|
| **0. No**<br>**1. Yes** | **1. Money lender**<br>**2. Farmer group/coop**<br>**3. Revolving fund** | **4. Microfinance**<br>**5. Bank**<br>**6. Relative.**<br>**7.Other, specify** | **1. Borrowing is risky**<br>**2. Interest rate is high**<br>**3. Too much paper work** | **4. Expected rejection, so did not try it**<br>**5. No money lenders in this area for this purpose** | **6. Lenders don't provide the amount needed**<br>**7. No credit association available**<br>**8. Other, specify…** |

G17 Can you easily get a credit from a bank, cooperative, credit institutions, or other formal source to buy agricultural inputs (seeds, fertilizers, herbicides/pesticides? ______ 1= Yes; 0=No

G18 Did the household save money in 2014/15 in any form? ______________________ 1=Yes; 0=No

G19 If yes to G18 above, saving balance during 2014/15__________________Birr

## G2. Access to extension services for soybean and other crops production

| **Issue** | **In the last 5 years, did you receive training or information? (Code A)** | | **Main source of information in the last 5 years (Code B)** | | **Number of contacts -with extension agent 2015/16 for soybean(days/year)** |
|---|---|---|---|---|---|
| | **Soybean** | **Other crops** | **soybean** | **Other crops** | |
| New crop varieties | | | | | |
| Field pest and disease control | | | | | |
| Storage pests | | | | | |
| Markets and prices | | | | | |
| Seed markets and prices | | | | | |
| Other crops (___________) | | | | | |

| **Code A** | **Code B** | | | | |
|---|---|---|---|---|---|
| **0. No**<br>**1. Yes** | 1. Government extension service<br>2. Farmer Coop or groups | 3. Neighbor farmers<br>4. Seed traders/growers<br>5. Relative farmers | 6. NGOs<br>7. Private trader<br>8. School | 9. Research center<br>10. Newspaper<br>11. Radio/TV | 12. Nigerian Seed Enterprise<br>13. Mobile phone<br>14. Other, specify……. |

G26 Do you know the recommended fertilizer application rate for soybean? _____(1= yes; 0= No)

G27 If yes to G26, do you apply as per recommendation? _____(1= yes; 0= No)

G28 If no to G27, why not? ___________________________________________________________

G29 Do you know the recommended seed rate of soybean? _____(1= yes; 0= No)

G30 If yes to G29, do you apply as per recommendation? _____ (1= yes; 0= No)

G31 If no to G30, why not? ___________________________________________________________

G29 Have you visited demonstration fields or attended participatory soybean variety selection field days in the last three years?_____ (1= yes; 0= No)

G30 Have you hosted soybean demonstration/ soybean participatory variety selection in the last three years?_____ (1= yes; 0= No)

**G3. Marketing**

G31. If you sell your crop produce, when do you sell it?

1. Immediately after harvest 2. Piece by piece 3. After storing for some time

G32. Where did you sell your crop output? 1. Local market 2. District market 3. On-farm

G33. During the last two years, What is the major marketing problem for your product?

| Crops sold | Marketing problem in **2014/15** | Marketing problem in **2015/16** | |
|---|---|---|---|
| Soybean | | | **Code**<br>1. Low Price<br>2. Low bargaining power<br>3.No buyer<br>4. ____________<br>5. |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

* Main months of sale for soybean in 2015/16

| **Month** | **Share of sale (%)** | **Average Price** |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |

G34. Walking distance to the nearest main (District) market in minutes of walk _____________

G35. Transport cost per person to the nearest main market using a bus/other (in ETB/person)___________

G36. Transport cost per kg of crop output to the nearest market (in ETB /kg)_______________

G37. Walking distance to the nearest main source of agricultural inputs minutes of walk _____________

G38. Transport cost per person to the nearest main source of agricultural inputs using a bus (in ETB) ________

G39. Transport cost per kg of input (seed, fertilizer) from the nearest input market (in ETB/kg)_____________

G40. Are you a member of group marketers for your products? __________ (1= yes; 0= No)

G41. If yes, what is the advantage of the group to sell the product? __________________________________

G42. If yes, what is the disadvantage of the group to sell the product? ________________________________

