ADOPTION OF AGRICULTURAL TECHNOLOGY PACKAGES IN BARLEY BASED FARMING SYSTEM OF ETHIOPIA

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Adoption of Agricultural Technology packages in Barley Based Farming System of Ethiopia

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DECLARATION

I, the undersigned, declare that this thesis entitled as “Adoption of agricultural technology packages in barley based farming system” is my original work and has not been presented for the award of any degree or diploma in this or any other university. All sources of materials used in the thesis have been duly acknowledged.

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STATEMENT OF CERTIFICATION

This is to certify that this thesis entitled as *"Adoption of agricultural technologies packages in barley based farming system"*, submitted in partial fulfillment of the requirements for the degree of Master of science in Development economics to the School of Commerce of Addis Ababa University, done by Ermias Getnet is an authentic work carried by his under our guidance. The theme embedded in this thesis has not been submitted earlier for the award of any degree or diploma in any other university to the best of our knowledge.

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ACRONYMS AND ABBREVIATIONS

AMF	Assela Malt factory
AgSS	Annual Agricultural sample survey
CDAIS	Capacity development for Agricultural innovation Systems
CGIAR	Consultative Group for International Agricultural Research
CSA	Central Statistical Agency
EAs	Enumeration areas
EIAR	Ethiopian Institute of Agricultural Research
ESS	Ethiopian Socio-Economic Survey
FAO	Food and Agricultural organization
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross domestic product
ICARDA	International Centre for Agriculture Research in the Dry Areas
ISA	Integrated survey on Agriculture
LSMS	Living standard measurement study
MEDAC	Ministry of Economic Development and Cooperation
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MVP	Multivariate probit
NGO	Non-government organizations
SPIA	Standing panel on Impact Assessment
SNNP	Southern Nation’s Nationalities and people’s

ABSTRACT

Despite the high production potential and the economic importance of the crop, adoption, and diffusion of barley technologies are constrained by various factors. To this end, this study aimed at identifying determinants of adoption of agricultural technologies in the barley-based farming system of Ethiopia, with the specific objectives of identifying factors affecting Agricultural technology package choice and to assess the interdependency between the technologies. The study used data from the Ethiopian socioeconomic survey. The descriptive and econometric analytical tools were applied. The descriptive result of the study identified that variables like education, family size, credit access, farm size, farm income, and age of the farmer play significant roles, across barley technologies. The results show that about 66.96%, 58.59%, 75.18%, 65.17%, and 75.99% of sample households were adopted an improved variety of barley, urea, dap, chemicals, manure, and crop rotation respectively. All the barley production technologies were complementary (i.e. urea, improved variety, dap, chemicals, manure, and crop rotation). Multivariate probit model results showed that Age of household head, Soil fertility, farm size, Training, and transportation cost affect the adoption of barley technologies negatively and significantly. Sex of household head, education level of household head, Farm income, tropical livestock unit, and access to credit affects adoption of barley technologies positively and significantly. Smallholder farmers were more likely to succeed than fail in jointly adopting barley technologies. Consequently, government policy and other concerned parties should emphasize the improvement of the institutional support system and decrease gender disparities in access to such institutions.

Keywords: Adoption, barley, agricultural technologies, multivariate probit

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Agriculture is the base for the whole socio-economic structure and has the main effect on all other economic sectors of Ethiopia (IBC, 2009). The sound performance of agriculture permits the availability of food crops. This achievement in agriculture does not only signify the adequate acquirement of food crops to attain food security but also heralds a positive aspect of the economy. Regarding this, collective efforts are being geared to securing agricultural outputs of the desired level so that self-reliance in food supply can be achieved and disaster-caused food shortages are contained in the shortest possible time in Ethiopia (CSA, 2020).

Agriculture is a leading sector of the Ethiopian economy which had a higher contribution to the Gross Domestic Product, foreign exchange earnings, and employment. Agriculture is quite supposed to remain a sector that plays a key role in encouraging the overall economic development of the country. This would be comprehended if and only if obstinate efforts are made by the government and other concerned bodies including farmers to boost agricultural production and productivity (CSA, 2016).

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

Crop production takes an average share of 60% in agricultural value-added products (MEDAC, 2010). According to (MoFED, 2006), the sector employed more than 83% of the population and was the source of over 90% of export revenues. In the sector, 60% of the agricultural GDP comes from crop production, while, 7% and 30% of it is generated from forestry and livestock sectors respectively(World Bank, 2007). Therefore, it is palpable that countries like Ethiopia, which are comparatively endowed with unskilled labor and arable land, would find it relatively easier to follow an agricultural development path. According to (World Bank, 2008), escaping poverty traps in many developing countries such as Ethiopia depends on the growth and development of the agricultural sector.

Barley is one of the essential food and survival crop in the country; it is an annual crop that is produced in more than 800,000 h. Barley is categorized into malt barley and food barley. Malt barley is a vital cash crop for resource-poor households in Ethiopia (Getachew *et al.*, 2007). Ethiopia commonly produces food barley, with its share estimated to be 90% while that of malt barley having a share of 10% (Daniel and Beyene, 2019).

Ethiopia is the largest barley producer in Africa, following by Morocco, estimating for about 25% of the total barley production in the area (FAO, 2014). It is one of the basic food crops in the continent accounting for 6 % of the per capita calorie consumption (Shahidur et al, 2015). Barley is the fifth cereal crop in terms of area coverage produced in different parts of Ethiopia following by teff, maize, sorghum, and wheat. In Ethiopia Barley is produced in wider environmental conditions, covering a total area of about 951,993 ha from which more than 3 million smallholder farmers drive their livelihood (CSA, 2018).

Cultivation of barley has a long history, which is believed to have coincided with the beginning of plow culture in Ethiopia (Teshome, 2017). In the highlands of Ethiopia, barley is predominantly cultivated in altitudinal ranges of 2000 to 3000 meters above sea level (m.a.s.l), but it can also grow from 1500 to 3500 m.a.s.l (Teshome, 2017). For smallholders of Ethiopian highlands, barley grain accounts for 60% of their food, and barley straw is a crucial component of animal feed especially during the dry season (Zemede, 2000).

However, despite a long history of cultivation and livelihood importance of barley, its productivity has never increased above 2.2 t ha^{-1}, which is about one-third of the potential yield of 6.0 t ha^{-1} obtained in experimental plots. The declines in soil fertility driven by high rates of soil erosion, suboptimal fertilizer application rate, nutrient imbalance, and limited access to improved varieties are among the major limiting factors claimed for low food barley productivity in Ethiopia (Habtamu, Bobe, and Enyew, 2014). Continuous application of DAP (18–46% N-P_2O_5) containing only nitrogen (N) and phosphorus (P) without due consideration of other nutrients is claimed for the depletion of other important nutrient elements such as S and micronutrients in soils (Abiye et al., 2004). Considering these problems, the Ethiopian government has been promoting the use of multi-nutrient blended fertilizer for the last few years along with liming (Simtowe, 2015).

1.2. Statement of the Problem

Agriculture remains to be the most important sector of the Ethiopian economy. Regardless of its importance, low productivity and a land fragmented farming system describe the country's agriculture. There is an output gap among the potential and definite production levels of several crops in Ethiopia (CSA, 2013). This is mainly attributed to the poor use of modern inputs such as fertilizers, improved seeds, and extension services which partly explain the less productivity of the sector and apart from this, the internal inefficiency of the farmers in using the available agricultural resources such as land and labor (Kinde, 2005).

An arrangement of many factors including weakly functioning agricultural markets, low the purchasing power of the consumers, overall low level of technical knowledge of the producers and a high illiteracy rate of the rural communities have hindered the much expected technical change and farm productivity (Birhanu, 2006). The incapability of producing enough food has, in turn, its backward impact on the unkind performance of the agricultural the sector through weak productivity of agricultural labor.

Barley can be produced in different parts of Ethiopia, the major areas currently growing the crop is located in the Oromia region Arsi and Bale zones produced barley a large, part of the west and east Gojam, as well as north and south Gondar in Amhara region, has been providing for brewery factory is insufficient to substitute import from abroad and alone couldn't able to keep with expanded capacity (Minale *et al.*, 2011).

Adoption of agricultural technologies in developing countries appeals to substantial consideration since it can offer the basis for rising production and income. The farmers' decision can adopt or reject agricultural technologies based on their purposes and limitations as well as costs and benefits adding to it (Million and Belay, 2004). Consequently, farmers will adopt only technologies that suit their needs. Numerous factors affect the adoption of agricultural technologies. Among these, social factors, economic factors, institutional factors, are the main variables that affect adoption. Accordingly, recent studies have been made on the determinants of adoption of barley and other crops both in Ethiopia and other countries (Ashenafi et al., 2020; Samuel et al,2019; Galmesa, 2018; Abiro et al, 2017; merkineh 2016; Audrey A, 2014; Ermias T, 2013;).

Furthermore, previous studies have focused mainly on factors affecting adoption of improved variety alone. Barley technology package consisting of improved seed, urea, dap, fertilizer rate and crop rotation was introduced to the study area to improve the food security status. Despite such intervention adoption of improved barley production package is still very low. Besides, there is also variation among farmers in their intensity of adoption of improved barley production package. However, so far there is no empirical information about the extent of adoption, various factors influencing adoption and intensity of use of the package. Therefore, this study was proposed to analyze determinants of adoption and intensity of use of barley production technology package to fill the existing knowledge gap. It assisted in providing policy recommendations on technologies supply based on farmers' input expenditure patterns. It is also possible to drive a demand system for agricultural technologies.

1.3. Research Questions

1. What are the determinants of farmer’s technology package choices decisions?
2. What are the determinants of the Relationship between different barley production technologies?

1.4. Objectives of the Study

1.4.1. The general objective of the study

To analyze the determinants of Adoption of agricultural technology packages in the barley-based farming system.

