FACTORS AFFECTING ADOPTION OF LEGUME TECHNOLOGY AND ITS IMPACT ON INCOME OF FARMERS: THE CASE OF SINANA AND GINIR WOREDAS OF BALE ZONE

M.Sc. THESIS

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Factors Affecting Adoption of Legume Technologies and its Impact on Income of Farmers: The Case of Sinana and Ginir Woredas of Bale Zone

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APPROVAL SHEET

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As Thesis Research advisors, I hereby certify that I have read and evaluated this Thesis prepared, under my guidance, by Yitbarek Tegegne entitled **'Factors Affecting Adoption of Legume Technology and its Impact on Income of Farmers:** The Case of Sinana and Ginir Woredas' of Oromia National Regional State'**.** I recommend that it submitted as fulfilling the thesis requirement.

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DEDICATION

This paper is dedicated to Dr. Addishiwot Messay.

STATEMENT OF THE AUTHER

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LIST OF ABBREVIATIONS

ADLI	Agricultural Development Led Industrialization
AI	Adoption Index
ATE	Average Treatment Effect
ATT	Average Treatment on treated
ATU	Average Treatment on untreated
CADU	Chilallo Agricultural Development Unit
CSA	Central Statistics Agency
DA	Development Agent
DAP	Di Ammonium Phosphate
EPA	Environmental Protection Agency
ESE	Ethiopian Seed Enterprise
FDG	Focus Group Discussion
FDRE	Federal Democratic Republic Of Ethiopia
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
ICARDA	International Center for Agricultural Research in Dry Area
m.a.s.l	Meter Above Sea Level
MoFED	Ministry Of Finance and Economic Development
MoARD	Ministry Of Agriculture and Rural Development
NGO	Non-Governmental Organization
OLS	Ordinary Least Square
PSM	Propensity Score Matching
SWC	Soil and Water Conservation
SDPRP	Sustainable Development and Poverty Reduction Program
TLU	Tropical Livestock Unit
PASDEP	Accelerated and Sustainable Development to End Poverty
HHs	Households

Factors Affecting Adoption of Legume Crops Technologies and Its Impact on Income of Farmers: The Case of Sinana and Ginir Woredas of Bale Zone

ABSTRACT

In Ethiopia, low productivity of crops has been one of the significant contributors to food insecurity. Encouraging the rural households' to use improved agricultural technologies and inputs to increase efficiency of production and productivity are among the important policy measures to address the problem undertaken by the government. The objective of this study was to analyze factors influencing the adoption of improved agricultural technologies (improved seed and fertilizer) and its impact on income of farm households of legume producers in Sinana and Ginir Woredas' of Bale Zone of Oromiya National Regional State. Primary data were collected from a sample of 210 households selected through stratified sampling techniques. Descriptive statistics and econometric models were used to analyze the data. The logit model for PSM and OLS models were used to analyze the impact of technologies and the factors influencing the adoption of agricultural technologies respectively. The results presented that technology access for improved farm inputs, credit accessibility, wealth status of farm households and education level of household head had a significantly influenced on the adoption level of both improved seed and fertilizer technology. On the contrary, high price of improved technology and family size had negatively affected the adoption level of improved farm inputs. Impact assessment of the marginal effect showed that farmers who had adopted improved technology could enhance their annual total income level by 2.8% and the crop income particularly from grain legume has been increased by 41%. The adoption typology of the farmers can be categorized in to four in relation to their current adoption status as tech-oriented, tech-fledglings, tech-adopters, and tech-dropouts. Based on the findings, the study suggests that strengthening the promotion of full scale technology adoption will have crucial role towards improving the livelihood of households in the study area. In doing so, managing the possible influencing factors that affect adoption of legume technology should be a prerequisite.

Keywords; *Leguminous technology, Technology adoption, Propensity score matching*

1. INTRODUCTION

1.1. Background of the Study

The vast majority of the poor lives in rural areas are engaged in agriculture, and therefore activities designed to address the vulnerability of these rural poor are often geared toward improving agricultural practices as a means of increasing productivity, efficiency and ultimately income (Parvan, 2010). In Ethiopia, agriculture is the source of spurring growth and a means to overcome poverty; it can be enhanced by the adoption of improved agricultural technologies (World Bank, 2008).

Technology adoption is among the most revolutionary and impactful areas in agriculture sector. Agricultural innovations also play a significant role in fighting poverty, lowering per unit costs of production (Kassie *et al*., 2011), boosting rural income, and reducing hunger (Maertens and Barrett, 2013). Improving the livelihood of rural households in the course of agricultural productivity would remain a mere wish unless the level of technology adoption is improved (Gemeda *et al*., 2007, Ajayi *et al*., 2003). In such regards, adopting agricultural technology become a concern of agricultural experts, policy makers, agricultural researcher, and other stakeholder.

Agricultural technology adoption is a gradual process. Based on the Rogers' (1995) theory of diffusion of innovations, such technology adoption is influenced by many factors including the characteristics of the adopters, the innovations, and social circumstances. The rate of adoption of a new technology is also subject to its profitability, degree of associated risks, capital requirements, agricultural policies consideration, and socioeconomic characteristics of farmers (ICARDA, 2005).

In Ethiopia Adoption of agricultural technology is not as such a long history in which traditional farming practices are still dominant in the farming system. The economic growth strategy of Ethiopia formulated in 1991, places high priority for accelerating agricultural growth and poverty alleviation by increasing yield with support of packages of technology that includes improved seed, fertilizer, and better management. Merely small number of farmers used improved varieties of crops, fertilizer, and farming practices in a limited area (Hailu, 2008). The country has more than 51.3 million hectares of land generally suitable for cropping activity while about 11.8 million hectares of land being cultivated traditionally (MoA, 2010).

Crop production pattern of Ethiopia vary markedly across the country in accordance with the agro climatic condition. Legume crops are the second abundant crop both in production and consumption next to cereals. Increasing productivity of legume presents opportunity in reversing trends of productivity, poverty and food insecurity due to its capacity to fix atmospheric nitrogen (Serraj, 2004). Legumes are the ultimate source of protein, dietary fibber, carbohydrate, minerals for the smallholder farmers. Amongst, faba bean and chickpea are most dominantly cultivated.

Ethiopia is considered as one of the core centres for diversified faba bean as its agro geographical factor is suitable for production (Asfaw *et al*., 1994). Faba bean grows as a field crop throughout the highlands of the country and it is very common legume crop in weina-dega within the altitude range of 1800m – 2400m above sea level (Asfaw, 1985). Similarly, the country is also the largest producer of chickpeas in Africa and is ranked number six in the global chickpea production (MoA, 2014).

Although cultivation of faba bean and chickpea are concentrated in northern and central part of the country, the Bale area (south west of Ethiopia) has a great potential offering for production of faba bean and chickpea. However, due to several shortcomings such as failures in adopting improved farm inputs and inadequate farm management, the production could not meet the expected outcome (Shiferaw, 2008). N_2Africa project is a project initiated by Bill and Melinda Gates Foundation aimed to improve legume production via delivering overall support. As this study conducted under financial aid of N_2-Africa project, the area, and the commodity has been preferred for the study.

1.2. Statement of the Problem

Utilizing improved seed and chemical fertilizers are important technological instrument in all crop based farming system and they are a key factors in determining the upper limit of yield (Cromwell, 1990). Use of improved seed holds the key to sustainable food crop production across the globe because seed is the basic agricultural inputs that brought improvement of agricultural productivity (Pelmer, 2005). Likewise, chemical fertilizer is regarded as a crucial component of farm inputs by small-scale farmers. In ideal farming condition, farmers should use fertilizer and improved seed together in order to achieve the optimal return of crop production (Nigussie *et al.*, 2012).

The development in cropping system helps for the improvement of standard of living of smallholder farmers who took the major part of the nations of Ethiopia. Despite the fact that farming technologies such as improved seed and chemical fertilizer is considered as contributing factors for development of the worldwide agriculture, Ethiopia has chronicle poverty and food insecurity problem for a sustained period of time. One of the reasons for the prevalence of food insecurity is low rate of adoption of improved farm inputs. In fact different agricultural technologies have been released to improve productivity of smallholder farmers in the country (Hailu, 2008). But the national adoption rate could not exceeded 11% in major farming inputs such as improved seed and chemical fertilizers. As a result, low crop production and household income remained to be endemic problems in the country (Paul and Shahidur, 2012).

Dealing on factors that affect adoption of farming technology would have a significantly contribution for the improvement of productivity. It helps to identify priorities in which within what conditions farmers can have a better adoption level. Having this, there are not sufficient studies undertaken both on determinants of adoption of agricultural technology (improved seed and DAP fertilizer) in relation with legume crops. Some of the past adoption studies indicated that adoption behaviour of the farmers remained unknown as technology has a

dynamic nature (Endrias 2003), (Assefa and Gezahagn, 2010). But there are prospects to predict the factors affecting adoption level via constructing semi-experimental scenarios.
This study is designed to determine the potential factors that affect the adoption of improved seed and inorganic fertilizer/DAP in case of legume farmers.

Impact assessment for intervention via adoption of improved seed and inorganic fertilizer has an immense role. It helps resource allocation particular for countries that have limited resources like Ethiopia. It also creates better understanding about the potential winner and losers of instruments (OECD, 2007). More importantly, Bale area where this study conducted, dominantly known in cereal production and most of the adoption studies associated with cereal crops while legumes are disregarded. Therefore, this study initiated to choose the study area to fill the mentioned location gap. Furthermore, as technology has a dynamic nature, its effect varies along with time and hence continuous updating adoption effect is required. In this regard, it is fundamental to researchers to measure the outcome of agricultural technology along with time.

Variations in level of adoption of technology can be a result of generalization of farmers by decision makers. Farmers' initiative towards responding a technology varied due to not only on agro ecological factors but also socioeconomic characteristics. Drawing key characterization elements among farmers will have an indispensable importance towards customizing technology adoption. Thus, it is better to develop a typology of legume farmers based on their current status in technology adoption.

In light of the above gaps, this study is intended to answer empirically following the research questions.

- What are the factors influencing level of agricultural technology adoption?
- To what extent the technology has impact on income and expenditure level of farming households?
- Is there variation in level of adoption of improved farm inputs among the farming households?

1.3. Objectives of the study

The general objective of this study was to develop the comprehensive relation that shows relevance of technology adoption for the legume farmers. The specific objectives were:

1. To analyze factors influencing the adoption of agricultural technology in the study area
2. To analyze the impact of technology adoption on households' income
3. To identify the typology of farmers based on their current adoption status

1.4. Significance of the Study

Development of agricultural technology by itself is not enough to bring growth of farmers' and improvement in livelihood. There should be an enabling policy environment which creates the condition where farmers have access to improved technologies and also to increase their production and productivity (Sitotaw, 2006). Dealing on adoption of agricultural technology from farmers' livelihood perspective has a significance to draw the clear picture for policy makers involved in development and dissemination of new technologies.

The result of this study could help stakeholders (agriculture offices, development partners, research institutions) to identify the pivotal issue to address the technologies in attaining the ultimate objectives. In addition, identifying factors which determine success or failure of technology adoption has importance to guide future research. This study expected to point out the main factors that influence the adoption level.

Technologies to be recommended for adoption should insure the livelihood of farmers. And hence, impact studies enables researcher to identify their end towards the most pressing issues. With this respect, the study shows to what extent adoption of technology influence their livelihood. Once knowing the impact of technology, designing appropriate policy and extension service that is directed towards fostering the adoption level by identifying the potential factors is important. Besides, it is expected that this study would serve as introductory to undertake detailed and comprehensive studies in related scenario.

Therefore, the study of adoption impact and factors impeding the adoption of legume technology would provide useful insight to policy makers, strategic planners, and administrators in the formulation of appropriate agricultural policy. This study also serves as a springboard for further detail research in legume grain farming.

1.5. Scope and Delimitation of the Study

The study has been carried out in Oromia National Regional State, two Woredas' of Bale zone, Sinana and Ginir. Since impact of technology adoption is influenced by demographic, environmental, and economic factors, the finding of the research may not fully represent farmers in different area.

Technology adoption may not have single effect like income or food security effect; instead it may stretch to other livelihood aspects of famers. Even the change of income due to technology adoption encompasses both the direct and indirect effect; the study is limited to the direct impact of technology on the income and expenditure. Moreover, conducting a more expanded livelihood impact study requires more resources and elongated period. Due to such constraints, this study is limited to the impact of legume (faba bean and chick pea) technology on the income and food security of smallholder farmers.

In the study area legumes are often produced through rain fed agriculture, and hence, the finding of this study is limited to show faba bean and chickpea production via rain feed. As a result, cultivations through irrigation or other ways of farming was dropped.

2. LITERATURE REVIEW

2.1. Definition and Concepts of Technology Adoption

Technology: refers to the application of knowledge to the practical aims of human life or changing and manipulating the human environment. It is an idea, object, or practice that is perceived as new by the members of the social system (Mahajan and Peterson, 1985). It includes the use of materials, tools, techniques, and sources of power to make life easier or more pleasant and work more productive. It is systematic application and collective human rationality to the solution of the problems through the assertion of control over nature and all kinds of human processes (Olayide, 1980).

Agricultural Technology: includes both the component and process of agricultural production process like production of plant, animal breeding (including biotechnology), and introduction of new crop varieties, mechanization services, infrastructural development and other inputs. Farming technologies are new farming solutions that enabling farmers to take more output than the previous by increasing quality, quantity and cost effectiveness. Successful farming technology has been largely attributed to improved farming technologies such as fertilizer, improved seed and soil and water conservation (Gebremedhin and Johnston, 2002).

Adoption: is the act or process of beginning to use something new or different within reasonable period of time (Ban and Hawkins, 1996). Integration of such innovations with farmers' normal activity over a period of time has brought adoption (Feder *et al*., 1985). Adoption of technology is not a one step process; it takes time for adoption to complete (Runquinst, 1984). On the other hand, adoption is the use or not to use of new technology by a farmer at a given period of time (Rogers, 1985). The adoption process is conceptualized to include several mental stages through which an individual passes after first hearing about an innovation and finally deciding to accept or reject for adoption. Rogers (1962) defined the adoption process as the mental process where an individual passes from first hearing about innovation to final adoption and proposes a different set of stages, such as awareness, interest, evaluation, trial, and adoption. Sometimes adoption is defined as the proportion of farmers using a technology, in other cases; it is the actual proportion of field or crop area under the new technology (CIMMYT, 1993). Adoption is the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the technology and its potential uses, whereas the aggregate adoption is measured by the aggregate level of use of a specific new technology within a geographic area or within a given population (Feder *et al*., 1985). Roger (1983) defines the aggregate adoption as the process by which a technology is communicated through certain channels over time among the members of social system. The author brought four elements of adoption; (1) the technology that represents the new idea, practice, or object being diffused, (2) communication channels which represent the way information about the new technology flows from change agents (extension, technology suppliers) to final users or adopters (e.g. farmers), (3) the time period over which a social system adopts a technology, and (4) the social system itself.

Van den Ban and Hawkins (1996) define technology adoption as a decision to apply an innovation and to continue to use it. According to this definition, the adoption process refers to changes that take place within the minds of an individual with regard to an innovation from the moment that he/she first becomes aware of the innovation to the final decision to continuously use it or not. Adoption is viewed as a variable representing behavioural changes like changes in knowledge, understanding and ability to apply technological information, changes in feeling behaviour such as interest, attitude, aspiration, and values (Aregay, 1979)

2.2. Legume Production in Ethiopia's Grain Farm

Legumes are grown traditionally in area of Mediterranean basin, Ethiopia, central and east Asia and northern Europe. More than 80% of faba bean cultivation is still being performed in developing countries where research funding and expertise approach is limited (Ana Torres and Carmen, 2011). Faba bean, chickpea, grass pea, and lentil are the most important crop within the crop livestock production system across the east African country (ICARDA, 2017).