G43. If not, why? ___________________________________________________________________________

## PART H. Farmers' perceptions on access constraints to key production inputs and services

| **Input and production constraints** | Is it a constraint now? **1=Yes; 0=No** | If yes in column 2, rate the problem (5 = most important and 1 = less important) | Was it a problem 10 years ago? **1=Yes; 0=No** | How did the situation change over the years? (1=improved, 2=Same 3=worsened) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |
| Timely availability of certified seed of improved varieties | | | | |
| Prices of certified seed of improved varieties | | | | |
| Timely availability of seed for landraces | | | | |
| Prices of seed for landraces | | | | |
| Getting seed for your preferred crop and variety each year | | | | |
| Getting required quantity of seed each year | | | | |
| Getting required quality of seed year | | | | |
| Availability of credit to buy soybean certified seed | | | | |
| Timely availability of fertilizers | | | | |

| Input and production constraints | Is it a constraint now? **1=Yes; 0=No** | If yes in column 2, rate the problem (5 = most important and 1 = less important) | Was it a problem 10 years ago? **1=Yes; 0=No** | How did the situation change over the years? (1=improved, 2=Same 3=worsened) |
|---|---|---|---|---|
| **1** | **2** | **3** | **4** | **5** |
| Price of fertilizers | | | | |
| Availability of credit to buy fertilizers | | | | |
| Availability of herbicides | | | | |
| Access to markets and information | | | | |
| soybean prices | | | | |

**PART I. How did the following conditions of producing and marketing improved varieties and local soybean and other crops change over the years?**

| S.N | Aspects of production/ marketing | Changes in recent years relative to previous years:<br>1= Decreased, 2=Same, 3=Increased | | | |
|---|---|---|---|---|---|
| | | Improved soybean varieties | Local soybean | Improved varieties of other crops | local of other crops |
| 1 | Number of plots | | | | |
| 2 | Total area under the variety | | | | |
| 3 | Yield | | | | |
| 4 | Prices | | | | |
| 5 | Market demand | | | | |
| 6 | Quantity marketed | | | | |
| 7 | Quantity consumed | | | | |
| 8 | Availability of fertilizer | | | | |
| 9 | Availability of herbicides | | | | |
| 10 | Availability of credit | | | | |
| 11 | Availability of extension services | | | | |
| 12 | Total area under all soybean or other crop varieties | | | | |

**Checklists for Key Informants Interview (KII)**

Please note that your insightful answers are crucial to our efforts in understanding overall assessment of adoption and impacts of improved soybean technology to small holder

1. Do many people participate in the agricultural extension services?

2. Do farmers participate in establishing improved soybean crop technology?

2.1. If yes, in what kinds of technologies? / improved feed,

3. What are the constraints for the adoption of improved soybean crop technologies?

4. What the community members involved in improved soybean extension (the rich/poor, female /male HHs, the literate/ illiterate, or other?)

5. Do improved soybean technologies improve production & productivity better than local seed? If yes how?

6. Do you farmers get sufficient extension service and training from GO & NGO?

6.1. Is the improved soybean technology profitable to farmers after participating in the technology?

7. What are the changes/ improvements/ you observed the impacts on household's status (income)?

8. What intervention must be used for better implementation of improved soybean technologies in the future to increase the level of adoption in the area?

9. Please mention all problems associated with improved soybean production in the area?

10. Describe any social, economic and environmental problems in the district associated with improved soybean technology adoption?

11. What potentials are there for improved soybean technology extension in your area?

**Check list for Focusing Group Discussion (FGD)**

**For extension agent**

1. Did you know about improved soybean concept?

2. What are the main constraints or challenges faced in the area during soybean technologies transfer?

3. How is the improved soybean adoption status of the household in the study area?

4. Which method you prefer to transfer improved soybean technologies in the area?

5. Did you get on improved soybean technologies and production related training?

**For sample households**

1. What is your perception on the improved soybean varieties?

2. How do you express the nature of improved soybean varieties?

3. Which improved soybean varieties are difficult to adopt (production, and marketing)?

4. What kind of problem faced time of adopting improved soybean varieties?