1.4.2. The specific objectives of the study:

1. To identify factors affecting Agricultural technology package choices.
2. To assess the inter-dependence of barley production technologies.

1.5. Significance of the Study

The output of the research has been identified and prioritized the key factors affecting the adoption of agricultural technologies in the barley-based farming system in Ethiopia. The identified factors, in turn, provide information and indicate intervention areas for policymakers, NGOs, and other development practitioners. Moreover, it has contributed a lot to research works accompanied in this thematic area by providing deep insights for other researchers. Therefore, the study will benefit farmers, governmental and non-governmental organizations for policy formulation, planning of appropriate production packages, and development of market integration.

The study also enabled us to critically identify relevant and most preferred technologies of barley crop by a different socio-economic group of farmers. The result has been valuable insight in understanding the socio-economic settings and concerns of technology users' domain. The result moreover makes us to better target farmers who demand different agricultural technology types. The study was also used as a major resource for research, extension, and development agents.

1.6. Scope and Limitations of the Study

This study mainly focused on identifying and analysing the determinants of agricultural technologies and indicating possible intervention areas in Ethiopia. It used the 2015/2016 Ethiopian Socioeconomic Survey (ESS) data to achieve the objectives. The data, however, covered barley production in major regions of the country more explicitly while peripheral regions are not covered.

In addition, the result of this study might apply to other areas of the region and the country where similar situations may prevail. The study focused only on identifying and analysing the determinants of agricultural technology packages and indicating possible intervention areas. The study was limited to the only adoption of barley technologies, however; the separate analyses of different crops will give a clear picture of the farming sector in the area that couldn't touch in this particular study. This is merely due to the limitation of time and other resources.

1.7 Organization of the Study

The thesis is organized into five chapters. The first chapter introduces the background, statement of the problem, research question, the objective, as well as the scope and limitation of the study. The theoretical review, empirical review, and relevant literature are reviewed in the second chapter. The third chapter discusses the research methodology used to undertake the study. Results are presented and discussed in the fourth chapter. Chapter five presents a summary, conclusion, and recommendations.

CHAPTER TWO

2. LITERATURE REVIEW

This chapter comprises literature review that is relevant to the research topic, and includes the theoretical literature on the adoption of agricultural technology among small holder farmers; role of barley in food security and the adoption of agricultural technology; factors affecting the adoption of agricultural technology; moreover empirical literature on the adoption of agricultural technology and conceptual frame work also made for the study. The aim of the literature review was to reveal the knowledge gaps which the study sought to fill in.

2.1. Theoretical Review

2.1.1. Concept of technology Adoption and diffusion

Adoption: - refers to the decisions that individuals make each time that they consider taking up innovation or decision of an individual to make use of an innovation as the best course of action available (Audrey, 2014)**.** Adoption at specific farmers' level is defined as the degree of use of new technology in long-run equilibrium when the farmer has full information about the new technology (Galmesa, 2018). This implies that aggregate adoption is measured by the aggregate level of specific new technology with a given geographical area or within the given population (Audrey, 2014).

Technology: refers to how to cultivate a crop successfully. This success can be obtained by knowing how to apply fertilizer, control pests, and take care of the plant for its healthy and good growing. Another definition is said that technology refers to what crop varieties and what kinds of fertilizers are suitable for the soil (Audrey, 2014). Technology is frequently reified in popular rhetoric and has come to be viewed as a system or a form of rationality rather than just a collection of artefacts.

Some view it as a kind of saviour, capable of solving most of the perennial problems of human existence; others view it as a kind of demon that threatens the health of human society and the environment (Kelvin, 1990). Some argue that a felicitous future will only be possible with continually increasing technological growth; others plead for the rejection of technology, arguing that it is intrinsically destructive

Technology choice:- The concept of technology choice may be defined as the concept that: there is frequently a range of alternative technological means available which are suitable for the attainment of primary objectives within a given field the number of alternatives in the range may be increased over time by conscious human effort alternative technological means of similar suitability, for the attainment of certain primary objectives, may vary widely in their suitability for the attainment of secondary objectives also the informed selection of technological means, taking into account secondary objectives as well as primary objectives, combined with long term efforts to expand the range of available alternatives, is an important element of social, economic and environmental policy (Kelvin, 1990).

There is often a significant interval between the time an innovation is developed and available in the market, and the time it is widely used by producers. Adoption and diffusion are the processes governing the utilization of innovations. Studies of adoption behavior emphasize factors that affect if and when a particular individual will begin using an innovation. Adoption may indicate both the utilizing and level of new technology usage by farmers. Adoption may be described by a discrete choice, whether or not to use technologies, or by a continuous variable that indicates to what extent a separable technology is used (David S and David Z, 2000). Consequently, one measure of the adoption of a high-yield seed variety by a farmer is a discrete variable representing if this variety is being used by a farmer at a certain time; another measure is what percent of the farmer's land is planted with this variety

Differentiation between diffusion and adoption is a social process while adoption is a mental and individual process. Diffusion and adoption are thus closely interrelated even though they are conceptually distinct. It takes time for an innovation to diffuse throughout society. It is unrealistic to expect that all farmers in a community will adopt an innovation immediately after its introduction. There is always a variation among the members of the society in the way they respond to an innovative idea or practice.

While there are always few members in the society who are so innovative that they adopt an innovation almost immediately after they come to know about it, the majority take a long time before accepting the new idea or practice. It is the first few adopters of innovation who influence the other members of a community to adopt the innovation as they interact with them. Definition of diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system (Kamala et al., 2018). In another word, it is a special type of communication, in that the messages are concerned with new ideas.

Agriculture is becoming more integrated with the agro-food chain and the global market, while environmental, food safety and quality, and animal welfare regulations are also increasingly impacting the sector. It is faced with new challenges to meet growing demands for food, to be internationally competitive, and to produce agricultural products of high quality. Today, farmers, advisors, and policymakers are faced with complex choices. They are challenged with a wide range of technologies that are either available or under development. The attention of the works was the adoption of technologies that have the potential to contribute to sustainable farming systems. Technology adoption, however, is a broad concept. It is affected by the development, dissemination, and application at the farm level of existing; it is also affected by education, training, advice, and information which form the basis of farmers' knowledge (OECD 2001). It also includes technologies and practices in the whole agro-food sector that have an impact at the farm level

The level of adoption is a numerical indicant of the sharpness of the adoption curve for an innovation. Diffusion of innovations refers to the distributions of those innovations through a population and is simply the result of a host of individual adoption decisions. If individual adoption decisions are, to an extent, predictable, then the larger diffusion process is also predictable. It follows a pattern, and that element of certainty has substantial implications. The diffusion of innovations is essentially a social process in which subjectively perceived information about a new idea is communicated (Kamala et al. 2018).

2.2. The theoretical literature on agricultural technological change

Technological changes in agriculture have been observed, as well as the impact of technological change, within the context of the dominant model of agricultural development and technological modernization. Technological change may indicate a partial restructuring of production, while agricultural and social restructuring, in general, and determine, more essentially, the specific character of technology itself. Acceptance of the existing organizational structure and emphasis on technical/production innovations determined by the requirements of the market suggests disregard of critical market failure to ensure sufficient employment and an environmentally and socially viable agricultural economy, misplacement of the factors which have led to the international crisis of the agro-food system, and neglect or abandonment of domestic or local productive practices and know-how, without taking into account specific social, natural and cultural characteristics(Marx k,1997).

2.2.1. Barley production and productivity in Ethiopia

Barley is one of the four major feed grains (corn, barley, oats, and wheat) and is widely used as a feed for livestock. The grain may be used as a major source of energy, protein, and fiber for ruminants, and a major source of energy and protein for swine. In Australia, barley and wheat are the grains most commonly used by Australian livestock industries which, when combined, represented around 60% of all cereal grains fed. Oats (20%), sorghum (10%), and triticale (10%) made up the other cereal grains used by the livestock industries. Approximately 40% of the barley was fed to feedlot cattle, 34% to dairy cows, 20% to pigs, and 6% to grazing ruminants. Less than 1% was used for poultry (mixture, 2010).

Ethiopia has a larger potential in the world in barley production with a share of 1.2 % of the world’s total production. Barley farming is broadly dispersed through the country on more than 1 million hectares of land and by over 4 million barley producers. Presently, it is grown solely for the domestic market and is neither imported nor exported. Barley is a high-opportunity crop, with great room for profitable expansion, particularly when connected with the country’s commercial brewing and value-added industries. It is the fifth most important cereal crop in Ethiopia after teff, wheat, corn, and sorghum (USAD, 2014).

Table 1 Variability in barley production, areas covered and yields, by region (2003 -2013)

The measure of Variability (2003-2013)				
Area cultivated ('000 Ha)	Mean	Annual Compound Growth Rate GCR (%)	Coefficient of Variation (CV)	Cuddly La Valle Index (CDV)
Tigray	96	2.81	0.35	0.34
Amhara	349	0.93	0.29	0.29
Oromia	483	0.70	0.29	0.29
SNNPR	83	1.96	0.38	0.37
National	1,014	1.14	0.25	0.25
Yield (Mt/Ha)				
Tigray	1.35	4.67	0.48	0.30
Amhara	1.29	4.45	0.34	0.22
Oromia	1.59	4.88	0.40	0.15
SNNPR	1.34	4.20	0.41	0.26
National	1.45	4.53	0.38	0.08

Source: Shahidur et al (2015) compilation reports (2003-2013)

2.2.2. Demand and supply of Barley

A higher amount of Ethiopian barley crop is used for human consumption by producing different nutrition. For preparing barley for different food items, its grains are passed through various manual processing steps which are very irritating and time-consuming. Moreover, although various spices and sauces are also used with different barley dishes and these ingredients or additives are known to improve taste, no information is available on their effects on the nutritive values of each dish. Dissimilar with the developed countries where barley is primarily used for animal feed, malting, and brewing, in developing countries like Ethiopia, it is produced mainly as a food crop. It is estimated that 90% of the produce is used for home consumption, of which about10% is for local beverages (Jemal et al. 2016). Through the manual processing and removal of the hull, there is wastage of some grains and it is also likely to hurt the nutritive value. It is important to investigate how Ethiopia can adapt to mechanizing many labor-intensive manual operations with simple utensils to maximize the benefits of barley as a food.