Ethiopia produces over 2.86 million metric tons of legume grain from a total area of 1.74 million hectares of land (CGIAR, 2012). Legume crops are grown as both cash crops (vegetables and potentially grain) and fodder crops. As rain fed crops, legumes are mostly mixed or intercropped with cereals or cultivated alone. Around twelve pulse grains are grown in the country; of these, faba bean (*Viciafaba L.),* field pea (*Pisumsativum L*.), chickpea (*Cicerarietinum L*.), lentil (*Lens cultinarisMedik.*), grass pea (*Lathyrussativus L.),* fenugreek (*Trigonellafoenum-graecum L.)* and lupine (*Lupinusalbus L*.) are categorized as highland pulses and grown in the cooler highlands. Conversely, haricot bean (*Phaseolus vulgaris L*.), soya bean (*Glycine max L*.), cowpea (*Vignaunguiculata L.),* pigeon pea (*Cajanuscajan L*.) and mung beans are predominantly grown in the warmer and low land parts of the country.

Though pulses are grown throughout the country, mostly the production is concentrated in highland areas of the country. The productions of legumes vary across the national regions of Ethiopia; where Amhara and Oromiya accounted the major pulses production.

Table 1. Major legume producing regions in Ethiopia

Production of major Pulse crops	Production shares (%) out of the country pulse production					
	Amhara	Oromiya	SNNPR	Tigray	Ben-Gumz	Total Crop Production ('*000 tonnes/year*)
Faba beans	48	37	10	4	0	696
Field peas	20	58	18	1	2	330
Chickpeas	62	30	3	5	0	312
Haricot beans	42	37	15	5	0	268

Source: Chilot *et al.*, 2010

Legumes have a significant role when applied to phosphorus-deficient soils and rates between 30-40 kg P_2O_5/ha are worth recommending. Pests and diseases restrict legume production and even as chemical methods of control are known, the development of cultivars resistant to pests and diseases is emphasized. Legumes can play a significant role in improving smallholders' food security, as an affordable source of protein (pulses make up approximately 15 percent of the average Ethiopian diet and also it can have an income benefit for smallholders, in terms of diversification and because they yield a higher gross margin than cereals.

The country is considered as the second center of diversity of legume grains and also one of the nine major agro-geographical production regions of faba bean (Asfaw *et al.,* 1994). It is the high legume crop widely used in human alimentation and livestock feeding. Faba bean is grown as field crop throughout the highlands and is most common in *Wayna Dega* between the altitudes 1800 m.a.s.l and 2400 m.a.s.l (Asfaw, 1985). Similarly, Ethiopia is one of the major producers of chickpea in the region occupying about 60% of the total area under legumes (Karanja, 2016). The recommended area for chickpea production is 200-1800 m.a.s.l. In Ethiopia chickpea do well in Oromiya (East Shewa zone) and in Amhara (North Shewa and Gonder zone). The yield of chickpea ranges 1100-3800kg/ha of land based on the agro ecological condition and the level of improved farm input applied.

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Considering the scheme of crop income of smallholder farmers, legume yields higher income compared to that of cereals (Chilot *et al.,* 2010). As per the author's demonstration shows that pulses are generally more profitable than cereals and giving incentive to legume farmers will have indirect impact for enhancing production of other crops. There is considerable scope for increasing legume production by popularizing the improved methods of intercropping, growing pulses even in non-traditional areas, cultivating them in off-season or growing them together with another crop in a traditionally mono-cropped area. The most common agricultural technologies applied in legume farming includes high yielding varieties of seeds, use of chemical fertilizers and pesticides, irrigation and improved planting and weeding practices (UNCTAD, 2010). Improved seed is the lifeblood of legume farming. Good quality of seed which have genetic and physical purity, health standards, and high germination and moisture practices can increase farmers' production by 20-30% (Mula, 2012). Out of these common agricultural technologies this study basically focuses on adoption improved seed and fertilizer technology in faba bean and chickpea production.

2.3. Seed and Fertilizer Technology

The contribution of new seed fertilizer technology to the rapid increase of agricultural productivity has been widely written. In Ethiopia, a range of policies and investments has been implemented to boost production and productivity. There are evidences to suggest that the process has lead to improvements in both output and yield. The quantity of improved varieties of seed supplied nationally has been increasing since 1996-97. But the adoption of improved varieties is 4-5% of cropped area was under improved varieties in 2007-08 (Spielman *et al*., 2009).

Despite the aggressive promotion of fertilizer use by the government increase in credit for purchase of fertilizer, the national consumption has lagged well behind the annual target of the government (Mulat *et al*., 1997). The demand for improved seed in Ethiopia based entirely on official projections. The responsibility of responding to these demand estimates lies primarily with the state-owned Ethiopian Seed Enterprise (ESE). Production and distribution of improved seed has been stagnant since about 2000. Demand has consistently fallen short of supply. In addition, shortcomings in seed quality and timeliness of delivery have been longstanding issues in Ethiopia.

The country's agriculture requires over 700,000 tons of seed each year to grow cereals (e.g. teff, maize, wheat, sorghum, barley and finger millet) and pulses (e.g. faba beans, field peas, haricot beans and chick peas) (Dawit *et al*., 2010). Farmers in Ethiopia can acquire seed in two ways; through commercial purchase or traditionally through collecting the better seeds from crop harvest. The interest for increasing the quality and usage of commercial seeds are high since widespread adoption could bring significant benefits to smallholder productivity. Studies indicated significant yield gap between actual yield and potential yields with improved seed varieties. Improved seed is the most fundamental agricultural research output which embodied with genetic material. Improved refer to any several desirable characteristics of the seed such as higher potential grain yield, responsiveness to other inputs (like fertilizer intake), greater tolerance to stress, drought, pest or disease, longer storage capability after harvest, higher nutrition content, better taste and higher fodder quality and quantity (Anderson,1997).

When crops are grown in a piece of land repeatedly nutrients of the soil will be depleted with the harvest. As crops took the nutrients of the soil, substantial amount of important nutrients are removed while crops are harvested. Though some nutrients can be returned to the field through crop residual and associated organic matter, this alone can't provide optimum fertilization and crop yields over time; which leads to adoption of mineral fertilizer. Mineral fertilizer can provide optimum nutrient balance, tailored the demand of specific crop, soil nature and climate condition so as to increase the production and productivity. The benefit of adopting improved seed is enhanced by application of fertilizer specifically in a favourable climatic condition (Feder, 1982; Byerlee and De Planco, 1986).

The demand for fertilizer technology depends on the contribution to the value of output. One of the factors that determine the adoption of fertilizer technology (Hailu, 2008) is the technical relationship between fertilizer use and the quantity of output and the additional output derived from additional units of fertilizer application. In Ethiopia, the uptake of fertilizer at the beginning of the 1970s' (when it was first introduced) and 1980s was about 950 and 43,200 tons, respectively. It increased to 250,000 tons (21 kg/ha) in 1995 and then to 323,000 tons (32 kg/ha) of product in 2004/05 and it has dramatically increased to 400,000 tons in 2008 (Speilman *et al*., 2012). It shows a continuous incremental trend reaching close to 600,000 tons during 2009/2010 cropping season. Government policy via ministry of agriculture mentioned as one of the reason for growth of fertilizer demand. Regarding the consumption, the Amhara, Oromiya, and SNNPR states constitute more than 50% of the national consumption (Mesfin, 2009). Most of recent agricultural development strategies and programs in Ethiopia are centered on fertilizer promotion, along with the provision of improved seeds, credit and farm management practices.

2.4. Empirical view of Adoption

As is the case in many developing countries with an agrarian economy, agricultural technology adoption has got a number of processes. It has both spatial and temporal dimension. It is argued that technology adoption is not a one of static decision rather it involves a dynamic process in which information gathering, learning and experience play pivotal roles particularly in the early stage of adoption and diffusion (Assefa and Gezaghegn, 2010).

Technology can be adopted when it is found to be beneficial while dropped over time if loss is entertained due to increasing cost of inputs, falling of yields or shift to other more profitable technology (Dinar and Yaron, 1992). There are various reasons that brought agricultural technologies to be adopted or brought for failed to do adoption. Quite much of the studies have been generated on determinants of technology adoption both domestically and internationally. Farmers move from learning to adoption to continuous or discontinuous use over time. The characteristics of both the user and the technology are important in explaining adoption behaviour and the pathway for adoption. The lag between learning and adoption, and the possibility of discontinuation imply that a longer period will be required for the majority of farmers to use the technology than if adoption was a one off decision leading to continuous use. This picture has been clearly demonstrated by the adoption process of the technology in the four regions of Ethiopia considered in this study.

The study conducted in Ethiopia and western Kenya using probit analytical model shows that gender, agro-climate zone, manure use, hired labour and extension service has a significant effect towards adoption of improved seed and fertilizer (Salasya *et al*., 1998, Cropenstedt *et al*., 2003). On the other hand a study conducted in the coastal low lands of Kenya shows that non availability and high cost of seed, unfavourable climate conditions, perception, and insufficient soil fertility has a negative and significant effect on adoption of technology.

The study conducted in Morena district of India, on wheat production, found that knowledge of farmers which may be acquired through education, training, and availability of information and the credit facility has a significance positive contribution to the adoption of improved technology (Kansana *et al*., 1996). Nkonya *et al*.,(1997), analysis factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania indicated that farm size, education and frequency of visits by extension agents significantly and positively influenced maize seed adoption where as the factors such as farmers' age, family labour and yield variability have not significantly influenced improved maize seed adoption. Batz *et al*., (1999) a study conducted in Meru district of Kenya to find out factors affecting rate and speed of adoption of technology, less risky technology is preferable and easily adopted.

Misfin (2005), on his study carried out to determine factors influencing adoption of triticale in Farta wereda of Amhara region using Logistic regression model, maximum likelihood estimation procedure, traced that distance to market center, distance to all weather road, access to leased-in land, perception about superiority of yield of triticale, livestock holding, off/non farm income and input price were found to influence farmers adoption decision of triticale (wheat crop).

Birhun *et al*., (2014), in their study conducted on hybrid adoption and chemical fertilizer, factors that affect the adoption decision has been indentified using probit model and the marginal effect using OLS estimates. The result shows gender, land ownership, irrigation use, access to credit, contact with extension agent, participation in off farm business activity have positive and significant relation with the adoption decision of chemical fertilizer;, while plot distance from the home stead, distance to the nearest market and TLU (Tropical Livestock Unit) has an inhibiting role in adoption decision. According to Yanggen *et al*., (1998), in Africa fertilizer application is determined by human capital (basic education, extension and health); financial capital (income, credit and assets); yield response (bio-physical technology and extension), basic services (infrastructure and quality control) and input output price (structure conduct and performance of subsector, competition and equity).

Foyed *et al*., (1999), in a study of adoption and associated impact of technology; conducted in the western hill of Nepal draw that a balanced investment in research and extension is needed to ensure adoption at the household level. The study found that the typical reason for failing of adoption is either lack of know how or supply of the technological inputs. So, in conditions where official sources are not available, farmer to farmer interaction is important. Farmer to farmer information flow can be built on by extending by the involvement of farmers in technology development and by developing methods that enables to enhance their current roles in technology dissemination.

Yu *et al*., (2011), in a study conducted on cereal technology adoption in Ethiopia, to examine the extent of adoption of fertilizer seed technology package and factors affecting the adoption of same using nationally representative secondary data, found that variables affecting the adoption of the new technology, like access to extension service, the level of adoption at the district level, and the experience of farmers using fertilizer in other crops, have a significant effect on the probability of accessing fertilizer and improved seed by farmers. Specialization, together with wealth and risk aversion, also plays a major role in explaining crop area under fertilizer, which should be related to better access to technology-related knowledge.

According to Feder *et al*., (1982) the conventional explanations for the sequential adoption process are: lack of credit, limited access to information, aversion to risk, inadequate farm size, and inadequate incentive associated with farm tenure arrangements, insufficient human capital, absence of equipment to relieve labour shortage, and inappropriate transportation infrastructure. Hailu (2008) used the probit and Tobit models to examine factors influencing adoption and intensity of teff technologies in Ethiopia. The study revealed that farmers education level, frequency of DA officer visits, credit availability and knowledge of farmers have positive influence towards technology adoption and adoption intensity whereas variables like age of farmers, number of family labour, frequency of risk were inhibiting adoption of technology.

Saha *et al*., (1994) divide the adoption process into three stages: information collection, decision on whether or not to adopt, and decision on how much to adopt. Filho (1997) applied both probit and logit models and duration analysis to explain the maize growers' behaviour in the adoption of new technologies. He found that both economic (such as yield level, income, and cost of adoption) and non-economic (such as behaviour of adopters' factors influences a farmer's decision to adopt the new technologies of maize. It shows that decision to adopt the sustainable technologies for maize is positively related to his/her contact with government/non-government organizations, the farmer's understanding of the negative effect of chemicals, the available labour force in the family and the soil fertility. Filho (1997) further concludes that the adoption is negatively related to farm size. According to Foster and Rosenzweig (1996), agricultural technology adoption decision was seriously been determined by imperfect information, risk, uncertainty of institutional constraints, human capital, input availability and infrastructural problems.

2.5. Impact Assessment of Technology and Household Income

Impact assessment is a process of systematic and objective identification of the short and long term effects of intervention on economic, social, institutional and environments. Such effects may be anticipated or unanticipated and positive or negative, at the level of individuals, households, or the organization caused by ongoing or completed development activities such as a project or program (Rover and Dixon, 2007, Omoto, 2003). Impact assessment evaluation is the extent to which a project has caused desired or undesired changes in the intended users. It is concerned with the net impact of intervention on individuals, households, or institutions attributable only and exclusively to that intervention (Baker, 2000). Impact on income is a reward that the owners of fixed factors of production receive as a result of allowing their land, capital, and labour to take part in production.

The very focus of impact analysis was the contrast of adopters to the counter factual non-adopters. Therefore, measuring the marginal effect of the adoptions of the new technology over the traditional practice is essential. According to FAO (2000), impact assessment is done for several practical reasons: (1) accountability – to evaluate how well we have done in the past, to report to stakeholders on the return to their investment, and to strengthen political support for continued investment; (2) improving project design and implementation - to learn lessons from past that can be applied in improving efficiency of research projects; and (3) planning and prioritizing - to assess likely future impacts of institutional actions and investment of resources, with results being used in resource allocation and prioritizing future projects and activities, and designing policies.

Technological change is very important in cases where there is limited scope for increasing agricultural production through increased use of input of factors like land (Solow, 1957). There are serious complexities associated with understanding the impact pathway through which agricultural technology adoption might affect household welfare. This is due to the fact that crop production can affect household welfare directly or indirectly. Crop production affects poverty directly by raising the welfare of poor farmers who adopt technological innovation though increased production, lowering cost of production, and improving natural resource management (Janvry *et al.,* 2001).

Sadoulet and De Jeanery (1992), show that relative magnitude of direct and indirect effect of technology change of agriculture on poverty can best be quantified by computing general equilibrium model. The author recommended that the direct poverty alleviation impact of agricultural technology is more important than the indirect effect. Estimating the impact of a project requires separating its effect from intervening factors which may be correlated with the outcomes, but not caused by the project. To ensure methodological rigidity, an impact evaluation must estimate the counterfactual, that is, what would have happened had the project never taken place (Baker, 2000). Impact assessment is a continuous process (Minong *et al.*, 2001). Impact studies essentially have the same process as technology development itself. It typically does this by comparing outcomes between beneficiaries and control groups (AIEI, 2010).

Since the data for this study was obtained from survey, non experimental impact evaluation design is preferred using propensity score matching method of analysis. According to Rosenbaum and Rubin (1983) and, Heckman *et al., (*1998), Propensity Score Matching is a non experimental method for estimating the average effect on social programs. The method compares average outcomes of participants and non participants conditioning on the propensity score values. In order to make causal inferences, random selection of subjects and random allocation of treatments to subjects was required. In observational studies, random limitations of an observational study are that there may be random selection of subjects but not random allocation of treatments to subjects. When there is lack of randomization, causal inferences can't be made because it is not possible to determine whether the difference in outcome between treated and control (untreated) subjects is due to treatment difference between subjects on other characteristics.

3. RESEARCH METHODOLOGY

3.1. Description of the Study Area

The study was conducted in Oromiya Regional State Bale Zone of Sinana and Ginir woredas'. The Oromia region is organized in 12 administrative zones and 180 woredas which extended from central and western to south-eastern part of the country. The total area coverage of the region is estimated 353,690 km^2 which took 32% of the national area coverage. Among these administration zones, Bale and Borrena accounts 45% of the total area of the region and 14% of the population resides on these places (Warner, 2015).