The malting barley industry worldwide has qualified continuous growth over the last four years, with increased barley yields and growing malt and beer production and consumption. Growth is particularly apparent in EU countries and emerging Asian and Latin American markets. Some of the largest malting barley producers, such as Germany, France, the UK, and Australia have developed a shorter cycle for the adoption of new varieties. In these countries, newly registered varieties (i.e. in the last ten years) have been actively grown and used in malt production (Tetiana Z, 2017).

The current state of barley production in terms of the demand and supply gaps, varietal adoption levels, and the commercial behaviors of smallholders in seed demonstrate the different key challenges and future areas of attention enhance demand and supply of seed from the formal sector through better demand assessment taking into account farmers' demand shift in response to emerging production and marketing challenges old commercial varieties dominate the formal sector for both malt and food barley showing low rate of varietal replacement.

Promotion of newly released improved varieties of barley for increased varietal and seed demand is critical for increased productivity; the commercial behavior of farmers for the seed of food barley and malt barley is different, where only 8.3% of the food barley and 38.5% of the malt barley growers purchased certified seed from formal sources. (Alemu and Zewdie 2015). This implies the need to improve the demand for certified seed of food barley varieties. Given the considerable use of saved seed of improved barley varieties, it will be important to promote an integrated seed system where community-based seed systems can contribute to the improvement of access to improved varieties

The malt barley market is fast-growing per annum. Investment in breweries has risen and accordingly the demand for malt barley has also increased significantly. Considering the recently established and newly emerging breweries in the country, malt barley demand reached about 214, 000 tons with an increasing trend. However, only about 40 % of the demand has been met through the domestic supply (Malt barley Public-Private Partnership Project report, 2014).

Barley production and productivity in a country have become an increasing order generally from year to year, while there was some variability in area harvested which is measured in a hectare. Barley production in Ethiopia is the most common and highly productive which shows, in turn, it is highly consumed by the consumers of the country (Samuel, 2016).

However, the share of malt barley is small estimated at 7 % of the total annual production. Currently, the cultivation of malt barley is mainly focused in the highlands of Arsi, West Arsi, and Bale administrative zones of the Oromia Regional State. Despite, its limited cultivation, malt barley represents an attractive market opportunity for smallholder farmers in the highlands where cold temperature limits the possibility of successfully growing alternative cash crops. Barley is among the priority crops that have attracted the attention of policymakers in Ethiopia. The government is keen to boost the production of barley through appropriately supporting smallholder farmers and attracting commercial farming. Recently, a lot of effort is being used to increase barley production by establishment barley research and scaling up existing barley technologies (Berhane et al., 2013)

2.2.3. Role of barley in food security

Barley is among the major food security crops in the highlands and an industrial commodity for the emerging brewery industry. Food security and livelihoods for a majority of Ethiopians depend on smallholder farming, and barley is an important crop grown by over 4 million smallholder farmers for multiple uses as food, feed, and as a cash crop for an emerging malting and brewing industry. However, Ethiopian barley varieties achieve low yields and are susceptible to losses from lodging, pests, and diseases. Ethiopia is a center of barley domestication and diversity, and barley has an important place in African dryland agriculture in general, resiliently producing stable yields under extreme temperature, drought, and salinity conditions, characteristics that will be increasingly important for food security under conditions of climate change. Research organizations in Ethiopia are beginning to provide access to new varieties with increased yield, and brewers have also introduced a few European semi-dwarf varieties for the malting barley sector (FAO, 2009).

In Ethiopia, barley-based foods are prepared as main, side, and ceremonial dishes (wedding and annual festivals). Sometimes they are primed as recuperating dishes and used to breastfeeding mothers with the belief that they increase breast milk production. Besides, some dishes are claimed to be a remedy for gastritis, while others are reported to be a good substitute for breast milk or good to heal broken bones and fractures. The major processes in the preparation of some traditional Ethiopian barley-based foods and the socioeconomic and cultural roles of these foods such injera, kita, beso, chuko, shamet, are the most commonly known traditional Ethiopian barley-based foods. Furthermore, barley is a popular hunger breaker or relief crop during periods of food shortage in some parts of Ethiopia as it is an early harvested crop and is also used as a substitute crop for wheat when wheat prices are high. Therefore, barley holds an important position in the food security of Ethiopia (Jemal et al. 2016).

Barley estimated for over 60 percent of the food of the people in the high lands of Ethiopia. It is used in varied methods that have deep origins in culture and tradition. Barley is the favored grain, after tef, for making Injera, which can be used in combination with tef flour or other cereal flours (Grando, 2005).

Farmers put in place their mechanisms of balancing producing for market and consumption and they confirmed that producing malt barley for the industry does not affect their food security efforts. Compared to the current situation, farmers are looking for the enhanced role of farmers' organizations, private organizations, and financial institutions in the malt barley value chain and the role of NGOs and government offices should be moderate (FAO, 2010). Improved seed, finance, pesticides/herbicides, extension support, and market linkage are identified as key supports required realizing the self-sufficiency of the country. Currently, the role of formal financial institutions in the barley is meager – only 4% of the respondents indicated that their source of credit is from formal financial institutions. It was found out that irrespective of the contract they have about 58% of the respondents store their barley for more than 2 months. (Tarekegn G, 2016)

Food security is one of the livelihood outcomes which has received much attention from international organizations, donors, and the public sector for many decades. During the World Food Summit held in Rome in 1996, the following definition of food security was formulated, food security occurs while all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their nutritional needs and food favorites for a healthy life (FAO,2008).

According to the FAO, households are food secure when they have year-round access to the amount and variety of safe foods their members need to lead active and healthy lives (FAO, 2010). Hence, looking at food security at the household level, food security refers to the ability of the household to secure, either from its production or through purchases, adequate food for meeting the dietary needs of all members of the household (FAO, 2010). The nutritional status of each member depends on several conditions. First, the food available to the household must be shared according to individual needs. Second, the food must be of sufficient variety, quality, and safety.

2.2.4. Barley production gaps in Ethiopia

Ethiopia has potential for barley production however; the farmers are faced with high postharvest losses. Barley markets are faced with the absence of storage, low pricing, and low quality of the product. Furthermore, the value chain of barley is faced with a shortage of supply of chemicals and high yield varieties, weed, and pest existence, soil infertility, susceptibility to frost and drought, major diseases like rusts, market price fluctuation rising, transportation cost (Samuel, 2016).

In Ethiopia, the gap between barley production and demand is high. In late 2015, brewing factories, such as the Assela Malt factory had to scale down their production due to the chronic shortages of malt barley in the market. More than 4.5 million smallholder farmers grow barley in Ethiopia with one of the lowest yields in the world. Getting new higher-yield varieties is a national priority. Working with the Ethiopian Institute of Agricultural Research (EIAR), ICARDA scientists are working to develop barley, faba bean, and chickpea varieties that are resistant to drought, disease, and pests and give a higher yield (Getachew *et al.*, 2007). As East African economies continue to grow, the demand for healthy food and malt beverages is increasing, expanding livelihood opportunities for Ethiopian farmers. Ethiopia is the largest producer of barley and faba bean in Sub-Saharan Africa and both crops are important for smallholder farmers (ICARDA, 2015).

Barley's profitability is determined by its yield. To increase yield, it is significant to confirm that the crop has a chance to succeed in different biotic and a biotic factors that have added to this low productivity. Some of the limitations are poor crop management, barley improved varieties are susceptible to mildew, barley yellow dwarf virus, weeds, pest, insects, and the essentially low yield potential of the dominant local varieties (Bayehe & Stefania, 2011)

The amount of malt barley produced by farmers and procured by the malt factory, farm size, and the malt produced by the malt factory fluctuate though the magnitude of the fluctuations is not so significant throughout 2007-2013. This shows the sufficiency of the barley produced in the study area to meet the total requirement of AMF if properly collected. However, a large part of barley is either consumed by farmers or goes through other competing channels (e.g. urban consumers or flour factories (Mulugeta et al., 2016). As such, AMF's demand is often not met.

2.2.5. Factors influencing adoption of agricultural technologies

In the industrialized world, scientific and technological advancements have benefited farmers by driving agriculture production. However, in the developing countries of the world, smallholder farmers who are responsible for 80 percent of the food have yet to see similar gains. There are two major drivers of successful agricultural technology in developing countries: the first one is the availability and affordability of technologies, and the second one is farmer expectations that adoption will remain profitable—both of which determine the extent to which farmers are risk-averse. Several factors drive the above expectations, ranging from availability and size of land, family labor, prices, and profitability of agricultural enterprises (Abdul and Imran, 2016).

Farmers' changes in technology use are influenced by technical training, meeting, oral transmission, and trust in technicians, and belief level on technology. The total environment can be divided into two elements: technology and human. Technology determines the type and the physical potential of livestock enterprises, and includes the physical and biological factors that can be modified through technology development (Chi and Yamada, 2002).

Most technology adoption studies consider agro ecological factors at the farm or regional level. However, relevant conditions may also vary within farms, which may explain why farmers adopt certain technologies on some plots but not on others. Important plot-level characteristics include plot size, slope, soil conditions, and ownership status (Amsalu and De Graaff, 2006; Marenya and Barrett, 2007; Noltze et al., 2012). For instance, soil and water management practices (terracing and soil bunds) are more relevant for locations with slopes. Technologies that require investments with longer-term impacts, such as terracing, are more likely observed on owned as opposed to rented plots.

2.3. Empirical Studies on Technology Adoption

Different studies were undertaken by different scholars to determine the adoption of agricultural technologies choices and intensity of use of the technologies. Some of the studies are discussed as follows:

Recent studies by Azumah, Tindjina, Obanyi, and Wood (2017), and Danso Abbeam and Baiyegunhi (2017), have shown that agricultural training received by farmers have enhanced farmers' adoption of improved agricultural practices. This study indicates that farmers' access to agricultural training significantly and positively influenced their adoption of nursery, spacing, line planting, urea briquette, irrigation, and bunding. The education variable had a negative and significant relationship with only harrowing.

Studies by Onumadu and Osahon (2014), Gyinadu,) have shown that inadequate access to farm credit impedes the adoption of improved technologies by farmers. Credit-constrained rice farmers were found to be more likely to adopt nursery, spacing, and irrigation, but less likely to adopt harrowing. This finding contradicts the work of Ahmed (2015), who found the credit variable to be redundant in explaining the adoption decisions of farmers. Meanwhile, Kassie et al. (2015) found that credit was necessary to assist farmers in Malawi and Ethiopia to adopt minimum tillage practice.

Galmesa (2018) in his study on determinants of adoption of improved soya bean varieties based on cross-sectional data from 146 randomly selected soya bean-producing households. The results of the study show that about 32.88% and 67.12% were adopters and non-adopters of the crop respectively. Double hurdle model results showed that sex of household, age, education level, farm experience, and training affected the probability of adoption of improved soya bean varieties positively and significantly while the distance to the nearest market affects it negatively and significantly. Age, training, livestock holding, and farm experience influenced the intensity adoption of improved soya bean varieties positively and significantly. The study recommends government support should be in the areas of education, extension service, training, infrastructural development, and credit.

Ermias (2013) studied factors that determine adoption and intensity of use of improved sorghum varieties and farmers' choice of most preferred sorghum varietal traits. Description, Tobit, and multinomial logit (MNL) were used to analyze the data. Results of descriptive analysis showed that adopters of improved sorghum varieties as compared with non-adopters were characterized by better agricultural extension experience and educational status, higher livestock assets ownership, less total cultivable farm but higher irrigable farm size, and most of them are located nearer to FTCs. In the Tobit model, 9 variables were found to significantly determine the adoption and intensity of improved sorghum varieties either positively or negatively. They are active labor ratio, the proportion of sorghum farm from the total cultivated farm, farm size, and distance from farmers' training center to home negatively significant. Tropical livestock unit, farmers' perception of yielding capacity and a taste preference for improved sorghum varieties, irrigated farm size striga infested and farm size positively significant.

Abiro et al. (2017) Conducted a study on the determinants of malt barley adoption of technology with due emphasis on factors affecting adoption and the intensity of adoption. The descriptive result of the study revealed that there is a lack of chemical fertilizers and quality seed, low product price, the high price of fertilizer, weed occurrence's and barley diseases were the major factors hindering the adoption of malt barley technologies. The econometric result indicated total farm size affected malt barley technology adoption negatively and significantly, while market distance, farmers' attitude towards malt barley technology, plot size, profit level affected barley technology adoption significantly and positively.

Multivariate probit model employed to estimate the determinants of adoption of improved agricultural technologies. There was complementarity among all the improved rice production technologies (i.e. nursery establishment, harrowing, line planting, spacing, urea briquette, irrigation, and bunding). Among the socio-economic variables, education, household size, experience, farm size, sex, and age of the farmer play significant roles, with differing signs across technologies. Among the institutional factors, membership of the farmer-based organization, access to research service, training, and credit was significant with differing signs across the improved technologies. The location also had significant and differing influence on adoption (Gumataw K et al, 2013)

(Samuel et al, 2019) a study conducted on the adoption of improved potato varieties in Ethiopia based on original data from 346 were Ethiopian potato farmers showed that the frequency of use of technical assistance from NGOs and access to credit positively affect the adoption of Improved varieties while the use of the main buyer as a source of advice negatively affects Improved varieties adoption. The study found that farmers have a preference for local varieties because of the perceived easier crop management and better stew quality attributes. Yield, disease resistance, and maturity period are less important attributes. Higher education of the household head and the presence of a radio and/or television also have a positive effect on adoption. These results imply that improved production-related quality attributes may not be enough to induce ware potato farmers to adopt new varieties. Local varieties with relatively low scores on production-related criteria continue to be appreciated by farmers due to demands from their customers.

Merkineh (2016) studied determinants of choice decisions for the adoption of conservation intervention practices. Descriptive statistics with appropriate statistical tests and a binary logistic regression model were used to analyze the data. The study findings from the chi-square test showed that the farmers' choice decision was positively and significantly correlated to family size, educational status, social position, source and distance of farmland, tenure security, off-farm income, training, and extension and credit service. Factors such as age, sex, farm size, farming experience, number of farm plots, slope gradient, and soil type were not significant.

Arif et al. (2015) a study conducted to investigate the factors affecting the adoption of organic farming in Peshawar-Pakistan. Binary logistic regressions were used in the study to categorize organic farming into adoption and non-adoption. The purpose of the model was to check the event probability for a categorical response variable with two outcomes. The results of the binary logistic show that factors affecting the adoption of organic farming have a significant effect on farmer productivity. Moreover, cost, productivity, profitability, compatibility, and efficiency have a positive and significant effect. Thus, it is obvious that adopting organic farming not only to increase the farmer income but also to protect environmental pollution by avoiding the toxic chemical and fertilizer.

Ashenafi et al., (2020) a study conducted on adoption and intensity of adoption among malt barley farmers in southern Ethiopia. Malt barley technology packages such as improved seed, fertilizer rate, and seeding rate, row planting, and plowing frequency were identified in the study. The results of the econometric model revealed that; access to training, land size, education, access to credit, family size, membership to cooperative, livestock ownership, access to a demonstration, and distance to nearest market are affected farmers adoption decision and intensity of adoption significantly in one or another way.

The empirical literature review above prevails that there is limited work in the area of adoption of agricultural technologies, with special emphasis on barley production in Ethiopia. Moreover, the multivariate probit regression is low adopted to study the adoption of different sectors, which has wider application and is also appropriate to use for the agricultural sector. Hence, this study adopted the most widely applicable method of estimating adoption, Correlation matrix, MVP, in estimating multiple technologies of barley production in Ethiopia.

2.4. Conceptual Framework of the Study

Different factors affect the adoption of agricultural technology choices. These factors are socioeconomic factors (livestock ownership, Oxen power, and education), institutional factors (Transportation cost, access to credit, frequency of extension contact, crop insurance, access to irrigation and training) Demographic factors (sex, age, and family size), and farm characteristics factors (farm size, farm income, Erosion, fragmentation size of farm and soil quality) are the main key variables that were expected to influence the adoption of agricultural technology of barley production were summarized in below figure

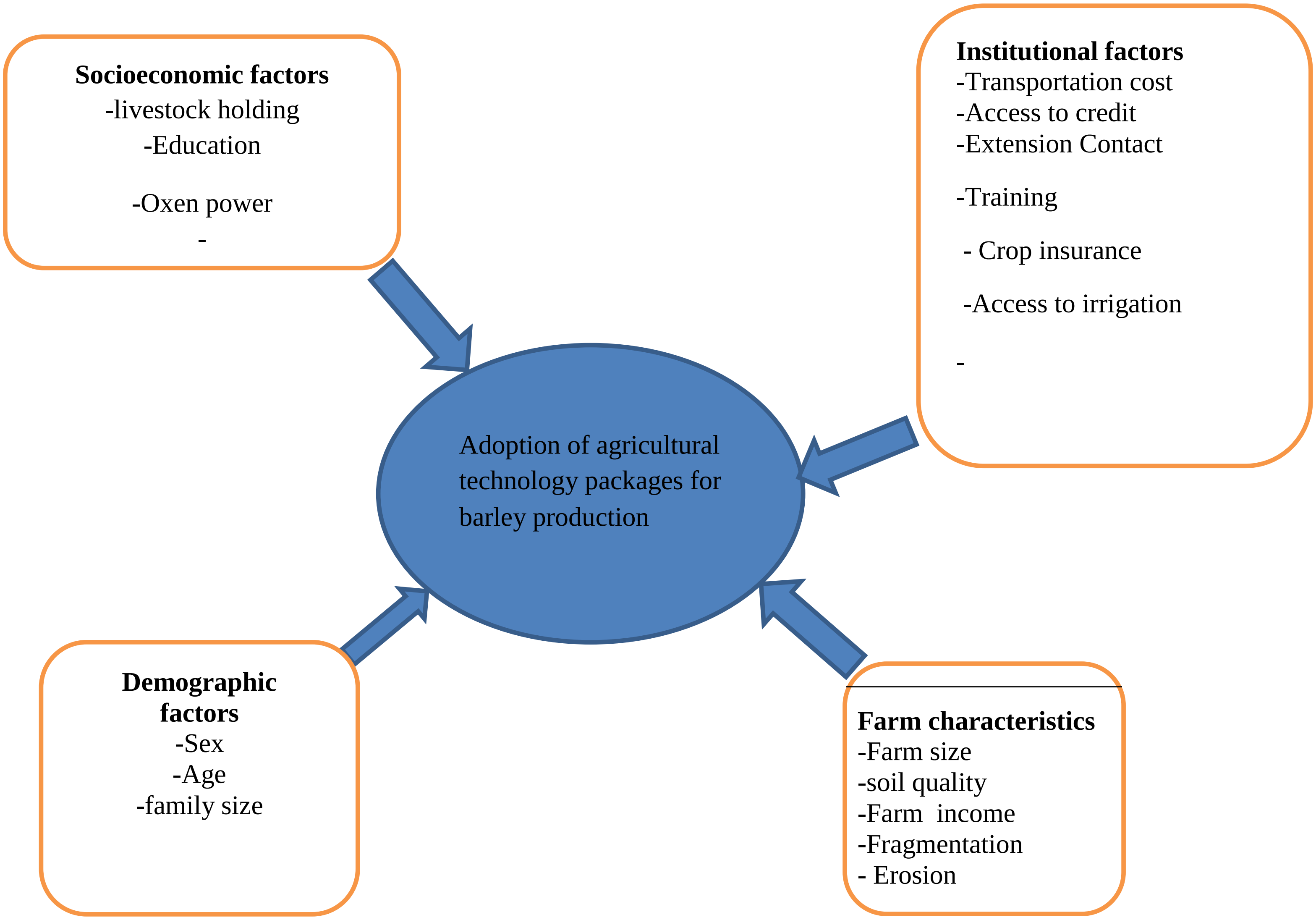

Figure 1 Conceptual frame work of the study

CHAPTER THREE

3. RESEARCH METHODOLOGY

In this section, a brief description of the study area, research approach, research design, sampling methods, sources and types of data, methods of data analysis, are presented.