Sinana is one of the woredas under Bale Administrative Zone. Sinana is bordered on the south by the Mena River which separated it from Goba, on the west by Adaba, on the northwest by Agarfa, on the northeast by Gaserana Gololcha, on the east by Ginir, and on the southeast by Goro, Oromia.

The altitude of the Sinana woreda varies from 2000 to 3600 m.a.s.l, with higher elevation in the Bale round district. Rivers include the Togona, Weyib and Shaya Rivers. A survey of the land in this woreda shows that 33.1% is arable or cultivable (29.8% was under annual crops), 30.4% pasture, 30.2% forest and other heavy vegetation, and the remaining 2.3% is considered swampy, mountainous or otherwise unusable. Sinana is one of the woreda's in this zone with abundant forests; the Bale Mountains National Park extends into the woreda. This woreda is potential in production of a surplus of food crops, like wheat and barley, and faba bean. There are two state farms in this woreda; the Sinana agricultural farm, with 38.38 square kilometres of area coverage, and the Robe with 25.79 square kilometres area coverage.

Regarding the demographic nature, the 2007 national census reported that a total population of Sinana woreda is 118,594, of whom 61,968 were men and 56,626 were women; 8,900 or 7.58% of its population were urban dwellers. The majority of the inhabitants said they were Muslim, with 85.98% of the population reporting they observed this belief, while 13.65% of the population practiced Ethiopian Orthodox Christianity. The woreda comprises 20 kebeles (Addisu, *et al.*,2015). The two largest ethnic groups reported in Sinana are the Oromo (89.73%), and the Amhara (9.02%); all other ethnic groups made up 1.25% of the population. Oromiffa was spoken as a first language by 88.6%, and 10.75% spoke Amharic; the remaining 0.65% spoke all other primary languages reported (Addisu *et al.*, 2015).

The other research site was Ginir (alternatively called Gindhir). Ginir is one of the woreda's of Bale zone located in North West corner of Bale which comprises 19 kebeles. The land composition statistics shows that, out of the total land coverage 30.5% is cultivable for agriculture purpose. The major part of the wereda is allocated for forest which comprises 35.6% and pasture has the next major portion of the land where 31.2% of the total land is left pasturing. Crops like wheat, barley, chick pea, Fenugreek (*abish*), oats, lentil, and pea are the major crops cultivated in the area. *Khat*, fruits and vegetables and coffee are also the major cash crops which grow in the lowland part of the woreda. Industry wise, Ginir woreda has 29 grain mills wherein most of the mill established for the purpose wheat flour making purpose and one brick factory established for the purpose of concrete pole Manufacturing. The woreda has twenty eight farmers associations and nine farmers' service cooperatives (Warner, 2015).

Regarding the infrastructure, Ginir woreda has 77 kilometres of dry weather and 101 all weather road for an average of road density of 75.7 kilometres 1000 square km. Demographically, the 2007 national census reported a total population for this woreda of 139,495 of whom 71,323 were men and 68,172 were women; 21,196 (15.2%) of its population were urban dwellers. The majority of the inhabitants said they were Muslim, with 76.64% of the population reporting they observed this belief, while 22.33% of the population worshiped Ethiopian Orthodox Christianity.

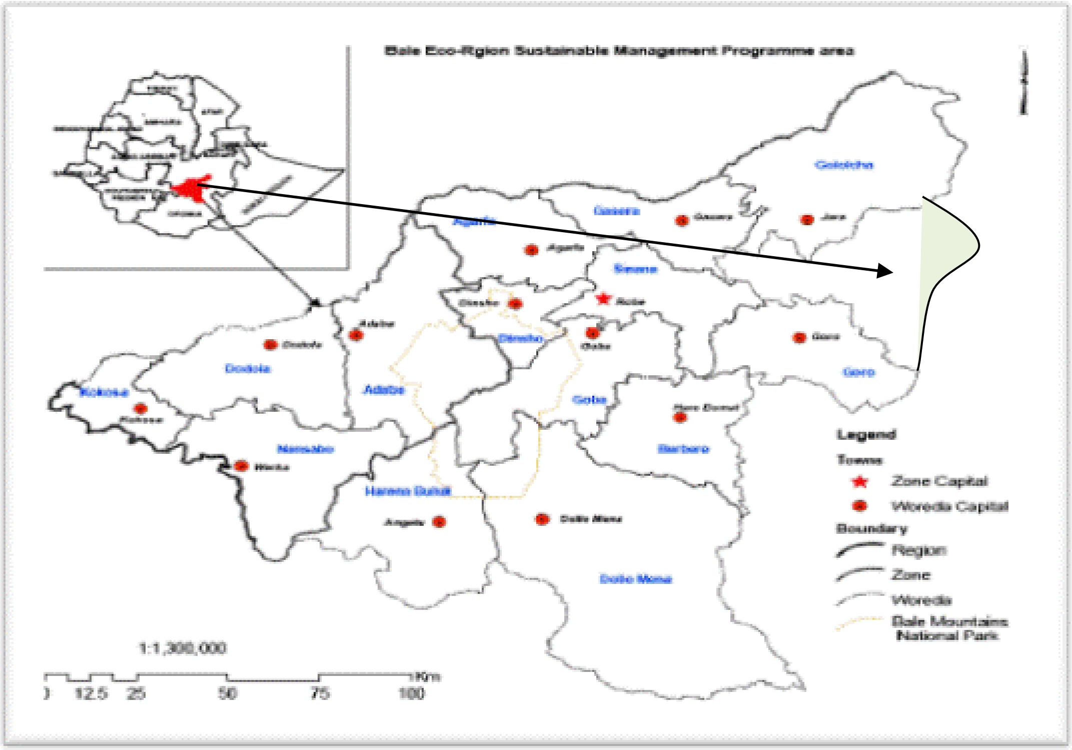

Figure 1. Location of the study area

3.2. Data Types, Sources and Methods of Data Collection

This study used both primary and secondary data. The data was collected from primary sources generated through case study, and structured questionnaire. Through the desk review, the study assessed the existing literature on the factors affecting level of technology adoption and its impact. More to this, case study was conducted as a pilot study and interview as well as discussion with concerned parties like Woreda agriculture offices, research office, NGO, and farming community.

i. *Qualitative and inductive study*: In the qualitative method, inductive (in-depth) case study was conducted in the selected research sites. The case study was conducted based on the procedure which was designed by emphasizing the main context (ecological, social, and economic) production and marketing systems. The case study taken interviews with 15 individual farmers, 3 development experts in the study area, 3 focus group discussions (FGD) with farmers where each group consisting of 5 to 8 individuals, 4 interviews with NGO representatives who are involved in the distribution of inputs to farmers, and 3 individual interviews with (output) traders in the area. This method of data collection was required to predetermine the important factors and incorporate in the model.

ii. *Survey using structured questionnaire:* Based on the insights of the case study, structured questionnaire was carefully designed to conduct a survey among the stratified sample of the selected households. The questionnaire included the semi-experiment scheme to be administered on farmers regarding their likelihood to adopt the level of adoption to certain technology.

iii. *Developing Scenarios:* different scenarios were constructed to test the relationship of factors affecting technology adoption with adoption level. Those independent variables that have a dummy nature were manipulated in a low versus high, presence versus absent and yes versus no. Accordingly price (low versus high), access to technology (yes versus no), access to credit (present versus absent), and development agent (present versus absent) were manipulated in a four by four scenarios. Farmers' likelihood of adoption of different technology packages is captured with a five point Likert type scale (Refer appendix 5).

3.3. Sampling Techniques and Sample Size

As the objective of this study was focused on legume technologies, the population of the study were those farmers who are engaged in production of legume (faba bean and chickpea) crops in both woredas'. Sinana and Ginir woredas were selected purposively wherein they are potential legume production as indentified by N2-Africa project (ILRI). Two stages stratified sampling procedure was used to select sample farmers. There are 20 kebeles and 19 kebeles belonged to Sinana and Ginir woreda respectively. Except few Kebeles, most of the area in Sinana wereda is suitable for faba bean production. Unlike to Sinana woreda, few kebeles (8-10 kebeles) are growing chickpea in Ginir woreda. Hence, only those kebeles growing chickpea were considered as a population for this study in Ginir. Once those areas identified as target population, kebeles were selected randomly. Based on this, four kebele from Sinana woreda and three kebele from Ginir woreda were selected and consequently, farmers were listed from each kebele in collaboration with the chairman of the kebele and development agents. In such perspective, 210 farmers were selected by using probability proportionate to size sampling.

Table 2. Distribution of sample households in selected Kebeles

Sinana woreda			Ginir woreda		
kebele	household size	sample size	kebele	household size	sample size
Welti Berissa	1582	32	Ebissa	1520	31
Kxi	1480	30	Lebocha	1665	33
Horeboka	1392	28	Jame	1485	30
Alage	1360	27			
Total	5814	**116**		**4670**	**94**

3.4. Method of Data Analysis:

3.3.1. Descriptive statistics

The data collected was analyzed using both descriptive statistics and econometric model. Descriptive statistics includes mean, standard deviation (SD), frequency, ratio, and percentage, tabular and graphical representation, which has been mostly used to examine the socio economic and farming characteristics of households and categorization of the famers' typology.

3.3.2. Econometric models

i. Ordinary Least Square (OLS) Estimates: Multiple linear regression models preferred to relate effect of explanatory variables on the level of technology adoption. In such model, each value of the independent variable (x_i) was regressed against the value of the level of technology adoption (y). Each hypothesized explanatory variable was captured in view of future scenario which measures the status of farmers' response towards the technology package assumed in this study. Some of the explanatory variables captured by constructing future scenarios prepared in likert scale. The value of response of individual farmers towards each scenario has been regressed against level of adoption. Level of technology adoption (y) is the extent that farmers used or consumed the technology or packages of technology relative to the recommended one. Level of technology adoption was measured by the likelihood of adoption each farmer indicated in a five point Likert type scale. Two regression models were designed; i) for improved varieties of seed and ii) for DAP fertilizer.

According to Maddala (1992), the multiple linear regression equation is specified as:-

$$Y = a + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_{8+} \beta_9 x_9 + u \qquad (1)$$

Where Y, is the dependent variable which measures the level of adoption for seed and DAP fertilizer technology separately

X_1- Price of technology (price of improved seed/DAP fertilizer)

X_2- Access to credit

X_3- DA Advice

X_4- Technology access (access to improved seed/DAP fertilizer)

X_5-Market access of product

X_6-farming experience

X_7- Education level

X_8- Cultivable area

X_9- Wealth status of farmers

α-The constant term (intercept)

β_{i-} regression parameter for the i^t explanatory variables which indicates the slope of the predictor variable

u_i= the error term of the model

ii. Propensity Score Matching Method (PSM) for impact analysis

Impacts are discreet (usually binary) variables. Treatments are heterogeneous in the population (Heckamn *et al.,* 1997. Robin 1997), developed a framework that each household has two potential outcomes; an outcome when adopting technology (y_1) and not adopting technology

(y_0). If we let the adoption status d, d=1 for adoption of technology and d=0, for not adoption, then it is possible to write the observed outcome y of the household performance as a function of the two potential outcomes as $Y = dy_1 + (1-d)y_0$ (2)

The causal effect of the adoption on its observed outcome y is the difference between the two outcomes (y_1-y_0). But because of the realization, the potential outcomes are mutually exclusive that is only one of the two outcomes has been observed at a time (Nguezet *et.al*, 2011). It is also impossible to measure the individual effects of adoption in any household. However, it can be possible to estimate the mean effect of adoption on a population household. Such mean parameter is called average treatment effect (ATE) (Imben and wooldridge, 2009).

$$ATE = \frac{1}{n}\sum_{i=1}^{n} \frac{d_i-(p(xi)yi}{(p(xi)(1-p(xi))} \qquad (3)$$

Where n is the sample size, n_1=$\sum d_i$, is the number of treated variable i.e. the number of seed-fertilizer technology adopting farmers and p(x_i) is a constant estimate of propensity score evaluated at x. It is possible to employee probit specification to estimate the propensity score.
Propensity score matching pursues a targeted evaluation of whether adopting a modern seed -fertilizer technology causes farmers to improve their performance.
There will be problem of avert and hidden biases and deal with the problem of non-compliance or indigenous treatment variable. In order to remove such biases Robin (1974) introduces egnorablity (conditional) assumption which postulates, the existence of a set of covariate x, which controlled for renders the treatment outcomes (y_1 and y_0). The estimation using the conditional independent assumption) or they are based on a two stage estimation procedure, conditional probability of treatment called propensity score.
From this we can develop two interrelated stages:

Estimating the propensity score- The first step in PSM method is to estimate the propensity scores by using either logit or probit models. Caliendo and Kopeinig (2008) noted that the logit model which has more density mass in the bounds could be used to estimate propensity scores, P(x) using a composite characteristics of the sample households and matching will then be performed using propensity scores, p-score, of each observation. Matching algorism will be selected based on the data to be collected after undertaking matching quality test. Overlapping condition or common support condition will be identified, estimating the average treatment effects of both outcomes (ATE_1 and ATE_0) after estimation of the propensity scores, seeking an appropriate matching estimator is the major task.

There are various matching estimators, which include the nearest neighbour matching, caliper and radius matching, stratification and interval matching, kernel and local linear matching (Caliendo and Kopeinig, 2008).The treatment effects will be estimated based on matching estimators selected on the common support region (owusu and Awudu, 2009).The average treatment effects can be estimated using the inverse propensity weighing estimates as stated in IPSW (Nguezet,, 2011) using matching techniques of Kernel Matching (KM), Nearest Neighbor Matching (NNM) and Radius Caliper Matching (RCM).

Nearest Neighbor Matching: Caliendo and Kopeinig (2008) said that NN matching is the most straightforward and frequently used matching estimator in PSM. The individual from the control group is chosen as a matching partner for a treated individual with the least distance in terms of propensity score (Becker and Ichino, 2002). Several variants of nearest neighbor matching are proposed, e.g. NN matching 'with replacement' and 'without replacement'. In the former case, an untreated individual can be used more than once as a match, whereas in the latter case it is considered only once. Matching with replacement involves a trade-off between bias and variance. If we allow replacement, the average quality of matching will increase and the bias will decrease while increasing the variance. This is of particular interest with data where the propensity score distribution is very different in the treatment and the control group. A problem which is related to nearest neighbor matching without replacement is that estimates depend on the order in which observations get matched. Hence, when using this approach, it should be ensured that ordering is randomly done. It is also suggested to use more than one nearest neighbor matching. Reduced variance will result from using more information to construct the counterfactual for each participant, with increased bias that results from on average poorer matches (Caliendo and Kopeinig, 2008).

Caliper Matching: To avoid the problems of bad matches resulted from the Nearest Neighbor matching; economists impose a tolerance level on the maximum propensity score distance (caliper). Imposing a caliper works in the same direction as allowing for replacement. Bad matches are avoided and hence the matching quality rises. However, if fewer matches can be performed, the variance of the estimates increases. Applying caliper matching means that an individual from the comparison group is chosen as a matching partner for a treated individual that lies within the caliper ('propensity range') and is closest in terms of propensity score (Caliendo and Kopeinig, 2008).

Dehejia and Wahba (2002) suggest a variant of caliper matching which is called radius matching. The basic idea of this variant is to use not only the nearest neighbor and limit itself within each caliper but all of the comparison members or observations within the caliper. The benefit of this approach is that it uses only as many comparison units as available within the caliper and therefore allows for usage of extra (fewer) units when good matches are (not) available.

Kernel Matching: With Kernel matching, all treated groups are matched with a weighted average of all control groups with weights that are inversely proportional to the distance between the propensity scores of treated and control (Becker and Ichino, 2002). But the matching algorithms discussed so far have in common that only a few observations from the comparison group are used to construct the counterfactual outcome of a treated individual. Kernel matching is a non-parametric matching estimator use weighted averages of all individuals in the control group to construct the counterfactual outcome. Thus, one major advantage of this approach is the lower variance which is achieved because more information is used. Caliendo and Kopeinig (2008) concluded that like other matching algorithms, Kernel matching has also its own drawbacks that arise from the nature of the matching algorithm. The major drawback of this method is the possibility of inclusion of observations with a very low and high propensity scores and may give bad matches. Hence, the proper imposition of the common support condition is of major importance for Kernel matching. To apply Kernel matching one has to choose the bandwidth parameter. The choice of the bandwidth parameter is quite pertinent with the following trade-off arising: High bandwidth-values yield a smoother estimated density function, therefore leading to a better fit and a decreasing variance between the estimated and the true underlying density function. On the other hand, underlying features may be smoothed away by a large bandwidth leading to a biased estimate. The bandwidth choice is a compromise between a small variance and an unbiased estimate of the true density function and it may not be a predetermined issue (Habtamu, 2010).