3.1. Description of the Study Area

The study was carried out in Ethiopia. Ethiopia is the second-most populous country in Africa with an estimated population of more than 100 million. Ethiopia is located in the horn of the continent covering the land with an area of 112.3 million hectares. Agriculture is the mainstay of its economy, accounting for 46.3 percent of gross domestic product (GDP). Out of the total land area, 16.4 million hectares are allotted for the production of perennial and annual crops (Deressa, 2007). According to Dorosh and Gemessa (2013), barley, wheat, teff, maize, and sorghum production constitutes the major food crops in the country, accounting for three-fourths of the total area of land under cultivation and 14 percent of GDP. Coffee, pulses, hides, skins, oilseeds, tea, honey, and beeswax are the major agricultural exports of the country.

3.2. Data Sources, type, and methods of collection

The study was used Ethiopian Socioeconomic Survey (ESS) data conducted by the CGIAR Standing Panel on Impact Assessment (SPIA) in collaboration with the LSMS-ISA project and the Central Statistical Agency of Ethiopia in 2015/2016 by extracting barley producers. The comprehensive survey was undertaken in four major regions of the country; (Amhara, Oromiya, SNNP, and Tigray) and Addis Ababa; quotas were set for the number of EAs in each region. The sample is not representative of each of the small regions including Somalie, Benshangul Gumuz, Afar, Harari, Gambella, Dire Dawa, and regions of the country. Moreover, regular statistical reports from sources like the Ministry of Agriculture and CSA have been reviewed.

3.3. Research Design

The research design of the study was a cross-sectional research design. The survey conducted by ESS was designed to be implemented in two visits following the AgSS field schedule. The qualitative and quantitative data were conducted from sample respondents in all selected areas. For rural and small-town households, the visit took place between September and October 2015. In this visit, the post-planting agriculture and livestock questionnaires were administered.

3.4. Sampling Design

The sample was designed in a two-stage probability sample. The first stage of sampling entailed selecting primary sampling units, or CSA enumeration areas (EAs). A total of 433 EAs were selected based on probability proportional to the size of the total EAs in each region. For the rural sample, 290 EAs were selected from the AgSS EAs. A total of 43 and 100 EAs were selected for small towns and urban areas, respectively. To ensure a sufficient sample size in the most populous regions (Amhara, Oromiya, SNNP, and Tigray) and Addis Ababa, quotas were set for the number of EAs in each region. However, estimates can be produced for a combination of all smaller regions as one “other region” category. However, estimates can be produced for a combination of all smaller regions as one “other region” category. During wave 3, 1255 households were re-interviewed by CSA enumerators yielding a response rate of 85 percent. However, the study was used 693 barley producing farmers

3.5. Method of Data Analysis

After the required data was gathered the next task is data coding, data entering, data cleaning, and analysis of the prepared data. In this study, both descriptive statistics and an econometric model were used to analyze the data.

3.5.1. Descriptive statistics

Descriptive statistics such as mean, frequencies, percentages, and standard deviation were used to have a clear depiction of the characteristics of sample units. A correlation matrix is also used to check technological complementarities or substitutability's in terms of dependent variables.

3.5.2. Econometric model

Different econometric models were applied in the literature to measure determinants of agricultural technology adoption with advantages and shortcomings. Linear probability is easiest for binary but difficult disturbance terms. Univariate model has problem to measure the potential correlation among the unobserved disturbance and relationship between different choices (Lin et al, 2005).

Multinomial logit model needs the choice variables to be mutually exclusive and assumes independence across outcomes (Cappellari & Jenkins, 2003). Multinomial probit models require multivariate normal integration to predict unknown parameters (Temesgen et al., 2009). MVP is the binary response regression model used to estimate both observed and unobserved influence on dependent variables by several independent variables simultaneously(Kariuki & Loy, 2016; Koo et al., 2014; Milioti, 2015).

Multivariate probit (MVP) regression was used to estimate the factors that influenced the adoption of agricultural technologies choice for barley production. Statisticians and econometricians view the multivariate probit model used to estimate different correlated binary outcomes simultaneously (Greene, 2002). Generally, a multivariate model extends to more than two outcome variables just by adding equations. Adoption of specific technologies depends on other technological choices on a similar farm. The MVP simultaneously models the relationship between a set of covariates and each of the different technologies, while allowing unobserved and unmeasured factors to be correlated. Correlation among the different adoption decisions may be due to technological complementarities or substitutability. When such correlation occurs, estimates of simple probit models would be inefficient and biased (*P. Wainaina et al./* 2016).In this study, six different agricultural technologies were identified for barley production **(**

Improved seeds, Chemical Fertilizers, Urea, Dap, manure, Crop rotation (CR)). Therefore the study has six dependent binary variables *yij* for household *i* and plot *j*.

$y^*ijm = Xijm\ \beta m + \varepsilon ijm \qquad m = 1, 2 \ldots 6$ …………………………………… (1)

$yijm = 1 \text{ if } y^*_{ijm} > 0$ ……………………………………………………. (2)

$\qquad 0$ if otherwise

Where *y*ijm* is a latent variable that captures the degree to which a farmer views technology *m* as beneficial. This latent variable is assumed to be a linear combination of observed plot and household characteristics, *X ijm,* and unobserved characteristics captured by the stochastic error term, *εijm*. The vector of parameters to be estimated is denoted by *βm*. Given the latent nature of *y*ijm,* estimation is based on observable binary variables *yijm,* which indicate whether or not a farmer used a particular technology in the reference year (*P. Wainaina et al./* 2016). A few previous technology adoption studies also used a multivariate probit model, such as Samuel and shaibu, (2019) who analyzed the adoption of improved agricultural technologies among rice farmers in Ghana: A Multivariate Probit Approach. The error terms *εijm* (m = 1, 2 . . . 6) is distributed multivariate normal each with mean 0 and a variance-covariance matrix V, where V has 1 on the leading diagonal, and correlations *pjk* = *pkj* as off-diagonal elements

$$\mathbf{V} = \begin{Bmatrix} 1 & p_{12} & p_{13} & . & . & p_{1k} \\ p_{21} & 1 & p_{23} & . & . & p_{2k} \\ p_{31} & p_{32} & 1 & . & . & p_{3k} \\ . & . & . & 1 & . & p_{4k} \\ . & . & . & . & 1 & p_{5k} \\ p_{j1} & p_{j2} & p_{j3} & p_{j4} & p_{j5} & 1 \end{Bmatrix}$$

P is the pairwise correlation coefficient of the error terms with regards to any two of the estimated adoption equations in the model. The correlation between the stochastic components of different improved technologies adopted is represented by the off-diagonal elements (e.g. ρ_{jk}, p_{kj}) in the variance-covariance matrix (*P. Wainaina et al. /* 2016). The correlation is based on the principle that adoption of a particular improved practice may depend on another (complementarity or positive correlation) or maybe influenced by an available set of substitutes (negative correlation) (Khanna, 2001).

Before running the econometric model, the data was tested against econometric problems. Accordingly, the data was checked for multicollinearity test for all variables was done using Variance Inflation Factor (VIF). However, the value of VIF were low and below 10 (Appendix Table 8), which indicate the absence of severe multicollinearity problem among the explanatory variables.

Moreover, Breusch-Pagan test was also used to detect the presence of hetroskedasticity. The test result indicated that there was no problem of hetroskedasticity in the model.

3.6. Variables description and measurements

3.6.1. Dependent variables

The dependent variables consist of dummy variables indicating the adoption of particular technologies, (from 1 to 6**),** such as improved seeds, Chemical Fertilizers, Urea, Dap, manure, Crop rotation. The multivariate probit model takes binary variables y_{ijm}, which indicate whether or not a farmer used a particular technology.

Table 2 Dependent variables and their hypothesized

Technology adoption dummies	**Description and measurement**
Improved seeds	Dummy=1 if used improved seed, 0 otherwise
Chemical Fertilizer	Dummy =1 if farmer used chemical fertilizers, 0 otherwise
Urea	Dummy =1 if farmer used Urea on the plot, 0 otherwise
Dap	Dummy =1 if a farmer used Dap on the plot, 0 otherwise
Manure	Dummy =1 if farmer used manure on the plot, 0 otherwise
Crop rotation (CR)	Dummy = 1 if practiced crop rotation on your land holding, 0 otherwise

3.6.2. Description of independent variables

Sex of the household head: Sex is a dummy variable and its one of the factors that affects adoption of agricultural technologies packages. It was represented by 1 for males and 0, for females. The gender gap is found to be one of the factors affecting the adoption of new technologies. Female-headed households are inefficient and unable to adopt agricultural technologies as compared to their male counterpart (Yemane, 2014, Samuel *et al* 2017*)*. Hence, it is expected that male household heads are more likely to adopt agricultural technologies packages than their female counterpart.

Age of the household head: Age is a continuous variable and it affects the adoption of agricultural technologies packages in one or other ways. There are several results from empirical analysis. Young farmers are more likely to adopt new technologies, hence they are more literate than older farmers and have been open to new ideas and they are more risk-takers. Instead, older farmers may have more experience, resources, which would allow them more possibilities for trying new technologies (Assefa and Gezahegn, 2010). Therefore, the age of farmers hypothesized to have a negative or positive influence on the adoption of agricultural technologies packages.

Education: - This variable is measured in years of formal education and was used as a proxy variable for managerial ability. The level of education was assumed to raise farmers' capacity to acquire, process, and use information important to the adoption of improved technologies package (Rahmeto, 2007). Education is therefore expected to increase the probability of adoption of agricultural technologies barley production package.

Farm size: This refers to the total area of farm (own, shared or rented in) land the household managed during a production year. It is a continuous variable measured in hectares. Landholding size is an indicator of social status and wealth and impact within a community. Some of the literatures argue that farm size affect technology adoption positively for that those large farmers have the required resource to adopt available technologies. Some others however argue that small farms are efficient as they intensively utilize technology and labor. This study follows the later argument and hypothesized a negative relation between cultivated farm size and adoption of barley technologies.

Household size: - It is a continuous variable measured in terms of adult equivalent of persons living together in the household. Family Size of the household is hypothesized to influence the choice of Agricultural technologies positively. As the size of the family increases, households sustainably need more produce. Market access on the other hand is more intended to create an incentive to increase surplus production (Ermias, 2013). Hence, it is hypothesized that the availability of labor has positively affected the adoption of agricultural technologies packages.

Contact with extension agents: This is a dummy variable, which takes a value of 1 if the household received extension service and 0, otherwise. The variable represents extension service as an important source of information, knowledge, and advice to smallholder farmers in Ethiopia. Access to extension services has positively affected the adoption of improved rice varieties (Yemane, 2014). It was hypothesized that extension services will increase the adoption of agricultural technologies for barley-producing farmers.

Livestock holding (LIVSTK): This is the total number of livestock owned in terms of Tropical Livestock Unit (TLU). Livestock could support crop production in many ways; they can be the source of cash, draft power, and manure that will be used to maintain soil fertility. It also serves as a shock absorber to an unexpected hazard in crop failure and the main source of animal labor in crop production (Solomon, 2012). Therefore, it is hypothesized that livestock positively affects the adoption of agricultural technology for barley producing farmers

Training:-Training is an important thing in constructing the managerial ability of the farmers (Daniel, 2010). This is a dummy variable that represents the access to training for farm-related activities. If the household has got training, the variable takes a value of 1 and 0, otherwise. So, households who received training service were hypothesized positively related to the adoption of agricultural technology for barley producing farmers.

Credit use: It is a dummy variable that takes 1 if the farmer obtained credit and, 0 otherwise. The accessibility of credit from appropriate sources helps farmers to increase their adoption of agricultural technologies. Hence, credit is hypothesized to influence the adoption of agricultural technology positively.

Crop insurance: - It is measured in terms of whether respondents have insurance access in terms of available insurance sources and the possibility of getting insurance. Farmers who have crop insurance may overcome their financial constraints and risk of crops. It is expected that access to Crop insurance will increase the probability of adopting agricultural technologies.

Soil fertility: It is treated as a dummy that takes a value of 1 if a household head observes his plots as fertile area and 0, otherwise. The more the land is fertile the more the gain will be (kinde, 2005). Therefore it is hypothesized that soil quality will positively affect the adoption of agricultural technologies.

Transportation cost: - It is continuous variables measured in terms of Birr. The farmers who have relatively large transportation costs will be less commenced to adopt barley technologies and. Hence, transportation cost is hypothesized to influence the adoption of agricultural technology negatively.

Oxen power: - It is a continuous variable measured in terms of the total number of oxen. It hypothesized that the farmer who has high oxen the more likely to adopt agricultural technologies.

Access to irrigation: It is a dummy variable that takes the value of 1 if the household uses irrigation practices in the production season and 0 otherwise. The farmers who have used irrigation facilities allow producing high-value crops and can adopt agricultural technologies than those who solely depend on rain-fed farming (Ayalew, 2020). Therefore, access to irrigation was hypothesized to positively affect the adoption of agricultural technology.

Land fragmentation: This is defined as the total number of plots that the household has managed during a production year. Larger land fragmentation leads to a shortage of family labor, costing time and other resources that should have been available at the same time (Fekadu and Bezabih, 2009). Therefore, this variable was hypothesized to have a negative effect on the adoption of agricultural technologies.

Erosion: - Erosion is a dummy variable that takes the value of 1 if the field is prevented from erosion use in the production season and 0, otherwise. The farmers whose field is more prevented from soil erosion are more likely to adopt agricultural technologies. Therefore, it is hypothesized that erosion is negatively affecting the adoption of agricultural technology for barley-producing farmers.

Farm income: The farm income refers to the total annual incomes of the household from the crop, livestock, and livestock sale after meeting family wants. Farm income is the main source of capital for purchasing agricultural inputs (Rahmeto, 2007). Therefore, it was hypothesized to affect the adoption of agricultural technologies positively.

Table 3 Independent variables and their hypothesized effects on household technology adoption

Variables	Type	Measurement of variables	Expected effect
Demographic factors			
Sex of household head	Dummy	Male-1,otherwise 0	+/-
Family size	Continuous	Number	+
Age of HH head	Continuous	Number	+/-
Socioeconomic factors			
Education level of HH head	Continuous	Number of years studied	+
Livestock owned	Continuous	Number	+
Farm income	Continuous	Number	+
Farm characteristics			
Farm size	Continuous	Hectare	+
Soil fertility	Dummy	1if Good. 0 poor	+
Oxen power	Continuous	Number	+
Land fragmentation	Continuous	Number	-
Erosion	Dummy	1 if the field is prevented from erosion 0, otherwise	-
Institutional factors			-
Transportation cost	Dummy	Birr	-
Access to credit	Dummy	If the household uses credit=1, otherwise, 0	+
Training	Dummy	If got training 1, otherwise 0	+
Contact with extension agents	Dummy	1-yes no- 0	+
Crop insurance	Dummy	1- If bought crop insurance, 0 otherwise	+
Access to irrigation	Dummy	1-if accessed -0 otherwise	+

CHAPTER FOUR

4. RESULT AND DISCUSSIONS

This chapter consists of the overall findings of the study to be presented in different sections. Barley production involves the use of different package practices. These include the use of urea, dap, chemicals, improved variety, manure, and crop rotation. After all substantial improvement in production and productivity depends on the extent to which a household has applied the recommended package practices. The level of adoption of barley production packages by farmers may vary depending on the socio-economic situation of the household as well as the institutional environment in which the household operates.

Both descriptive and econometric methods were used to analyze the data. Descriptive statistics were employed to describe the socio-economic, demographic, and institutional characteristics of sample barley-producing farmers. Econometric analysis was also used to identify determinants of the adoption of agricultural technology packages in barley-based farming systems. Before analyze the model result the multi-collinearity and heterosedasiticity problems were checked. There is the absence of multi-collinearity between explanatory variables with VIF =1.46 and absence of heterosedasiticity with Breusch -pagan /Cook-Weisberg test.

4.1. Descriptive Statistics Results

4.1.1. Demographic characteristics households

The study required to find out the gender distribution among the respondents in Ethiopia. The respondents were asked to indicate their gender, this was done to assess if gender had any influence in the adoption of agricultural technology in barley production, and the results are shown below Table 4.

Table 4 Sex characteristics of respondents

Sex of household head	Freq.	percent
Male	582	83.98
female	11	16.02

Source: Own Computation, 2021

According to the result, the majority of the respondents were males (582) while the rest were females (111). The results illustrated that number of males who participated in barley production was more than that of females. Therefore, gender equity among the respondents who participated in this study was not achieved. This could also point out the low participation of women in agricultural activities in Ethiopia.

The results show in Table 5 indicated that the average age of a farmer was found to be 43.47 years, with a minimum age of 21 and maximum age of 80 years. This indicates there is a relatively youthful age for barley farmers in Ethiopia. This meant that majority of the respondents were mature middle-aged people. This was an indication that the respondents had varied age distribution and therefore gave different views on the factors influencing the adoption of agricultural technology among barley farmers in the area.

Table 5 Age of sample households

Variable	Mean	Std. Dev.	Min	Max
Age	43.47042	11.72411	21	80

Source: Own Computation, 2021

4.1.1.1. Sex characteristics of respondents in technologies adoption

Accordingly, the results from Table 6 indicates out of the total sample, about 58.58% of sampled households adopt urea during the study year, reflecting a moderate adoption of urea in barley production; hence 50.79% of urea was adopted by male's household heads. The data revealed that 75.18% of sampled households adopt dap during the study year, from that only 11.54 %

practiced by the female household head, reflecting a low degree adoption of dap by female household head. The results of the study revealed that only 19.62% sampled households adopt chemicals in the barley field during the study year, besides that 15.15% were adopted by male household heads reflecting a low-level adoption of chemicals in Ethiopia

About, 71.71% of sampled households practiced crop-rotation in a field during the study year from that 60.62% practiced by the male household heads, reflecting a high level of practicing crop rotation that used to reduce damage from insect pests, to limit the development of barley diseases, and to manage soil fertility in Ethiopia

The results of the study show that about 66.96% sampled households adopt improved variety in barley field during the study year, from that only 9.67 % adopted by female household head indicating low awareness and knowledge about improved variety in the female household head rather than their male counterpart, moreover, the result shows there is a high-level adoption of improved variety in Ethiopia

Accordingly, about 65.37% of sampled households adopt manure in barley fields during the study year, from that only 9.53 % practiced by female household head indicating low adoption of manure in the female household head rather than their male counterpart, furthermore, there is high-level adoption of manure in Ethiopia. Generally, the results indicated a low degree of adoption of barley production technologies by female household heads relative to their male counterpart, the results are shown in Table

Table 6 Sex characteristics of respondents in technologies adoption

	Urea				**Dap**				**Chemicals**			
	Adopter		Non		adopter		Non		Adopter		Non	
Sex	No	%	No.	%	No	%			No	%	No.	%
Male	352	50.79	230	33.19	441	63.64	141	20.35	105	15.15	477	68.84
Female	54	7.79	57	8.23	80	11.54	31	4.47	31	4.47	80	11.54
Total	406	58.58	287	41.42	521	75.18	172	24.82	136	19.62	557	80.38
	Improved variety				**Crop rotation**				**Manure**			
	Adopter		Non-adopter		practiced		Not-practiced		adopter		Non -adopter	
Sex	No	%	No.	%	No.	%	No.	%	No.	%	No.	%
Male	397	57.29	185	26.7	420	60.62	162	23.38	387	55.84	195	28.14
Female	67	9.67	44	6.35	77	11.13	34	4.91	66	9.53	45	6.49
Total	464	66.96	229	33.04	497	71.71	157	28.29	453	65.37	240	34.63

Source: Own Computation, 2021

4.1.2. Socio-economic characteristics

Table 7 provides a summary of results in descriptive statistics for explanatory variables of socio-economic characteristics used in this study. Household size is a key variable that characterizes farm households. The average household size was found to be 6.94, with a minimum of 1 and a maximum of 30 family members, showing that the family size was large.