The question remains on how and which method to select. Clearly there is no single answer to this question, Bryson *et al.* (2002) stated the choice of a given matching estimator depending on the nature of the available dataset that is it depends on the data in question, and in a particular on the degree of overlap between the treatment and comparison groups in terms of propensity score. It should be clear that there is no 'winner' for all situations and that the choice of a matching estimator crucially depends on the situation at hand. When there is a substantial overlap in distribution of propensity score between the comparison and treatment groups, most of the matching algorithms will yield similar results (Dehejia and Wahba, 2002).

Dehejia and Wahba (2002) also stated that a matching estimator which balances all explanatory variables (i.e., results in insignificant mean differences between the two groups), a model which bears a low pseudo R^2 value and results in large matched sample size is a preferable matching algorism. So, for this study among matching algorithms, kernel matching with bandwidth of 0.1 was found to be the best matching estimator for the data at hand and based on matching quality criteria.

Treatment effect on the treated: To estimate the effect of technology adoption to a given outcome (Annual income per household), is specified as:

$$\tau_{ATT} = Y_i(d_i = 1) - Y_i(d_i = 0) \qquad (1)$$

Where τ_i is treatment effect (effect due to adopting farm inputs), Y_i is the outcome on household i, d_i is whether household i has got the treatment or not (i.e., whether a household using farming technology or not). However, one should notice that Y_i (d_i=1) and Y_i (d_i=0) cannot be observed for the same household at the same time. Depending on the position of the household in the treatment either Y_i (d_i=1) or Y_i (d_i=0) is unobserved outcome (counterfactual outcome). Due to this fact, estimating individual treatment effect τ_i is not possible and one has to shift to estimate the average treatment effects of the population than the individual one. Two treatment effects are most frequently estimated in empirical studies (Dillon, 2008). The first one is the (population) Average Treatment Effect (ATE), which is simply the difference of the expected outcomes after using a technology or not:

$$\Delta Y_{ATE} = E(\Delta Y) = E(Y_1) - E(Y_0) \tag{2}$$

This measure answers the question what would be the effect if households in the population were randomly assigned to treatment. But this estimate might not be of importance to policy makers because it includes the effect for which the intervention was never intended (Dillon, 2008). Therefore, the most important evaluation parameter is the so called Average Treatment Effect on the Treated (ATT), which concentrates solely on the effects on those for whom the interventions are actually introduced. In the sense that this parameter focuses directly on those households who participated, it determines the realized impact of improved farm input usage and helping to decide whether participation on technology is successful or not. It is given by:

$$\tau_{ATT} = E(\tau / d = 1) = E(Y_1 / d = 1) - E(Y_0 / d = 1) \tag{3}$$

This answers the question, how much did households using farming technology benefit compared to what they would have experienced without using. Data on E (Y_1/d=1) are available from technology users. An evaluator's classic problem is to find E (Y_0/d=1). So the difference between E (Y_1/d=1) - E (Y_0/d=1) cannot be observed for the same household. Due to this problem, one has to choose a proper substitute for it in order to estimate ATT. The possible solution for this is to use the mean outcome of the comparison individuals, E (Y_0/d=0), as a substitute to the counterfactual mean for those being treated, E (Y_0/d=1) after correcting the difference between treated and untreated households arising from selection effect. Thus, by rearranging, and subtracting E (Y_0/d=0) from both sides of equation (10), one can get the following specification for ATT.

$$E(Y_1 / d = 1) - E(Y_0 / d = 0) = \tau_{ATT} + E(Y_0 / d = 1) - E(Y_0 / d = 0) \quad (4)$$

Both terms in the left hand side are observables and ATT can be identified, if and only if E (Y_0/d=1)-E (Y_0/d=0) =0. i.e., when there is no self-selection bias. This condition can be ensured only in social experiments where treatments are assigned to units randomly i.e., when there is no self-selection bias (Caliendo and Kopeinig, 2008; Dillon, 2008). In non-experimental studies one has to introduce some identifying assumptions to solve the selection problem. The following are two assumptions to solve the selection problem.

Assumptions:

Assumption1: Conditional Independence (Unconfoundedness): There is a set X of covariates, observable to the researcher, such that after controlling for these covariates, the potential outcomes are independent of the treatment status

$$(Y1, Y0) \perp d/X$$

The potential outcomes are independent of the treatment status, given X. Or, in other words after controlling for X, the treatment assignment is “as good as random.” This property is also known as Unconfoundedness or selection on observables. The CIA is crucial for correctly identifying the impact of participation, since it ensures that, although treated and untreated groups differ, these differences may be accounted for in order to reduce the selection bias. This allows the untreated units to be used to construct a counterfactual for the treatment group (Heinrich *et al*., 2010).

Assumption 2: Common support (Overlap): This assumption rules out perfect predictability of d given X. That is

$$0 < P(d = 1/X) < 1$$

This equation implies that the probability of receiving treatment for each value of X lies between 0 and 1. By the rules of probability, this means that the probability of not receiving treatment lies between the same values. Then, a simple way of interpreting this formula is the following: the proportion of treated and untreated individuals must be greater than zero for every possible value of X (Caliendo and Kopeinig, 2008; Heinrich *et al*., 2010). The second requirement is also known as overlap condition, because it ensures that there is sufficient overlap in the characteristics of the treated and untreated units to find adequate matches (or a common support). When these two assumptions are satisfied, the treatment assignment is said to be strongly ignorable (Rosenbaum and Rubin, 1983).

Given the above two assumptions, the PSM estimator of ATT can be written as:

$$\tau_{ATT} = \mathrm{E}(Y_1 - \mathrm{Y}_0 / d = 0, P(X)) = \mathrm{E}(\mathrm{Y}_1 / d = 1, P(X)) - \mathrm{E}(\mathrm{Y}_0 / d = 0, P(X))$$

Where P(X) is the propensity score computed on the covariates X. Equation is explained as; the PSM estimator is the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants.

Estimation of standard error: Testing the statistical significance of treatment effects and computing their standard errors is not a straightforward thing to do. The problem is that the estimated variance of the treatment effect should also include the variance due to the estimation of the propensity score, the imputation of the common support, and possibly also the order in which treated individuals are matched. These estimation steps add variation beyond the normal sampling variation (Heckman *et al.*, 1998). For example, in the case of NN matching with one nearest neighbor, treating the matched observations as given understate the standard errors.

Bootstrapping: this method is a popular way to estimate standard errors in case analytical estimates are biased or unavailable (Caliendo and Kopeinig, 2008). Each bootstrap draw includes the re-estimation of the results, including the first steps of the estimation (propensity score, common support). Bootstrap standard errors attempted to incorporate all sources of error that could influence the estimates. Because analytical standard errors are not computable for the Kernel-density matching methods, Bernard *et al*., (2007) have used 100 bootstrap replications to compute robust estimates for standard errors of the outcome indicator. Thus, the bootstrapped standard error must be reported on the ATT.

3.5. Variable Specification and Hypothesis

Dependent variables:

Table 3. Definition of dependent variables

Variables	Symbol	Type	Measurement
Level of improved seed adoption	LIS_AD	Continuous	Percentage
Level of fertilizer adoption	LF_AD	Continuous	Percentage
Participation in adoption	FR_PR	Dummy	1, if adopting 0, otherwise
Outcome variables			
Annual Income Level	INC_LEV	Continuous	Birr
Crop Income	CR_INC	Continuous	Birr

The main variables that intended to be measured in this study were level of technology adoption and income change entertained from technology adoption. Level of technology adoption is the rate at which the intended package of technology implemented by farmers'. It tells us to what degree the adoption rate could vary by a unit change of various factors. Participating in technology adoption is a dependent variable in impact analysis using PSM with outcome variables of income of households.

Explanatory Variables:

The objectives of this study were to relate technology adoption with farmers' income and how the level of technology adoption is influenced by various factors. The definition of variables and the respective hypothesized effect on adoption presented as follows:

Wealth status of farmers (WL_STFR): is a potent variable which determine the position of the farming community in status of life. Wealth is important because it gives rise not only to income in a variety of forms but because it also provides security, freedom of manoeuvre and it seems to be much more unequally distributed than income and has a major influence on the overall degree of inequality (Atkinson, 1980). Wealth is a measure of the level of financial or economic resources that a household and its members belongings at a given point of time. Wealth also can be measured in different social aspects like social values (social acceptance in the society) and asset values (TLU, machinery and other business). In this study wealth referred values of tropical livestock units. Value of Wealth was hypothesised to favour adoption of technology in this study.

Access to credit (CR_CRDT): most literature defined credit access as the supply side phenomenon of the credit market because mostly it is the lender who decides whether to access or not the credit (Okurut and Schoobe, 2007)**.** This happens in area where there is limitation in accessing the credit service due to fewness of crediting agents. Economists usually view lack of credit as an indication of market failure.

Improving credit access often regarded as the key element for increasing agricultural productivity and has been an effective strategy to increase smallholder productivity and alleviate poverty (Adugna and Heidhues, 2000). It enables to relax the liquidity constraints that smallholder farmers' face to improve their risk bearing capability, influencing adoption of new technology. Credit access can have positive influence on level of adoption. In this study credit refers to the availability of loan to afford technological packages under consideration. Many adoption studies considered credit availability with respect to the presence or not the credit service. However, farmers are sensitive to the cost of money, delivery the credit and returns of investment. Credit access was expected to influence level of adoption positively.

Access to technology (TECH_ACC): getting improved agricultural technologies close to the farm or near by the farmers' village, particularly improved seed, and chemical fertilizer is the key constraint that affect farmers' desire to adopt (Solomon *et al.*, 2011)**.** This is mainly due to imperfections in local input markets and lack of availability of the inputs in the desired quality, quantity, and time**.** There is a considerable shortage of improved seed in Ethiopia. Despite good reasons to invest in this market, private sector investments are not observed to the expected level (Hussmann, 2015). Accessibility in this context is the presence of the intended technology in the vicinity of the farmers and the farmers able to avail same at the required time without resourcing visible cost for mobilization and transportation**.** Accessibility supposed to have positive impact on level of technology adoption.

Development agent advice (DA_AD): Advice of development agent refers the involvement of agricultural experts in developing the general cognitive ability of farmers via training, experience sharing and practical help. Thus, any assistance that emanate from development agents for the proper implementation of the intended technology considered as development agent advice in this study. Farmers' Knowledge included the general cognitive ability that obtained from training, formal education and experience that expected to generate from development experts. If farmer get knowledge or help that enable him to put the technology into operation, we can say DA advice is there. Farmers' level of satisfaction by the role of DA experts has been captured in scale wise in the scenario (appendix 5).

Education level (EDU_LEV)*:* the accruement of knowledge via formal education is supposed to be important factor in a way that education would have the capacity to adopt the technology in a proper way and can assure the end target expected from the technology. As a result, education presumed as an important explanatory factor in household decision-making towards favouring the adoption process. Education level of household can be captured scale wise which ranges from illiterate to high school and above grade of accomplishment.

Output market access (MKT_ACC)*:* Getting secured market for improved product at acceptable price could be a riddled issue in the marketing front. There is significant limitation in terms of value addition of legume crops in Ethiopia where exporting may be difficult in raw form of the legume crops. On the consumer side, taking legume products cultivated via improved technology sometimes being perceived as losing of organic nature (own case study). Farmers sometime, are reluctant to invest time and money in crops which have no guaranteed market. So far the atomized structure of small producers did not organize common efforts to open new marketing channels. As a result, accessing appropriate market can be considered one of the factors for technology dissemination process. The inaccessibility of market for legume products is proposed to affect the adoption of seed and fertilizer technology adversely. The presence or absence of output market can be captured as dummy.

Price of Technology (PR_TECH)*:* new technologies may incur adoption cost through learning of new skill, implementing new practice, need of complementary practice and the purchase of the technology itself. Hence, cost of technology which will be paid in all forms to avail and adopt technology can be termed as price of technology. It has been included in the selling offer of a particular technology. Technology in this study defined the selling price of the technology when it reached to the farmer. High price of technology is hypothesized to have negative outcome in favouring adoption of technology.

Cultivated area (CULT_AR): it refers to the net amount of land devoted to crop cultivation. Farm size can have different effects on the rate of adoption, depending on the characteristics of the technology and the institutional setting. If technology is subject to economies of scale, then large farms will achieve greater profits from innovations than small farms. high fixed costs reduce the tendency towards adoption by small farms, while large farms are identified as earlier adopters, as they have more flexibility in their decision-making, greater access to discretionary resources, more opportunities to test new technology and an enhanced ability to bear risks associated with early technology adoption (Amsalu and Graaff, 2007). In this study, farmers who have large land size hypothesized to have better status of technology adoption.

Family size (FAM_SIZ): it is the number of people living in a house as a parents, children, and relatives leaving under one household leaders. It is a continuous variable which indicate the number of person living in the house of the farmers. It is expected that as the size of the house hold increases, the adoption of new technology to increases. This indicates the family with large number is more involved in adopting the new technology during their farm production effort.

Table 4. Definition and measurement of explanatory variables

Variable	Symbol	Type	Measurement
Wealth status of farmer	WL_STFR	Continuous	TLU
Market access for output	MKT_ACC	Dummy	1 if accessible, 0 otherwise
Price of Technology	PR_TECH	Dummy	1 if high price, 0otherwise
Access to credit	AC_CRDT	Dummy	1if credit is available, 0 otherwise
Technology accessibility	TECH_ACS	Dummy	if there is market access, 0 otherwise
Cultivable area	CULT-AR	Continuous	Hectare
Development agent advice	DA_AD	Dummy	1 if DA advise, 0ptherwise
Education Level	ED_LEV	Scale	continuous
Family size	FAM_SIZ	Continuous	Countable number

4. RESULT AND DISCUSTIONS

The result of descriptive statistics and econometric model results and discussions are presented in this chapter in two sections. In the first section descriptive statistical results and main survey observation of household are presented and explained. In the second section, econometric model results for chick pea and faba bean grains are presented and explained.

4.1. Descriptive Statistic Results

4.1.1. Demographic characteristic of farm households

The survey was conducted in two woredas of Bale zones; Sinana and Ginir woredas. Prior to conducting the formal survey, case study was made to have an insight about linkage of the community with the intended research objective. The demographic information of the sample household with respect to adopters and non-adopters is summarized in the table below.

Table 5. Demographic characteristics of sampled farmers

Character	Total Sample		Adopter of Technology				Non-adopter of Technology				t-value
			Seed		Fertilizer		Seed		Fertilizer		
	mean	st.dv	mean	st.dv	Mean	st.dv	mean	st.dv	mean	st.dv	
Age	44.99	0.83	44.56	11.55	43.33	10.42	46.79	13.76	47.12	13.63	44.43
Family size	6.82	12.26	6.95	2.79	6.75	2.52	6.52	2.94	6.86	12.75	28.99
Farming Experience	22.58	2.83	22.24	11.64	22.4	11.08	23.36	12.62	22.75	1.93	22.82
Children <14 Years	2.45	11.91	2.41	1.61	2.32	1.67	2.54	2.21	2.59	1.18	16.36
Child employed off farm	0.83	1.81	0.96	1.28	0.93	1.26	0.54	1.02	0.74	3.12	8.24

Source: Compiled from survey data

The average age of the sample household was 44.99 with a standard deviation of 0.83. The average ages of the adopter of improved seed and fertilizer technology were 44.56 and 43.33

years respectively while the non-adopters have a mean age of 46.79 and 47.12 years for improved seed and fertilizer technology in the respectively.

In terms of the number of family member, a household has an average of 6.95 family members. There was no significant difference between adopters and non-adopters in terms of household family size. However, concerning the family member age composition, the household who has more children aged below 14 years belongs to the non-adopter category of farming technology. As revealed from the survey results, out of the stated member households, an average of 2.41 were children below 14 years old.

4.1.2. Education status of sample farm households

Table 6. Education levels of sampled household

Education Level	Total Sample		Adopters of technology				Non-adopter of Technology			
			Seed		Fertilizer		Seed		Fertilizer	
	Number	%	Number	%	Number	%	Number	%	Number	%
Illiterate	86	41	44	51	21	25	42	49	64	75
Traditional/Religious	23	11	14	63	7	31	9	39	16	69
Elementary (1-6)	26	17	11	44	10	40	15	57	16	60
Junior level (7-10)	46	22	23	50	11	25	23	50	35	75
High school & Above (>grade 10)	19	9	6	31	9	46	13	69	10	54

Source: Compiled from survey data

The educational background of the sample household shows that 86 (41%) household heads were not formally or informally getting the education except that of the experience derived from farming activity. out of the enumerated households, 11% were getting traditional education (mostly religious education) but not enrolled in formal education. Comparing the education level between the adopters and non-adopters, 44% of the adopters were illiterate while the percentage grown to 49% for non-adopters.

4.1.3. Farming system and characteristics

4.1.3.1. Land use pattern

The overall average farm size was 3.42 hectares per sample household, of which 3.03ha is allotted for crop cultivation purpose. Cereal crops take the largest portion of land in the cropping scheme in which 50.8% of the total landholding has been given for it. Leguminous crops are the second crop which takes the next largest proportion of land where faba bean was cultivated on 0.91ha (26.6%) of land while 0.63ha (18.4%) was allocated for chick pea production irrespective of the household technology adoption status in the production season. The average farm size in the study area is greater than that of the country which is 1 hectare (EEA, 1999/2000) as well as the region's average of 1.36 hectares. The average farm size for adopters was significantly higher than that of non-adopters at less than 1% probability level (Table 7)

Table 7. Land use patterns of household

Land Holdings	Total Sample		adopters of Technology						Non-adopters of Technology						t-value
			Seed			Fertilizer			Seed			Fertilizer			
	Mean	St.dv	N	mean	st.dv	N	mean	st.dv	N	mean	st.dv	N	Mean	st.dv	
Landholding	3.42	1.92	141	3.85	1.95	101	3.68	1.87	60	2.41	5.68	101	3.17	1.96	21.12
Cultivable land	3.03	1.77	139	3.35	1.78	99	3.14	1.71	53	2.2	0.72	92	2.91	1.83	20.03
Land for faba bean	0.91	2.43	112	0.9	2.83	87	1.11	3.2	43	0.92	0.77	69	0.64	0.64	3.92
Land for chick pea	0.63	0.51	25	0.57	0.38	10	0.5	0	13	0.75	1.44	28	0.68	0.59	6.4
Land for other crops	1.49	7.43	77	1.88	7.99	60	1.53	8.89	27	0.53	1.4	43	1.59	4.58	3.82

Source: Compiled from survey data

4.1.3.2. Cropping system

Though there are various crops growing in the area, cereal (mainly wheat and barley) dominate the farming activity. There are two main cropping seasons; one is the main Meher (*June to September*) season the other Belg (March-April) season. In these two cropping seasons, the farmers are engaged in cultivation activity such as land preparation, planting, weeding and field management, cultivation and finally harvesting.

Farmers use oxen for draft power for cultivation of crops in the area. However, sometimes rented tractors and combine harvesters from nearby seed enterprises are used based on the urgency of the need to perform farming activity. Most of the time tractors and combine harvesters are used in case of cereal crops while cultivation of legume crops is done using draft power.

More than 98% of faba bean and chick pea producer farmers used draft power (oxen) to plough the land. Considering the plating season, 77% of faba bean farmers produced faba bean in belg season while in case of chick pea only 20% of the household produced in belg season. Most of the chickpea production was made in meher season using residual moisture since chick pea needs comparatively less moisture. There are also farmers growing chickpea in belge season. Row planting and broadcasting methods are used in faba bean production whereas in chickpea production only 10% of sample households used row planting. Out of the considered sample households, 75% of faba bean farming and 10% of chickpea farming households used row planting. Broadcasting method is dominated in chick pea farming in which 87% of chick pea farmers used broadcasting method. Both chickpea and faba bean farms need weeding of at least two times in a planting season. Generally, the legume agronomy summarized in the table below;

Table 8. Agronomic activities of legume production

Agronomic Activity		Faba Bean Number of respondents	%	Chick Pea Number of respondents	%
Ploughing method	Oxen	147	98%	58.2	97%
	Tractor	-	-	-	-
Ploughing Frequency	Once	2	1%	6	10%
	Twice	22	15%	49.8	83%
	thrice	120	80%	18	30%
Planting Season	Meher	30	20%	25.8	43%
	Belg	116	77%	16.2	27%
	Belg & Meher	3	2%	16.2	27%
Planting Method	Raw	113	75%	6	10%
	Broadcasting	84	56%	52.2	87%
Weeding Frequency	Once	36	24%	12	20%
	Twice & More	124	83%	48	80%

N.B. The percentage is taken independently for each crop

Source: Compiled from survey data

While considering the cropping system of the farmers in the study area, the two Woredas have difference with respect to legume production. Ginire is known in chick pea and lentil farming while Sinana is mostly known in faba bean and pea production. Out of the average cultivable land of 3.42ha, about 66% (2.26ha) was allocated for wheat production. As mentioned above, more land is allocated for cereal production like wheat, barley, and oats. Taking yield as comparison parameter, wheat has been the first crop in which 54.3 quintal from 2.26 ha of land was produced by sample farm households. Obviously, the yield level of cereal is higher as compared to leguminous crops. This is basically due to the fact that there are various parties which are working to assist the farmers both in technical support and input supply since long. Leguminous crops in general has better market price and hence 70-80 percent of the production is for market. The quantity grain supplied to market accounted to more than90% in some legumes crops like chickpea lentil, and pea (Table 9).

Table 9. Plot size, productions of major crops and amount supplied to market

Major Crops	Plot Size (Ha)		Production (Qt)		Annual sales (Qt)	
	Mean	st.dv	Mean	st.dv	Mean	st.dv
Wheat	2.266	1.81	54.33	54.37	42.946	49.224
Barely	1.0295	1.2535	14.157	13.08	12.15	12.995
Faba bean	0.755	0.941	4.9665	7.2884	3.428	2.807
Maize	0.814	1.03	8.57	7.54	6.72	4.704
Oats	4.7407	2.739	7.321	4.419	4.74	2.739
Lentil	1.465	3.297	9.5	6.221	8.66	6.173
Pea	5.65	5.07	1.48	3.15	6.93	4.14
Chick pea	0.668	0.507	8.5	4.5	8.16	2.5
Teff	0.88	0.76	7.25	4.02	5.00	3.22
Abish	1.414	1.6	14.42	7.54	13.9	7.54

Source: Compiled from survey data of sample household

4.1.4. Adoption of technologies in legume farming

4.1.4.1. Input supplying parties

There are various parties involved in distribution of farm inputs; improved seed, fertilizer, inoculants and chemicals of pesticides and herbicides. These technologies are distributed since long with various extents which vary along with the time and the advancement of the technology. The distribution channel; sometimes differ with respect to the technology. Development and multiplication of seed technology mostly performed domestically by research organization while other farm inputs like fertilizer and chemicals are imported from the international market. Improved Seed development in case of leguminous crops (pulses) is under taken by the Ethiopian Agricultural Research Institute, Ethiopian Seed Enterprise, and Oromiya Seed Enterprise. These are the main sources in seed distribution for the bale province in general. In case of fertilizer, regional government imported fertilizer and distribute to the farmers along with chain of the organization. Pesticides and herbicides chemicals are distributed both though governmental organization and private traders. Out of the household considered in this study 74% of the households were preferred governmental organization like agriculture office at different level to distribute farming inputs. Input distribution through cooperatives and union takes the second ranked in farmer input distribution. There are public cooperative and union which are working to distribute farmer inputs. Seko Mendo input distribution and mechanization service is one of the unions working in the area.

Table 10. Households' preference of institution for input delivery

S.No	Input delivery institutions	Number of sample households	**%**
1	Governmental organization (*Agricultural office, Development Agent…*)	143	74%
2	Cooperatives and unions	39	14%
3	Research institutions	15	5%
4	Traders	10	3%
5	Community association (*Idir, Equib*)	6	2%
6	Development partners (*NGO, AO*)	4	1%

Source: Compiled from survey data

4.1.4.2. Trait preference of farmers'

Taking traits like level of yield, colour, taste, drought resistance, maturity, disease resistance and storability as comparison parameters, farmers preferred improved variety than local varieties in all comparison parameter except taste of the crops. About 79% of the farmers have been preferred improved legume variety as the yield level is quite higher compared to improved variety. Farming households preferred local varieties for its favourable taste. Out of the considered traits, colour is not as such mattering where the households' shows almost equivalent preference for local and improved varieties of chick pea and faba bean varieties. Farmers' response regarding drought and disease resistance, 60% and 58% of the sample households preferred improved seed to local verities. Table 11 further shows the farmers varietal preference towards the various traits of faba bean and chick pea;

Table 11. Variety's trait preference

S.N	Grain traits	Improved Variety		Local Variety	
		Number	%	Number	%
1	Yield	165	79	74	34.2
2	Color	79	37	130	35
3	Taste	35	17	45	62
4	Storability	120	57	42	21
5	Early maturity	123	59	39	20
6	Drought Resistance	126	60	44	19
7	Disease Resistance	122	58	74	21

Source: Compiled from survey

4.1.5. Farmers typological arrangement

Dissemination of technology depends not only on the types of technology but also on the characteristics of the end users; in this research case farmer. Heterogeneity of attitudes of farmers affects the level of adoption and thus, leads to categorizing the farming community in various forms. A farm typology can be used to classify farming households based on farmers' current position of adoption of technology. Classifying farmer adoption status can exhibit different behaviour of farmers with regard to the technology. The current adoption position has been measured using adoption index. Adoption index measures the extents of utilizing a particular technology per recommended unit (Umar *et al.*,2011). Based on the level of adoption and current status, it is possible to draw a typology of farmers with respect to status of adoption.

- **TECH_ORIENTED**: these are households who have future plan to adopt technology but currently they are not in a position to do so. Tech_ oriented farmers are farmers who have information about the technology but need further assurance and practical proving from earlier adopters. They are in need of time that enables them to focus on future particularly on how to achieve the future goal through adopting improved farm inputs in one hand. On the other hand, tech oriented farmers would like to assure the success/failure story of previous adopters. Solving the limitation of knowledge gap and demonstration in particular and smoothing the barriers in general will bring these farmers to the tech fledgling cluster.

- **TECH_FLEDGLING:** households who participate in technology adoption and these are new entrants to the adoption process. These adopters can be forced to utilize the technology but may not be sure about the outcome of the intended technology on their livelihood. In case of fledgling adopters, the adoption index is low. The tendency of continuity of the adoption status of these farmers mostly depends on the outcome of the technology. Impressive outcome will lead the farmers to adopter stage. Fledging adopters includes farmers adopting a technology for trial purpose.
- **TECH_ADOPTERS:** households who are adopting technology in the previous cultivation seasons and continuing the adoption process can be clustered to technology adopters. Theses farmers are normally disposed to take favourable events from technology consumption. As the farmers have familiar attachment with technology, they are not easily convinced by a spot bad adverse outcome of technology. Looking the adoption level, the index can increase to 100% in the adoption index scale.
- **TECH_DROPOUTS:** households who are adopting a technology in the past but terminated the adoption process at this juncture. There could be dropouts both from tech fledglings and tech adopters. Usually, technology impact can be slow while once farmers incurred costs, expecting outcomes are automatically in the coming harvesting season. But such expected outcome might not realize immediate to as planned by the farmers. Reasons associated with broader farming system, community believe change getting alternative technology; family and community pressure could contribute for the farmers to be lagged from the adoption process.

The adoption categorization of the study area with respect to adoption of various technologies presented as follows:

Table 12. Adoption status of sample households for main farm inputs

	Current Adoption Status							
	Tech_ Fledgling		Tech_ Adopters		Tech-Dropouts		Tech_ Oriented	
	Number	%	Number	%	Number	%	Number	%
Improved seed	0	-	146	69.3	5	2.7	42	20.5
DAP- Fertilizer	7	3.4	159	76	-	-	50	24.7
Inoculants	29	14.4	55	26.7	-	-	119	58.2
Chemicals(pests and herbicides)	3	1.4	101	49.3	3	2.1	95	46.6

Source: Compiled from survey data

The survey result reveals that 69.3% of the total sample households using improved seed since long and still continuing the adoption process. About 2.7% of the seed technology adopters have been dropouts of improved seed technology. Out of the total non-adopter of seed technology, 20.5% of sample households were oriented to adopt improved seed. About 76% of sample households were using fertilizer for legume production. There were no dropouts' status in case of adopting fertilizer technology. Inoculants are bio fertilizer where the adoption is started recently.

Generally the time period where inoculants started to be applied in the legume production in the study area is not more than four to five years. Currently, only 26.7% of the sample households brought the inoculants technology in to their farm in previous years. About 119 households (58%) have a plan to adopt inoculants in the coming production season. To summarize, the sample survey results revealed that, taking farm inputs (seed, fertilizer, inoculants and chemicals of pesticides and herbicides) as a package, the overall adoption rate reached to 55.32% while the termination rate is 2.4%.

4.2. Econometric Analysis

Before taking the variables into the OLS model, some assumptions were tested among the explanatory and dependent variables and there is no serious problem of OLS assumption to be violated. The test results of some of the OLS assumption has been described as follows;

Normality: Normality has been tasted to get the residuals normally distributed using Smirnov-Kolmogorov test. This tests the cumulative distribution of the residuals against that of the theoretical normal distribution with a chi-square test to see whether there is a statistically significant difference. However; in this study, Smirnov-Kolmogorov test, result reveals that the residuals are normally distributed.

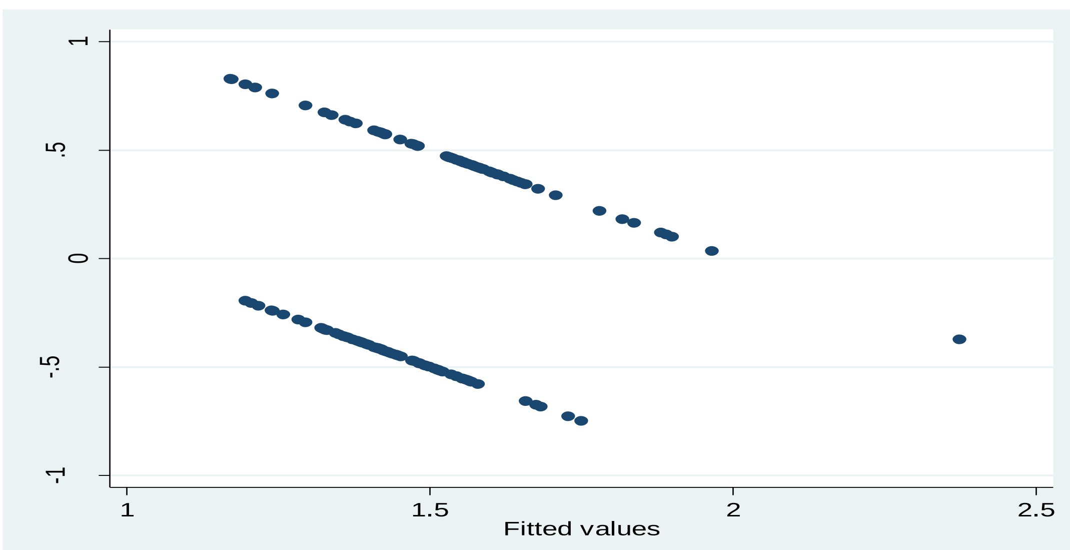

Figure 2. Model sketch of normality test

Source: own computation of multicollinarity test

Multicollinearity: before running the model, the hypothesised explanatory variables were tested for existence of multi colinearity problem that is the situation where the explanatory variable is highly interrelated. The variance inflation factor (VIF) shows absence of multi colinearity problem among the independent variable**.** It was concluded that in this study there was no serious multicollinearity problems among the explanatory variables, as their respective values were less than 10.