Education can affect the productivity of barley farmers and the adoption of agricultural technology packages. Therefore, literate barley producers are estimated to be in a better knowledge and use information which used to develop their adoption of agricultural technologies. According to the survey results indicates, the overall average year of formal schooling of the total sampled household heads had up to only 5 years of formal education, with a minimum of 0 grade and a maximum of level-2 vocational and technical course of formal education. This indicates a low level of formal education among barley farmers in Ethiopia. Accordingly, the result of the study revealed that the average landholding per barley farmer was found to be 4.3 hectares, with a minimum of 1 of and a maximum of 9(ha) of land owned by barley producers. This indicates that the farmer the average landholding for barley production was high in the area; the findings are shown in Table7

On average, a farmer had up to 1.34 oxen in a number, with a minimum of 0 and a maximum of 14 oxen. This finding indicates a farmer had a small number of oxen to enrich agricultural activities in the area, consequently, farmers enforced to rent oxen as require as the size of a farm. On average, farmers have 13 numbers of plots, with a minimum of 1 and maximum 20 numbers of fields. This finding indicated that a higher land fragmentation in Ethiopia, having of larger fragmented land it might be difficult to manage a farm properly and unable to produce quality standard barley grain.

Farm animals are a source of draught power, food, animal dung for organic fertilizer, cash, and used as means of transportation. To help with the analysis, the livestock number was converted to a tropical livestock unit (TLU). The average number of livestock owned by sampled households which were measured by tropical livestock unit (TLU) is 5.4 tropical livestock units, with a minimum 0 of and maximum 45.55 TLU. The number of livestock owned accounted for all types of livestock possessed by the household. This indicates the farmers had high livestock units which are important for the source of income of agricultural activities in the area. Hence, a household with large livestock holding can have good access to more draught and it is one of the main cash sources to purchase inputs (Rahmeto, 2007).

Farm income is believed to be the main source of capital for purchasing agricultural technology packages. Thus, those farmers with a relatively higher degree of farm income are more likely to purchase agricultural technologies for barley production. On average, the annual income from the sale of crop and livestock for sample households was 1572.07 birr with a minimum of 0 and a maximum of 34355 birr from crop and livestock sales. This indicates a sample of households had a lower level of farm income to purchase improved seeds, fertilizers, chemicals, or other agricultural inputs in Ethiopia, the findings are shown in Table 7.

Table 7 Socio-economic characteristics of sample households

Variables	Mean	Std. Dev.	Min	Max
FamliySize	6.943723	3.9795	1	30
HHEDU	5.005772	2.692845	0	14
FarmSize	4.379509	2.532788	1	9
OxenPower	1.379161	1.460921	0	14
LandFragma~n |	13.61216	7.470333	1	20
TLU	4.440147	3.843299	0	45.55
TotalIncome	1572.07	3220.39	0	34355
Transporta~t |	39.41477	100.6367	0	850

Source: Own Computation, 2021

4.1.3 Adoption of agricultural technologies by barley farmer

Table 8 presents different agricultural technologies and levels of adoption practice among barley farmers in Ethiopia. The results reveal that about 58% of the respondents practiced urea on barley farm plots. Accordingly, about 75% of the samples respondents adopt dap. Only 19% of the farmers practiced chemicals on barley production. Moreover, the results of the adoption of agricultural technologies of barley production below show that the respondents adopt manure, improved variety, and crop rotation with the adoption rate of 65%, 66%, and 75% respectively, the findings are shown in Table 8.

Table 8 Agricultural technologies

Technologies	**Freq. (No. farmers practicing)**	**%**
Urea	**406**	**58.59**
Dap	**521**	**75.18**
Chemicals	**136**	**19.62**
Manure	**453**	**65.37**
Improved variety	**464**	**66.96**
Crop rotation	**497**	**75.99**
N=693		

Source: Own Computation, 2021

4.1.4 Adoption and Intensity of Adoption of barley production package

Seeding rate

The practice of appropriate seeding rate is one of the most important uses in agricultural production. Excessive or underutilization of seed will result in poor production performance. Generally, research recommends a specified level of seeding rate for a given variety or crop with a given range of seed feasibility (Rehmeto, 2007). The extension also advises farmers based on this research recommendation. The recommended seeding rate of barley variety is 100-125 kg per ha vary from region to region (MOA, 2018). Farmers' adoption of the recommended seeding rate however based among numerous things on the relevance of the recommended rate itself, availability of quality seeds, uncertainty in its germination percentage, and other household-related socio-economic problems (knowledge/awareness level). The result of the average seeding rate across adoption categories as indicated in Table 9.

Table 9 Improve variety rate of application

Variable	Mean	Std. Dev.	Min	Max
Seed Quantity	93.31009	92.47105	0	300

Source: Own Computation, 2021

Farmers in Ethiopia were found to use varying seeding rates of improved barley variety. Concerning variability in the amount of seed-applied per hectare of land among sample respondents, farmers applied a minimum of 0 kg, and a maximum of 300kg, of the improved seed of barley farmers on average, applied 93.31kg of seed per hectare of land, which is close to barley production recommendation rate, the results are shown in Table 9.

Fertilizer application package

Barley production, like any other crop, requires the use of different inputs. Urea and dap are the most important fertilizers used for various crops, to boost the production and productivity of crops. Fertilizer application is one of the most important practices that need to be adopted by barley growers (Rehmeto, 2007). Moreover, proper application of the recommended rate of urea (50-100 kg/ha) depending on N stress level is important to obtain the required yield, while the proper application rate of dap is 100kg/ha (MOA, 2018). As far as urea and dap fertilizers use is concerned, farmers in the area use varying fertilizer rate, which is below the recommendation. The average fertilizer application rate is shown in Table 10.

Table 10 Fertilizer rate application

Variable	Mean	Std. Dev.	Min	Max
Urea Quantity	49.7875	68.99082	1	200
Dap quantity	51.48904	69.43529	.25	300

Source: Own Computation, 2021

The average rates of urea application for barley production by sample respondents during the production year was 49.78 kg/herewith the standard deviation of 68.99. The mean of Dap applied rates of barley production by sample respondents was 67.07kg/ha. The farmers had used a low level of fertilizer rather as recommended as per hectare shown in Table 10.

Sample respondents have mentioned different reasons for their use of such low fertilizer rates. In the first place, they were claiming lack of financial capacity and unavailability of fertilizer at the right time was mentioned in the second place. In their view, the amount of fertilizer to be applied per hectare of land depends on attention paid to land preparation and the fertility status of the land. Lack of soil moisture and lack of irrigation facilities may also result in low fertilizer use. (Rahmeto, 2007). It is a consequence for research indicating the need to restudy the previous research recommendation by conducting additional site-specific fertilizer trials.

4.1.5 The relationship between the agricultural technologies – Correlations matrix residuals

Table 11 presents the results of the correlation matrix from the multivariate regression. The results indicate that all pairwise coefficients were positively correlated, positive correlation indicating complementarity among the barley production technologies. The relationships among all the technologies were significant except for chemical and urea, manure and chemical, improved variety, and chemicals.

There are several positive correlations in table 11, indicating technological complementarities. The adoption of dap is positively correlated with the adoption of urea. The adoption of chemicals is positively correlated with the adoption of dap at a 5% significance level. The adoption of manure is positively correlated with the adoption of urea; dap, at a 1% level of significance. The adoption of improved variety is positively correlated with the adoption of urea, dap, and manure, at a 1% level of significance. The adoption of crop rotation is positively correlated with the adoption of urea, dap, manure, and improved variety, at a 1% significance level. The adoption of crop rotation is positively correlated with the adoption of chemicals, at a 5% significance level. The highest correlation was between the adoption of improved variety and manure (95.70%); the findings are shown in Table 11.

Table 11 Correlation matrix of the technologies from the multivariate probit model

	Urea	Dap	ChemicalF	Manure	ImprovedV	CropRotation
Urea	1.0000					
Dap	0.5581*	1.0000				
ChemicalF	0.0300	0.1656**	1.0000			
Manure	0.8611*	0.6418*	0.1401	1.0000		
ImprovedV	0.8206*	0.6192*	0.1267	0.9570*	1.0000	
CropRotation	0.6881*	0.8331*	0.1523**	0.8132*	0.7958*	1.000

Source: Own Computation, 2021

4.2. Results of the Econometric Model

This section presents the econometric results of the study. In this subchapter, the results of the multivariate probit model were presented and discussed. Several factors can affect barley farmers' decision to adopt one particular technology or the other. Numerous variables are significant across several places and over time in amplifying the adoption of technologies by farmers. Many factors are expected to affect the adoption of agricultural technologies based on theoretical models and empirical evidence. Moreover, this section identifies the variables which determine the adoption of agricultural technologies by barley farmers using a multivariate probit model, the findings are shown in Table 12.