Heteroskedasticity: brush pagan (hattest) test was employed just to detect heteroscedasticity problem, the case in which the estimate variance of the residual from a regression are dependent on values of the independent variables. The test result detected presence of heteroscedasticity problem. As a remedy, robust test standard error test was applied. The inclusion and exclusion of irrelevant variable were tested using link and omitted variable test respectively.

Measures of Goodness of Fit: The values of multiple coefficient of determination Adjusted R^2 (is indicates that, the OLS regression model explains about 68.5% of the model has been explained in the analysis of adoption of improved seed against the hypothesized explanatory variable. The adjusted R^2 result was found 0.443; for OLS result of the adoption of DAP fertilizer in which the model is explained about 44.3%.

4.2.1. Factors affecting adoption of legume technologies

Attempt was made to examine factors affecting adoption level of improved seed and DAP fertilizer technologies adoption using econometrics analysis. Many variables may influence the adoption level of technologies. The model estimation was projected in a way that the adoption of improved seed and DAP fertilizer given that chickpea and faba bean as legume crops aggregated as legume packages. Variables with statistically significant coefficients were then identified so that it can measure the level of importance to determine were proposed to affect the adoption. The result of the OLS model on factors affecting level of technology adoption is summarized in the table 13.

Table 13. Factors affecting adoption level of improved seed technology

Variables	Coefficients B	Coefficients Std. Error	t	P-Value
(Constant)	.855	.138	6.210	.000
Price of technology (PR_TECH)	-.135*	.042	-3.225	.001
Technology access (TECH_ACC)	.338*	.055	6.194	.000
Credit access (AC_CRDT)	.177*	.054	3.277	.001
DA advise (DA_AD)	.174**	.057	3.070	.002
Market access (MKT_ACC)	-.003	.039	-.068	.946
Family Size (FAM_SIZ)	-.026**	.009	-2.836	.005
Wealth status of farmers (WL_STFR)	.030*	.004	.6.713	.000
Cultivable area (CULT_AR)	.008	.009	.917	.359
Education level (EDU_LEV)	.642**	.024	26.813	0.000
	Adjusted R Square	Std. Error of the Estimate		
	.443	.765		

*, ** and *** refers significant at 10%, 5% and 1% respectively

Source; OLS result of own computation

In case of DAP fertilizer adoption, the OLS result shows that out of those nine variables proposed to affect the level of adoption, seven variables found to be a significant variables that affected the level of adoption of DAP fertilizer.

Table 14. Factors affecting adoption level of DAP fertilizer

Explanatory Variables	Coefficients		t	P-Value
	B	Std. Error		
(Constant)	.317	.102	3.123	.000
Price of technology (PR_TECH)	-.083**	.031	-2.749	.006
Technology access (TECH_ACC)	.279*	.040	6.909	.000
Credit access (AC_CRDT)	.171*	.0040	4.258	.001
DA advise (DA_AD)	.047	.042	1.130	.259
Market access (MKT_ACC)	.007	.042	.230	.818
Family Size (FAM_SIZ)	-.016**	.007	-2.347	.019
Wealth status of farmers (WL_STFR)	.006*	.003	1.702	.000
Cultivable area (CULT_AR)	.031**	.012	2.631	.009
Education level (EDU_LEV)	.855*	.017	48.927	.000
	Adjusted R Square	Std. Error of the Estimate		
	.682	.568		

*, ** and *** refers significant at 1%, 5% and 10% respectively

Source; OLS result of own computation

Accessibility of market: The OLS result shows that access to output market (market for faba bean and chickpea products) has no significant effect on the adoption of improved seed and DAP fertilizer. The simple comparisons between adopters and non-adopters demonstrate that the adopters groups are significantly distinguishable in terms of farmers' integration into output market /marketed surplus (Solomon *et.al*, 2011). This is no inline with the finding of Shiferaw and Tekelewold (2007) which state that production of chickpea and faba bean for food security in Ethiopia, lack of technological change and market imperfections have often locked the small producers in to subsistence production and contributed stagnation of the sector During conducting case study with key informants, they disclosed that facing marketing problem for selling their faba bean grain of the improved varieties. The descriptive result suggested that 75% of the respondent has generally a serious marketing problem; of that 43%

of the respondents were reported that the faba bean market is dominated by few buyers and absence of large buyer being a serious problem. Similarly 23% of the respondent also confirmed low selling price is quite a serious problem for improved faba bean products. Market distance and infrastructure problem were also mentioned as a challenge in the marketing front in the case study.

Wealth Status of farmers: the regression result revealed that wealth which is measured in terms of tropical livestock unit has significant contribution to the adoptability of seed and fertilizer technology at 1% significant level. This can support the finding of (Bola *et. al*, 2012), that household wealth is important to affect technology adoption positively.

Access to credit: the result shows that, the impact of access to credit on adoption, and a good deal of it showing that credit has a positive effect on adoption. Cornejo and McBrid (2002) highlighted that credit access is one of the key factor affecting technology adoption not only for seed and chemical fertilizer but also for most of agricultural innovation The result of this study also proved that farmers' adoption level significantly improved given that the credit is available. However, case study result shows that there is a big limitation in delivering the credit service for the faba bean farming. Household access to financial service influenced by the location, conditions to deliver the credit and the priority area that financing institutions steered. As the area is dominantly wheat and barley growing, the farming culture is cereal focused and the creditors pays more effort in financing cereal based farming activity. As a result, the credit given for pulse crops relatively limited but it is a significant factor that influence the level of adoption of both legume seed and DAP fertilizer at 1% significant level.

Technology access: Most of the time, smallholder farmers do not adopt all components of packaged technologies in which farmers only take those technologies components that they perceive as useful and economical within their reach**.** The accessibility of improved technology near to the village of the farmers households influencing the adoption status of both seed and DAP positively and significantly at 1% significant level. Accessibility of technology nearby to the farmer's village can create opportunity to know detail about the technology and further open the chance to adoptability rate.

Development agent advice (DAAD): as is assumed to mean a new, scientifically derived, often complex input supplied to farmers by organizations with deep technical expertise and hence development agent advise was hypothesised to have significant effect towards the improving the adoption level of technology. In line with the initial hypothesis, the OLS result shows advice of development experts has a significance and positive influence towards the adoption of improved seed technology. Unlike to seed, development of experts advice has no significant effect for DAP fertilizer adoption.

Size of cultivable land: the size of the landholding for cultivation purpose has a significant positive influence to the adoption improvement of DAP fertilizer at 1% significant level while it has no significant effect to the adoption of improved seed. This can be further interpreted as small land size can limit the adoptability of fertilizer technology while the size of the cultivable lands no significant contribution towards the adoption improved seed. The more the farmers having cultivable land could able to adopt higher adoption rate of DAP than the one who has less land.

Price of technology: Price of technology includes the purchase price of the improved farm inputs including transportation and other transaction costs. The OLS regression resulted that price of technology has a negative impact on the adoption of fertilizer and seed technology at 5% and 1%significant level respectively. But, it has no significant relevance to affect the status of improved seed technology. This can be further explained that farmers are highly sensitive for the price of farming inputs in which higher input price will have lower rate of adoption level.

Education Level of household head: in line with the hypothesis, level academic qualification of farmers has a significant influence in favour of the adoption of both improved seed and fertilizer technology at 1% and 5% significant level respectively. It is observable that in the farming community, the higher the academic qualification of the household member will exposed to leading position in most of the hierarchy of the kebele administrative units. As a result, they will be the first community organs that receive the technology and initiated to be taken as the role model for the higher ruling organ. Besides, they will have better chance to get the technology.

Family size: Initially household size was expected to have positive effect on the adoption of technology. However, the regression result shown that higher household size has a significant and adverse effect on the adoption level of both improved seed and fertilizer. One of the reasons why farmers adopting technology associated with cost reduction. Households who have larger family size would like to reduce the cost via participating family members in the farming activity instead of adopting technology through. The FGD result shows that most of the larger family sized households were leaving in lower life standard than those of small family size. As a result, larger family size households may be against adoption of agriculture due to fear of cash expense for purchase of technology.

4.2.2. Propensity cores matching (PSM) estimating of impact

The study provided evidences as to compare whether or not application of improved seed and chemical fertilizer technology brought a significant impact on the farmers income. The logistic regression model was used to estimate propensity score for adopters and non-adopters of improved seed and fertilizer technology. Users of agricultural technology were taken as dependent variable with 1 for adopter and 0 for non-adopter. The pre- intervention were taken as explanatory variables and assumed to affect participating in adopting technology.

A result presented in Table 15 below shows the estimated model appears to perform well for the intended matching exercise. The pseudo-R^2 value is 0.1937, a low R^2 value shows that faba bean farming households do not have much distinct characteristics overall and as such a good match between adopters and non adopters of technology becomes easier. The objective of matching procedure is to get similar probability of using or not using the technology under consideration within a given explanatory variables.

Table 15. Log result of PSM estimation

Variables	Coefficient	Std. Err.	P>z
(PR_TECH)	0.432***	0.263	0.010
(TECH_ACC)	-0.007	0.061	0.908
(AC_CRDT)	0.892**	0.443	0.044
(DA_AD)	0.771***	0.565	0.072
(MKT_ACC)	0.151**	0.447	0.035
(FAM_SIZ)	-0.015**	0.411	0.069
(WL_STFR)	0.025	0.021	0.240
(CULT_AR)	0.044	0.074	0.549
(EDU_LEV)	0.275**	0.136	0.043
_cons	-4.071	1.490	0.006

Number of obs	203
LR chi2(13)	25.69
Prob > chi2	0.0187
Pseudo R^2	0.1395
Log likelihood	-79.216542

*, ** and ***statistically significant at 10, 5 and 1 % probability levels, respectively
Source; Own computation

The table given above shows the marginal effect estimation of the logit model with adoption of agricultural technology. From the estimation result of the marginal effect, there were variables (marked with*) that are statistically significant.

4.2.3. Common support condition

After estimating values of propensity score for technology users and non-users the next step in propensity score matching technique is the common support condition. Only observations in the common support region matched with the other group considered and others should be out of further consideration. Once the region of common support is identified, sample households that fall outside this region have to be dropped and the treatment effect cannot be estimated for these sample households. The kernel density estimate in figure-4 revealed that the distribution of the total sample households, adopters, and non-adopters of sample household with respect to estimated propensity scores.

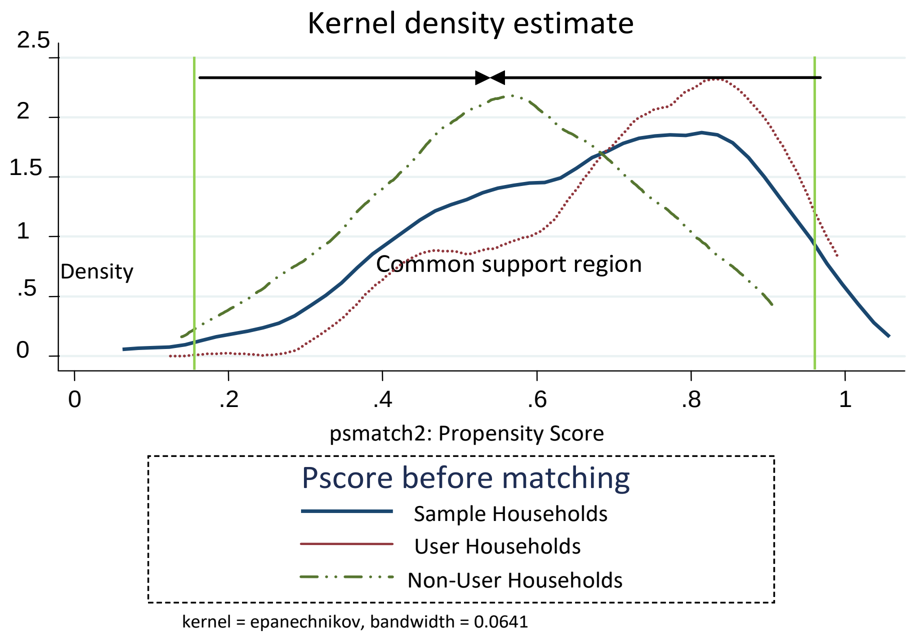

Figure 3. Density of propensity score distribution before matching

The treated (use of technology) groups were densely found to the right of the graph while the control group symmetrically found in the midlines of the density estimate graph. After estimating values of adoption (propensity scores) of technology users and non-users the second step is matching users and the control group by imposing a common support condition.

The estimated propensity score has within the range of 0.121 and 0.663 with a mean of 0.723 for adopters of technology (treated groups) and in arrange of 0.138 and 0.9054 with a mean of 0.172 for non adopter (control groups).

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Table 16. Distribution of estimated propensity scores

Group	Obs	Mean	STD	Min	Max
Total HHs	203	0.668966	0.192679	0.126188	0.993461
Treatment HHs	135	0.723020	0.179315	0.126188	0.993461
Control HHs	68	0.559730	0.17278	0.138965	0.905424

Source; result of PSM estimation

The common support region would then lie between 0.138 and 0.905 it excludes treated units whose propensity score is higher than the highest propensity score of the control units and control units whose propensity scores are lower than the lowest propensity score of the treated units. Therefore, households whose estimated propensity scores less than 0.1389 and larger than 0.9054 were not considered for the matching exercise. With this restriction, totally 19 households from adopter side were discarded from the analysis. The common support condition obliges to drop down observations with probability of participation greater than 0.9054. Accordingly 116 observations from the participants and 67 participants from non-adopters groups satisfy the common support condition.

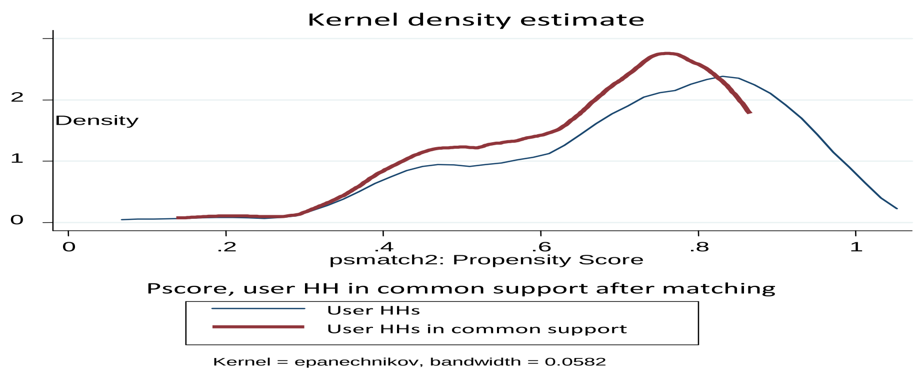

Figure 4. Kernel density participants estimates after matching in common support user HH

In case of non-adopter households, most of the observation aligned to the center with gentle slope to the right of the graph. No observation from the non participant household fall out of the common support region. Thus, all the 68 observation were considered in the pscore matching.

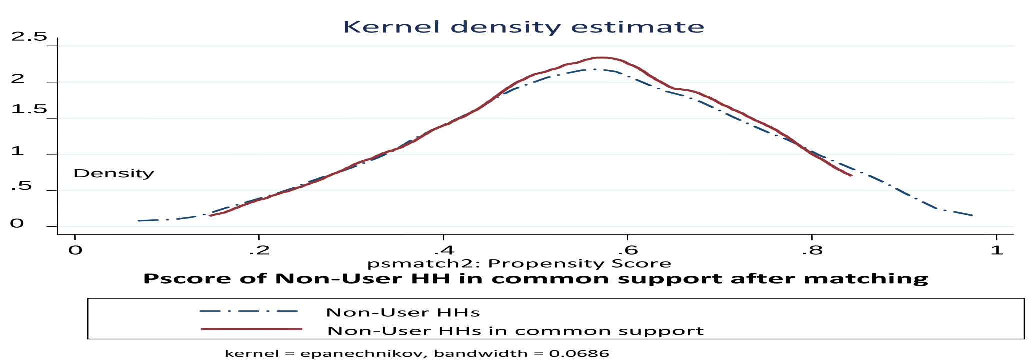

Figure 5. Kernel density estimate after matching in common support for non-adopter HH

4.2.4. Choice of matching algorithm and matching

Alternative matching estimators can be employed in matching the treatment and comparison groups in the common support region. The final choice of a matching estimator can be done by taking selection criterion either of balancing test, pseudo-R^2, and matched sample size. Accordingly, a matching estimator which balances all explanatory variables (i.e., results in insignificant mean differences between the two groups), a model which bears a low pseudo R^2 value and results in large matched sample size is a preferable matching algorism (Dehejia and Wahba, 2002). The karnel matching that matches a treated unit to all control units weighted in proportion to the closeness between the treated unit and the control unit.

Table 17. Selection of matching algorithm

Matching Algorithm	Result of criteria for selection		
	Balancing test*	**Pseudo-R^2 After matching**	**Matched sample size**
Kernel			
Band width (0.01)	9	0.050	183
Band width (0.1)	**9**	**0.015**	**183**
Band width (0.25)	9	0.030	183
Band width (0.5)	9	0.067	183
Nearest Neighbour			
NN(1)	9	0.062	183
NN(2)	9	0.048	183
NN(3)	9	0.026	183
NN(4)	9	0.029	183
NN(5)	9	0.033	183
Calliper			
cal 0.01	9	0.049	183
cal 0.05	9	0.039	183
cal 0.1	9	0.064	183
cal 0.20	9	0.186	183
cal 0.50	9	0.574	183

N.B. Number of explanatory variables with no statistically significant mean differences between the matched groups of user and non-user households after matching.
Source; own computation

4.2.5. Testing the balance of propensity score and covariates

This kind of test is carried so as to know whether there is a statistical significant difference in the mean values of covariates between user of technology and those of non-adopters. The higher the Balancing test in this context is a test conducted to know whether there is a statistical significant difference in the mean values of covariates users and non-adopters of technology. The higher the covariates with minimum mean difference after matching is the more balanced covariates. Keeping other selection criterion, the balancing test indicates the quality of the matching algorithm implemented.

While evaluating treatment effect, the major econometric problem is selection bias as stated in Maddala, (1983), percentage of bias before matching is in the range of 2.7% and 25.5% while after matching, percentage bias lies between 0.2 % and 15.8 %, which is below the critical level of 20% . In all cases, it is evident that sample differences in the unmatched data significantly exceed those in the samples of matched cases. The process of matching thus creates a high degree of covariate balance between the treatment and control samples that are ready to use in the estimation procedure. Similarly, t-values show that before matching six of chosen variables exhibited statistically significant differences while after matching all of the covariates are balanced (no statistical difference).

Table 18. Pscore and covariates balance

Variable	Before Matching (N=203)				Kernel Matching (Band Width 0.1) (N=183)			
	Treated	Control	% bias	t	Treated	Control	% bias	t
_pscore	0.69055	0.68515	3.1	0.23	0.68094	0.67376	4.1	0.28
(PR_TECH)	3.0988	3.1605	-7.1	-0.46	3.0864	3.1381	-6.1	-0.38
(TECH_ACC)	7.8367	7.4482	8.8	0.58	7.7884	7.5451	6.2	0.35
(AC_CRDT)	0.4321	0.3642	14	0.88	0.44444	0.3807	13.2	0.82
(DA_AD)	0.8642	0.88272	-4.9	-0.35	0.8642	0.88152	-4.5	-0.33
(MKT_ACC)	0.37037	0.46296	-19.4	-1.19	0.38272	0.40897	-5.5	-0.34
(FAM_SIZ)	0.53086	0.60185	-14.1	-0.91	0.53086	0.58521	-10.8	-0.69
(WL_STFR)	21.802	22.127	-2.7	-0.16	22.185	21.9	2.3	0.14
(CULT_AR)	6.9383	6.7284	7.4	0.46	6.8148	6.8096	0.2	0.01
(EDU_LEV)	2.9738	2.7173	14.4	0.93	3.0047	2.8973	6.4	0.39

Source; own survey result

The joint significance test and the pseudo R^2 are also good indicators of matching quality (Table 18). The low pseudo-R^2 and the insignificant likelihood ratio tests (indicated by the higher p-value after matching) support the hypothesis that both groups have the same distribution in covariates X after matching.

Table 19. Chi-square test for the joint significance of variables

Sample	Pseudo R^2	LRchi2	P>chi2
Unmatched	0.1395	25.69	0.0187
Matched	**0.015**	3.43	0.998

Source: Own calculation

The chi-square test result shows that the covariates in the unmatched and matched groups have been balanced. The result is important to compared observed outcomes for adopter of technology with those of non-adopter have shared a common support region.

4.2.6. ATT estimation of impact of technology on HH income

Farm income enables household to purchase its basic needs of life; per capita expenditure reflects the effective consumption of households and therefore provides information on the food security status of households. Before proceeding to estimate the treatment effect of technology, we have to be sure that reliability of participants and controls to have uniform distribution on its observed and non-observed characteristics of sample households. The average treatment effect measures the average difference on the household income as well as expenditure between the matched adopters and non-adopters of the intended technology. The ATE for the matched users and non-adopter has been found using kernel matching at bandwidth of 0.1.

Table 20. Treatment effect on HH income and expenditure

Variable	Matching Estimator	Treated	Controls	Difference	S.E$^{\Psi}$.	T-stat
Annual Income	Karnel with bandwidth (0.1)	68185.9	66296.2	1889.66	10098.4	0.19*
**Annual Legume Crop Income		7821.28	3210.24	4611.04	4204.10	0.94

[**] legume crop income refers the income earned from sales of chickpea and faba bean

*****statistically significant at 5 % probability levels

Source: Own computation

The estimation result in table 19 provides supportive evidence about the effect of technology on household welfare performance. The study basically focused on impact of technology on the total income and legume crop income of household. Income of household indicates that the ability of household to purchase its basic needs of life and hence it ultimately shows the livelihood performance of the farmers as stated in Nguezet *et.al.,* (2011). Results of the analysis farm income of the sample household who were adopting the improved seed and fertilizer technology earned Birr 68,185.89 while those non-adopters earned Birr 66,296.2317 on average basis. In particular, the annual income that earned from sales of legume grains of chickpea and faba bean is Birr 7821.28 for adopters while it is Birr 3210.24 for non adopters.
The impact analysis of the PSM result showed, after controlling for pre-intervention differences of the adopter and non-adopters of improved seed and fertilizer technology packages, the gross income of adopters has been increased by 2.8% (to Birr 1,889.66) on average basis and the legume crop income increased by 41% (Birr 4611.04) . The PSM result shows that adopting farming technology has significant contribution on both the aggregate income and crop income in particular. The t-test analysis revealed that the mean difference of income and expenditure level between the two groups was statistically significant at 5%probablity level.

4.2.7. Sensitivity analysis

There may be hidden biases against the result of matching estimators and hence testing robustness the result is recommended. As it is not possible to estimate the magnitude of the selection bias with non-experimental data, the problem can be addressed through using sensitivity test.

The basic issue in testing sensitivity is to check whether the treatment effect is due to unobserved factor or not. Rosenbaum (2002) proposes using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT. The results shows that the impact of technology intervention is not changing through participates and non participants' households if it is allowed to differ odds of being treated up to Gamma=3. That means for the outcome variable estimated, at various level of critical value of gamma, the p-critical values are significant which further indicate that consideration of important covariates that affected both adoption and outcome variables. We couldn’t get the critical value gamma where the estimated ATT is questioned even if we have set gamma largely up to 3, which is larger value compared to the value set in different literatures which is usually 2 (100%). Thus, it can be concluded that the impact estimates (ATT) are insensitive to unobserved selection bias and are a pure effect of income due to technology adoption.

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary

The survey was conducted in two woreda's of Bale zone Sinana and Ginir Woredas of Oromiya regional state. A total of seven kebele were enumerated as a sample for this study. The descriptive result of the sample household indicated that the mean age of the farming household is 44.9 years. The average age of adopter of technology is 44.56 years while it is 46.79 years for non adopters of technology.
The percentage of technology adopters were high within the academic categories of elementary, junior level and high school academic status where 41.7% of seed adopters and 37% of fertilizer adopters were falling under in such categories. Concerning the land use pattern, the average farm size was estimated to 3.2ha per household of which 3.03ha of land was allotted for crop cultivation purpose.

Cereal crops taken the principal portion of cultivated land in which 50.8% was allocated for it while leguminous crops (basically faba bean and chick pea) occupied 26.6% of the cultivated area. Legume cultivation has been made both in *meher* and *belg* season. Legume farmers mainly use oxen for ploughing in which 98% of faba bean and 97% of chick pea farmers used as a draft power. The seeding methods of legumes used by the farmers are both row planting and broadcasting. Various parties are involved in distribution of farm inputs like improved seed, chemical fertilizer, inoculants, pesticides, and herbicides in the area.

The farming communities have better perception in preferring government institution in input delivery system and cooperative and unions next. The number of households adopting other technologies like inoculants, pesticide, and herbicides were quite less in number. About 70% of the sample households have a plan towards adopting these technologies in the future. Households adopted improved varieties in terms of better yield, drought resistance, and early maturity while local varieties preferred in terms of taste.

The farming community of the study area can be classified in to four major clusters based on current status in relation to adoption. These are; tech_ oriented tech_ fledgling, tech_ adopters, and tech-dropouts. Tech_oriented are those farmers who have information about the technology but not implemented and those Tech_ fledglings are farmers who are new participant joined the adoption of the technology. Adopters are, farming community who are properly working with the support of technology for a sustained period of time. There are also farmers who lose their adoption tendency and diminishing their adoption index due to various reasons that are referred tech- dropouts.

Factors affecting the level of adoption of improved seed and fertilizer technology were identified using OLS regression model. Out of nine explanatory variables hypothesised to influence the level of adoption, of which the accessibility of technology, credit availability, advice of development agent and education level are factors which affected the adoption of both seed and fertilizer technology positively. While high price of technology is prohibiting adoptability of farming technology. Furthermore, better wealth status and having more cultivable land has a positive effect towards the adoption of fertilizer technology but has no significant effect on the adoption of seed. On the contrary, participating in the social community has positive contribution for the improvement of seed adoption. Furthermore, the effect of technology on the livelihood of smallholder farmers basically reflected on its income and expenditure. Impact of technology on income and expenditure of households estimated using propensity score matching. The impact analysis result revealed adopting technologies has significant role on the improvement of level of total income and it has so impressive impact on crop income. It shown that total annual income of adopter improved by 2.8% and 41% improvement on the crop income relative to non adopting farmers.

5.2. Conclusion and Recommendation

Leguminous crops are the second crops both in production and consumption in Ethiopian farming system next to cereals. It has also the big market share in the export market and generating foreign currency for the national economy. Leguminous are the ultimate source of protein in diet complements of these substance-farming communities but are rarely the major focus of attention. Predominantly legume farming is carried out traditionally without the relief of agricultural technology. In recent years, the adoption of agricultural technologies such as improved seed, fertilizer, and farming equipments being utilized by the farming community but still the rate of adoption is in its lower level. The typology of farmers shows that, there are farmers still not deciding to adopt farming technology (tech- oriented) and there are also farmers that quit adoption (tech- dropouts) while the remaining are adopting legume technology at various rates. The farmers' adoption status shows that 20.5% and 24.7% of households have not a touch of using improved seed and fertilizer technology respectively.

The study brought out that adopting agricultural technology has a considerate impact on the improvement of livelihood of farming community. It is also observed that population density in highlands of the country is concentrated in which the cultivable land holding became small. One of the important strategies to meet the increasing food demand is boosting the production within a limited resource through the adoption of improved farming inputs.

According to the PSM estimation, the adoption of improved technology has a dual impact on household wellbeing; yield increasing and cost reduction. With this respect, allowing farmers to interact with farming technology not only have a direct impact on the income and expenditure but also has a direct substitution effect on other livelihood aspects. This leads to a conclusion that adopting technology will be one of the basic instruments to enhance the leaving standard of farming community. Technology effect tends to optimized by addressing the possible influencing factors.

Relaying on the finding of this empirical study, the following recommendations are suggested: First, high price of technology and larger family size has a significant influence against the adoption of improved agricultural inputs. Farmers are sensitive to pay for technology as they may not be sure about outcome resulted from using a technology. Due to such facts, the government should subsidize the price of technology especially for new entering agricultural technologies.

Secondly, creating access for farmers to get the technology along with the credit has a considerable role for the adoption and ultimately for improvement of livelihood. Almost the entire smallholder farmer cultivating leguminous crops through seasonal rain fed. Hence, accessibility is not a matter of only availing the technology but it extended to getting at the time when demanded. Thus, suppliers and distributors of improved technology need to align with the season in which a particular input required and the government should assure the proper distribution of inputs.

Thirdly, access to credit can enhance technology adoption provided that the time, the condition of lending, and the cost of the money (interest) properly addressed. For farmers getting upfront cash at the time of harvesting is quite limited. As a result, credit availability became the outermost choice. With this fact, designing special line credit for purchase of farming inputs will be expected from policy makers.

Fourthly, Farmers' typological arrangement is critical for decision making towards the adoption of technology therein designing a policy that enable to attain the target around a particular cluster. Status of adoption varied among farmers due to various factors. Generalized decision will not be effective while farmers belonged in different status of adoption. Thus, technology shall improve provided that decisions are given based on farmers' typical clusters of uniformity.

Finally, technology is dynamic by its nature; it ever changing with time and hence factors continued to vary in similar pace. So, researcher should contemplate future possible factors affecting the adoption in each particular period. In doing so, the stakeholders engaged in input development and distribution should identify the main concern of the farming community before releasing the technology. From cases study, Farmers are observed to have been better trust on the government organizations and hence tempting those organs will improve the intake of technologies.

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7. APPENDICES

Appendix 1. VIF test result (estat VIF)

Variable	VIF	1/VIF
DA_AD	1.82	0.549763
TECH_ACC	1.62	0.617803
ACC_RDT	1.51	0.660885
EDU_LEV	1.35	0.741517
PR_TECH	1.32	0.754909
WL_STFR	1.07	0.931861
CULT_AREA	1.03	0.971179
MKT_ACC	1.02	0.980125
FAM_EXP	1.02	0.980133
Mean VIF	1.31	
Mean VIF		**1.34**

**9-p, 10-tech acc, 11 credit, 12 da, 13mk

Appendix 2. Brush Pagan Test

Brusch Pagan Test for hetroskedasticity result
H0: constant variance
Variable: Fitted values of level of adoption
Chi2 (1)=0.03
Prob>chi2=0.8723

Skewness/Kurtosis tests for Normality

			joint	
Variable	Pr(Skewness)	Pr(Kurtosis)	adjchi2(2)	Prob>chi2
resid	0.743	0.480	0.78	0. 6136

Appendix 3. Treatment result of PSM

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Annual Expenditure	Unmatched	15291.65	18748.53	-3456.88	3556.86	-0.97
	ATT	15294.67	23478.12	-8183.45	4054.31	-2.02
	ATU	19298.47	10655.10	-8643.37	.	.
	ATE			-8350.04	.	.
Annual Income	Unmatched	70077.8	50904.7708	19173.024	8694.6002	2.21
	ATT	68185.89	66296.2317	1889.6572	10098.405	0.19
	ATU	50820.2	51011.9063	191.71068	. .	
	ATE			1274.6529	. .	

Appendix 4. Sensitivity test

Rbounds legume income level ,gamma(1(.25)3)

Rosenbaum bounds for legume income (N =131 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	12870.4	12870.4	9579.9	17107.5
1.25	0	0	11125.7	15050	7919.85	19401.3
1.5	1.20E-15	0	9517.5	17167.5	6723.6	21915.8
1.75	1.30E-13	0	8323.08	18693.8	6032.66	23320
2	4.40E-12	0	7516.84	20085.9	5530.17	24992.5
2.25	6.90E-11	0	6803.76	21713.9	4930.83	26632.5
2.5	6.20E-10	0	6340.92	22590	4222.02	27700.8
2.75	3.80E-09	0	5997.27	23405	3651.21	28466.2
3	1.70E-08	0	5702.39	24341.7	3280.42	29559

amma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

sig- - lower bound significance level

t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .95)

CI- - lower bound confidence interval (a= .95)

rbounds Income Level gamma(1(.25)3)

Rosenbaum bounds for Income level (N = 131 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	55143.8	55143.8	48675	62850
1.25	0	0	51500	59225	45075	67625
1.5	2.20E-16	0	48600	63000	41930	72475
1.75	3.00E-14	0	46305	66140	39760	76625
2	1.10E-12	0	44250	69100	37525	80193.5
2.25	1.80E-11	0	42250	71940	35735	83410
2.5	1.70E-10	0	40900	74600	34262.5	86912.5
2.75	1.10E-09	0	39625	76909	33100	90200
3	4.90E-09	0	38300	79110	31950	93846

* gamma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

sig- - lower bound significance level

t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval (a= .95)

CI- - lower bound confidence interval (a= .95)

Appendix 5. Survey Questionnaires

Dear répondent! This survey questionnaire is designed with the objective of collecting information on the technology adoption of farmers. It therefore meant only for research purposes. For this purpose your genuine responses to each of the survey questions are highly useful.

There are no “right” or “wrong” answers. Your responses will be confidentially used for this research purpose only.

We highly appreciate for your willingness to participate as a respondent in this survey.

For all closed type questions please put <X> mark where appropriate and please strictly follow the instruction given in each part of the questionnaire

Interviewer (Enumerator) Name: ____________

Tell: _____________________

Name of PA: _________ code; ________

Name of respondent: ________________

I. Demographic & geographic information

1. Sex: Male ☐ Female ☐
2. Marriage status: married...............☐ Divor☐.....
   Unmarried........... ☐ widowed.......... ☐
3. Farming experience ____years
4. Religion: Orthodox Christian...☐ Muslim..........☐
   Protestant.................. ☐hers (specify): ....
5. Household size (number of family members in a house hold)__________
6. Age of the household head:________________________
7. Education level of the respondent:

a) No education (illiterate)_______

b) Traditional education (Mosque or church education)_____

c) Elementary education (1-6 grades)

d) Junior level education (6-8 grades)

e) Others:..........................

8. What is the house you owned and live in?

Grass roofed and muddy wall............. ☐

Corrugated tin roof and muddy wall...... ☐

Corrugated tin roof and Bullock wall... ☐

Other (please specify)................................

II.Socio-economic characteristics

1. what is the source of income for your household *(more than one answer is possible to give)*

- Farming (crop cultivation).............. ☐
- Animal husbandry.......................... ☐
- Crafts man....................................... ☐
- Employed (salary)............................. ☐
- Trading... ☐
- Other (*please specify*) __________________

2. Landholding status (Timad):

   2.1. Total landholding: ________

   2.2. Total cultivable land: _______

   2.3. Land allocated for legume production: _____

   2.4. Land allocated for other activity (please specify): __________

3. What are the main use of legume grain for you

Use of legume produced	**% (from annual production)**
For consumption	
For sale	
Source of livestock	
For soil fertility purpose (crop rotation)	
For other purpose (*Please Specify*)..................................	

4. What are the main crops you cultivate in your farm and how much area is allocated for each crops? Please fill the requested information here below:

Main crop	Area cultivated (Timad)			
	2007 E.C Meher	2007 E.C Belge	2008 E.C, Meher	2008 E.C, Belge

5. Would you expect that use of farm inputs like improved seed, fertilizer, inoculants, pesticides and herbicides has improving role on yield of legume crops?

Yes ☐ No. ☐

6. If your answer is yes for Q # 5, would you give your response for the following information:

Farm inputs used for legume farming	Purhase price/unit	Quantity purchased/Year

7. What are the farming cultiture that your implement in cultivation legume grains crops?

Practice	Fava bean	Check pea	Others
Land ploughing (tractor/oxen)			
Frequency of ploughing before sowing (*once, twice, three times*)			
Planting time			
Planting method (*raw or broadcasting)*			
Weeding frequency			
Harvesting time			
Other activity (*please specify..)*			

III. Adoption status of agricultural technology

1. Have you ever used improved seed varieties of legume grain in your farm operation?

Yes...... ☐ No................ ☐

2. If yes, for Q# 1, where do you get these seed?

Research center.. ☐

Government supply.. ☐

Purchase from market.. ☐

Supply of development partners (e.g. NGO).......... ☐

Other source (please specify)..................................

3. Have you applied fertlizer for legume production? Yes. ☐ ☐

4. If your answer is yes for Q #3 , fill the type of fertlizer that you applied and the respective quantity as requested here below;

S.N	Type of Fertlizer	Qunatity utlized per croping season	Purchase Price per/Qt
1	DAP		
2	Urea		
3	Innoculant (bio-fertlizer)		
4	Compost		

5. Have you ever been utilized chemical inputs *like herbicides, pesticides, and fungicides* in production of grain legume? Yes ☐ No. ☐

6. If yes for Q#1,3,5 why you using these improved farm inputs?

Improving yield performance ☐ Increasing income.......... ☐

Reducing cost of production ☐ improving soil fertility..... ☐

Offsetting environmental effect ☐ food security...................... ☐

Other (*please specify…)* ___________________

7. If you say no for Q#1,3,5, why you are not in a psotion to use these farm inputs?

High purchase price .... ☐

Aceceblity problem.................................... ☐

Incopatible weather condtion...................... ☐

Other (*please specify)* ....

8. What is your current state in utlizing farm inputs (*improved seeds, fertlizer, chemicasl...)* in your legume production?

Put 1-if you started adoption recently,

2-if you continued adoption with increasng rate

3- if you adopting with decreasing rate

4- if you terminated adotption

5- if you have a plan to adopt

Farm inputs	Adoption status
Improved seed	
Innouclants	
Fertlizer	
Chemical (pesticides, herbicides, ..)	
Farming techniques (*spacing, raw planting, ...)*	
Other (*please specify*)	

9. Do you face any challenge in adoption process of farm inputs (*fertilizer, chemicals, seed, spacing......)*

Yes ☐ No. ☐

10. If your answer is Yes for Q#,9, what are the major challenges that affect the use of these farm inputs

1. __________________ 4.__________________

2. __________________ 5.__________________

11. Which of the following ways is/are better to address farm inputs (*seed*, *chemicals*, *fertilizers*) to the farming community? Please rank the ways of inputs dissemination from best (first) to worst (the last)

Input dissemination institutions	Rank
Through gov't organization (*Agri office, DA*, kebele...)	
Through devt partners (*NGO…*)	
Through community associations (*Idir, equib, …)*	
Through cooperatives, unions	
Through traders	
Through research institutions	
Others (*please specify…)*	

12. Do you think the improved legume inputs is better than local varieties in terms of the following traits (mark <X> for the better one in the table below)

Traits/	Fava bean		Chickpea		Pea		Lentil	
characteristics	Local	Improved	Local	Improved	Local	Improved	Local	Improved
Yield								
Colour								
Taste								
Drought resistance								
Maturity period								
Disease resistance								
Storability								
Other *(please specify..................)*								

13. Give a priority order for which you most focus from the above traits; first /most priority to last/least priority

1. ______________________ 5.__________________
2. ______________________ 6. __________________
3. ______________________ 7. __________________
4. _______________________ 8. __________________

IV.Issues on factors of technology adoption

1. Do you have extension agent (DA) advice to use inputs in legume produ☐on? Yes ☐ No

2. If your answer is yes, for the question #1, how often did the extension agent contact you?

Weekly basis.................................. ☐

Twice per month............................. ☐

Monthly basis.................................. ☐

Frequently at the time of cultivation.... ☐

Other (please specify..

3. If yes for Q#1, how can the development agent help you for the effective application of farm inputs?

Practical assistance at farm .... ☐
Demonistartion.................................. ☐
Training at FTC .... ☐
other (please specify) ________________

4. If yes for Q#1, How do you evalatue the assistance given by the development agnet service for the sucessful adoption of farm inputs (*improved seed, fertlizer, pestcides, herbicides., farming techinques etc*)?

Excellent ☐ Very good ☐ Good ☐ poor ☐
other source (please specify)..

5. If your souce of fund is credit for Q#5, do you easily get credit? Yes ... ☐ No. ☐

6. if No for Q#6, What are the major problem you face to get farm input on credit?
   - Absece of the credit agnet .... ☐
   - high interest rate .... ☐ (Interest rate.....%)
   - Problem of timely affording the credit......... ☐
   - Beroucratic nature of the credit process.......... ☐

7. If your farm is operating with credit for purchase of farm inputs, which of the folwing are source of your credit?

Commercial Bank of ethiopia....... ☐ Agricultural office ☐
Local money lender.................... ☐ NGO (Develoment partners) ☐
Coopratives.............................. ☐ others (please specfy) __________

8. Would the governmmnet encourage you to use farm inputs in your prvious legume production activity?

Yes ☐ No. ☐

9. If your answer is yes for the Q#10, in what way the government can support you?

Through giving subscidising the inputs ☐
Through giving incentives ☐
Through easly availing the inputs on time ☐
Other (*please spacify…*) ______________________________

10. Have you participated in social organization in the community? Yes ☐ No. ☐

11. If your answer is yes for the above question, which of the commnuity asscoation do you involve? fill your response as requested here below

Social particpation	1- if particpated, 2 - if not
Idir	
Equib	
Farming coopratives/unions	
Trade unions	
Religious assocoations	
Females asscoaitions	
Other please specify	

12. Do you expect any risks to be driven due to devoting technologies in legum production? ☐

Yes ☐

13. If yes for Q# 12, What are the failures (risks) noticed in the adopting farm inputs in the legum production?

Reduction in yield .... ☐ increase in cost of production...☐

Loss output market.......... ☐ other (*please specify…)*_________________

Polultion of environemnt.....☐

14. Would you have faced any agro - ecological problem in your legume farming activity?

Yes ☐ ☐

15. If your answer is yes the above quation, what is the exsting problem you faced in your previous legume cultivation?

Shortage of rain fall ☐snow ☐

Infertile nature of rain fall ☐ diseasse occurance ☐

Exess/irratic nature rain ☐ other please specify☐

V.Issues on Impact analysis

1. What is your total farm income in annual basis (please put your response in terms on Birr)

   Crop sale...................................

   Sales of fruit & vegetable...........

   Livestock sale.............................

   Livestock products (e.g. butter or milk)........................

   Off-farm activity (business other than agriculture)........... ....

   Remittance....................................

   Rental income................................

   Other (please specify).....................

2. What was your total farming and consumption expenditure in annual basis (please put the expenditure in terms of Birr)

   Consumption expenditure.............................. (Expenditure for food, cloth, other...)

   Labour (any labour cost related farming activity)..................

   Purchase of farm tools................

   Purchase of fertilizer...................

   Purchase of seeds.........................

   Purchase of chemicals inputs........

   Draft power...............................

   Rent of farm machinery.............

   Other expenses............................

3. If you are user of farm inputs, how much you produced from a hectare (4 -Timad) of land

legumes	With inputs	
	Yield (qt)	Income (Birr)
Fava bean		
Chick pea		
Peas		
Lentil		
Other legume		

4. If you are not user of farm inputs (improved seed, fertilizer, inoculants, chemicals...) how much you produced from a hectare (4- Timad of land)

Legume type	Yield (Qt)	Income (Birr)
Fava bean		
Chick pea		
Peas		
Lentil		
Other legume		

5. Have you faced marketing problem in selling of your product that produced using improved farm inputs? Yes ☐ No ☐

6. If your answer is yes for the above question, what is the challenge you faced in selling of your harvested legume crops?

No surplus product for sale	☐	distance of market	☐
No potential Buyer	☐	other (please specify)	☐
Poor price offered	☐		

7. Give your response on the level of your argument on the marketing problem you faced in legume grain market as given below

Challenges for marketing of legume products	Very big problem	Big problem	Fairly big	Small problem	Not a problem at all
Distance to market is very far					
Very few buyers					
Transport cost is very high					
Prices offered is low					
Impassable roads					
There is oversupply of the commodity in the market					
Quality not acceptable to buyers					
Other (specify)					

8. Please fill the level of production that can be earned through using improved farm inputs and the level of income earned as requested here below:

Type of crop	Plot size (Timad)	Total production/annum	Consumption (Qt)/annum	Sold	
				Qt	Birr

9. If you are influenced by the technology adoption, please indicate your level of agreement with respect to the following traits?

Item	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Increase in my yield level from legume production	1	2	3	4	5
More income generated from legume production	1	2	3	4	5
I got more respect in my community after adopting legume technologies	1	2	3	4	5
I opened a small shop in a town	1	2	3	4	5
I built a nice house	1	2	3	4	5
I save more money than before	1	2	3	4	5
I started to diversifying my activities after adopting the new technologies	1	2	3	4	5
Other impact (please specify....)	1	2	3	4	5

VI. Scenarios for semi-experimental question on technology adoption of farmers

The following descriptions are imaginary future scenarios. We are going to ask you about your decision to continue with the existing local varieties or adopt new varieties. Please carefully understand each description and respond accordingly. There are two scenarios: high technology input price scenario and low subsidized technology price scenario. In both scenarios, there is information on the price level of the new technologies. And the new technologies can be accessed easily in your village sometimes; but sometimes also you have to travel to towns to get them by your own transportation. Credit could be available sometimes but sometimes it is also not available. The development agent (DA) is available in your village to give advice on the new technologies; but sometimes they are not available and hence no advice from them. Please check carefully which of the above elements are available in each part of the scenario to make decision with respect to the level of your adoption of the new technologies.

S11: High technology input price scenario:

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer).* Assume that the technologies will be available easily in your village and no need to travel to towns to get technology. **Price** of these technologies is high but you have **access to credit** to purchase these inputs in case of cash shortage. **Development agents** (**DA**s) are also on your side to help and advise you how to use these technologies to improve your yield level from new technology.

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S12: High technology input price scenario: no access to credit

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer)*

Assume that the technologies will be available easily in your village and no need to travel to towns to get technology. **Price** of these technologies is high and there is no any possibility to get **access to credit** to purchase these inputs. Because of this you will buy from your own cash. **Development agents** (**DA**s) are also on your side to help and advise you how to use these technologies to improve your yield level from new technology

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S13: High technology input price scenario: (no access get input in the village)

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved see and fertilizer).* But to get the technologies you have to travel to towns and transport to your village by yourself; including any transportation charges. **Price** of these technologies is high but you have **access to credit** to purchase these inputs in case of cash shortage. **Development agents** (**DA**s) are also on your side to help and advise you how to use these technologies to improve your yield level from new technology.

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S14: High technology input price scenario: (no DA)

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer).* Assume that the technologies will be available easily in your village and no need to travel to towns to get technology. **Price** of these technologies is high but you have **access to credit** to purchase these inputs in case of cash shortage. You have to use technologies by your own and d**evelopment agents** (**DA**s) are not going to give advice about the new technologies to you.

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S21: Subsidized (low) technology input price scenario:

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer).* Assume that the technologies will be available easily in your village and no need to travel to towns to get technology. **Price** of these technologies is low because it is subsidized by NGOs and government and you still have **access to credit** to purchase these inputs in case of cash shortage. **Development agents** (**DA**s) are also on your side to help and advise you how to use these technologies to improve your yield level from new technology.

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S22: Subsidized (low) technology input price scenario: no credit

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer)*. Assume that the technologies will be available easily in your village and no need to travel to towns to get technology. **Price** of these technologies is low because it is subsidized by NGOs and government, and there is no any possibility to get **access to credit** to purchase these inputs. Because of this you will buy from your own cash. **Development agents** (**DA**s) are also on your side to help and advise you how to use these technologies to improve your yield level from new technology

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S23: low technology input price scenario: (no access in the village)

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer).* But to get the technologies you have to travel to towns and transport to your village by yourself; including any transportation charges. **Price** of these technologies is low because it is subsidized by NGOs and government and still also you have **access to credit** to purchase these inputs in case of cash shortage. **Development agents** (**DA**s) are also on your side to help and advise you how to use these technologies to improve your yield level from new technology.

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***

S24: low technology input price scenario: (no DA)

Imagine that you have appropriate land for legume production and you expected to entertain a **high yield** due to operating with improved technologies (*Improved seed and fertilizer).* Assume that the technologies will be available easily in your village and no need to travel to towns to get technology **Price** of these technologies is low because it is subsidized by NGOs and government and you still have **access to credit** to purchase these inputs in case of cash shortage. You have to use technologies by your own and d**evelopment agents** (**DA**s) are not going to give advice about the new technologies to you.

Please indicate to what extent you are likely to adopt different technology packages?

Improved legume seed ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***
DAP fertilizer ***Less likely to adopt 1 2 3 4 5 Most likely to adopt***