Sex of household head: As the results indicate the sex of the household head had a positive and significant influence on the adoption of urea at a 1% level of significance, the findings are shown in Table12. This revealed that being male-headed households have better access to information on barley production technologies and are more likely to adopt urea than female-headed households. Galmesa (2013) probit regression model results revealed that the adoption of improved soya bean production technologies is biased by gender, where male-headed households are more likely to adopt soya bean varieties than their counterpart.

Age of household head: Age was negatively related to the adoption of improved variety and adoption of urea at a 5% level of significance, the findings are shown in Table12. The result of the multivariate probit model indicates that younger households are more likely to give a higher amount of land to improved varieties and more likely to use urea than old-age households. The impact of this result is that younger farmers had a higher probability of adopting new technologies than older barley farmers. Moreover, Samuel et al. (2019) found a negative effect of age on the adoption of harrowing, irrigation, and bunding, the findings are shown in Table12.

Education: Education was found to have a positive and significant relationship with the adoption of urea, manure, and improved varieties at 5%, 1%, and 1% level of significance respectively, the results are shown in Table12. In other words, the result means that higher educational status increases farmers' awareness about the benefits of adopting urea, manure, and improved varieties. A better-educated farmer has more lucrative income sources and thus fewer capital constraints to invest in external inputs. While education had a negative and significant relationship with the adoption of chemicals at a 5% significance level but failed to explain the adoption decision of, dap and crop rotation. Samuel et, al (2019) using the multivariate probit model to study the adoption of Improved Agricultural Technologies among Rice Farmers in Ghana concluded that education increases farmers' awareness of improved technologies.

Family size: Family size was hypothesized to have a positive effect on the adoption of improved variety and manure technologies since the family is the major source of labor for agricultural activities. However, contrary to the prior expectation, it has turned out to influence the adoption of improved variety and manure negatively and significantly at a 5% level of significance, the results are shown in Table12. Hence, given the higher opportunity cost of labor in Ethiopia, the application of more labor for other jobs will affect the adoption of agricultural technologies for barley production negatively. This finding contradicts the work of Samuel et, al (2019), who found that household size was significant and correlated positively with the adoption of bunding.

Soil fertility: The result revealed that soil fertility was negatively and significantly related to the adoption of urea, improved barley variety, and manure at 1%, 5%, and 1% level of significance respectively, the findings are shown in Table12. The result of the multivariate probit model revealed that the farmers whose farmland was infertile more likely to adopt urea, manure and improved variety than those have fertile soil. Hence, the application of animal manure is used for the restoration of soil fertility and the improvement of crop production. Generally, the application of improved variety, urea, and manure increases the supply of nutrients to the crop and increases the organic matter content of the soil (De Ridder and Van Keulen, 1990).

Farm size: Farm size was significant and had a negative relationship with the adoption of improved barley variety and manure at a 5 % level of significance; the findings are shown in Table12. Meaning, farmers with bigger farm sizes had a lower probability to adopt improved barley variety and manure compared with those who had smaller farm sizes. The negative correlation between farm size and the probability of adopting improved barley variety and manure is due to the labor-demanding and capital-demanding nature of package approaches and resulting difficulty for poor farmers regardless of their farm sizes (Lucia and hadush, 2018). This could be so because adopting these technologies would come with extra costs aside cost of seed and labor for manure application (Samuel et, al, 2019).

Extension Contact: Household extension contact was only significant and negatively related to the decision to adopt, chemical at 5% level of significance, redundant in explaining the adoption of the other technologies, the findings are shown in Table12. This finding did not meet the a priori expectation since the agricultural extension is meant to influence technology uptake by farmers. However, Samuel et al. (2019) posit that the household extension method does not promote cross-learning and experience sharing among farmers from different homes and backgrounds since it is carried out only within the household of the person transmitting the information.

Access to credit: - As the multivariate probit model result indicates, it had a positive and significant influence on the adoption of urea, dap, manure, improved variety, and crop rotation at a 1% significance level, the results are shown in Table12. The results of multivariate probit indicate that those households who have access to credit are more likely to adopt barley technologies than those who have no access to formal credit. Hence, accessibility of credit from appropriate sources helps farmers to purchase essential agricultural inputs. Rahmeto (2007) using the Tobit model to study determinants of adoption of improved haricot bean production package concluded that farmers who have access to credit, are more likely to adopt improved haricot bean technology.

Training: Training was significant and negatively related to the adoption of urea, dap, improved variety, manure, and crop rotation at a 1% level of significance, the results are shown in Table12. This implies there is a promotion of inappropriate technology, insufficient adaptive research in the barley-based training section, which might be due to the range of (class, gender, literacy, and location). The weakness in the state-led agricultural training systems has also led to the assumption of responsibility of investigating and disseminating information to farmers in Ethiopia. Contrary to *a priori* expectation, however, access to training access had a significant but negative relationship with the adoption of barley technologies, contradicting the findings of Samuel et, al (2019) indicates that farmers' access to agricultural training significantly and positively influenced their adoption of nursery, spacing, line planting, urea briquette, irrigation and bunding.

Tropical livestock unit: Number of livestock owned as measured by tropical livestock unit. TLU has a significant and positive influence on the adoption of dap, manure, and improved variety at a 5 % level of significance, the findings are shown in Table12. A larger number of livestock units on the farm are associated with a higher probability of manure use and with a lower probability of retaining crop residues in the field. The result revealed that high livestock leads to exhaustive farming practices as these smooth financial constraints to purchase the agricultural technology packages and hire extra labor for the duration of peak agricultural seasons (Luchia and Hadush, 2018).

Farm income: Farm income was positive and significantly related to the adoption of dap and urea at a 5 % level of significance. Farm income was also positively and significantly related to the adoption of manure, improved variety, and crop rotation at a 1 % level of significance, the findings are shown in Table12. The multivariate probit model result indicated that those barley farmers with a relatively higher degree of farm income are more probable to purchase urea, dap, and other agricultural inputs.

Transportation cost: Transportation cost was negatively and significantly related to the adoption of urea at a 1 % significance level. Additionally, it was negatively and significantly related to the adoption of dap, improved variety, manure, crop rotation at a 5 % level of significance, the results are shown in Table12. The multivariate probit model indicates that those farmers who have fewer transportation costs are more likely to adopt barley technologies than those who have high transportation costs. The possible explanation for this is that farmers who have higher transport costs might face far away from market centers and lack of information on the availability of the newly released technology provided by the extension system.

Table 12 Result of multivariate probit model

Variables	Urea		Dap		Chemicals		Improved variety		Manure		Crop rotation	
	Coef.	Std error	Coef.	Std error	Coef.	Std error	Coef.	Std error	Coef.	Std error	Coef.	Std error
Age	-.004**	.002	-.001	.002	.001	.001	-.004**	.002	-.003	.002	-.004	.002
sex	.341*	.115	.206***	.110	.156***	.091	.261**	.112	.245**	.113	.232**	.106
HHedu	.030**	.012	.003	.011	-.024**	.009	.039*	.012	.037*	.012	.004	.011
Family size	-.012***	.006	-.009	.006	.006	.005	-.014**	.006	-.013**	.006	-.009	.006
FarmSize	-.021	.012	.007	.012	.012	.010	-.025**	.012	-.025**	.013	.001	.012
SoilQuality	-.139*	.041	-.004	.039	.012	.032	-.101**	.039	-.105*	.040	-.029	.038
Irrigation	-.097	.119	-.125	.113	.173***	.093	-.056	.114	-.002	.123	-.105	.11
ExtContact	.207***	.116	.171	.110	-.258*	.091	.090	.112	.066	.114	.205***	.107
Credit	.488*	.164	.509*	.157	.122	.129	.536*	.158	.523*	.162	.519*	.152
Training	-.599*	.183	-.539*	.174	-.115	.144	-.547*	.176	-.552*	.181	-.610*	.169
OxenPower	-.022	.021	-.035***	.020	.023	.016	-.026	.020	-.026	.020	-.018	.019
Land.frag	.003	.004	.0062	.003	.005***	.003	.002	.003	.003	.003	.004	.003
CropInsurance	.093	.090	.088	.086	.071	.009	.053	.087	.031	.089	.059	.084
Erosion	.083	.053	.060	.051	.042**	.083	.082	.051	.095	.053	.041	.049
TLU	.011	.008	.016**	.007	.006	-.002	.017**	.007	.016**	.008	.008	.007
income	.001**	0.000	.000**	0.000	7.8-06	7.8-06	.000*	.006	.001	0.016	.003*	0.000
Tcost	-.000*	.000	-.006**	.000	.002	.006	-.000**	.005	-.004**	.0002	-.000**	.000
_cons	1.075	.276	.747	.263	.217	1.492	1.065	.266	1.099	.272	.787	.256

Notes: N = 693; log likelihood = -1892.60239; Wald chi2 (102) = 787.98; likelihood ratio test of rho chi2 (15) = **701.843.** *, **and *** represent 1%, 5%, and 10% level of significance respectively

Source: Own Computation, 2021

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATION

5.1. Summary and Conclusions

This study aimed at analyzing the determinants of adoption of agricultural technologies packages in the barley-based farming system of Ethiopia, with the specific objectives of identifying factors affecting the adoption of agricultural technologies packages and identifying the types of agricultural technologies in the barley-based farming system. The data were accessed from the Ethiopian Socioeconomic Survey (ESS) conducted by the CGIAR Standing Panel on Impact Assessment (SPIA) in 2015/2016 by extracting barley producers.

Results of descriptive analysis showed that out of the total interviewed barley producers 582 (82.98%) were male respondents and the remaining 111 (16.02%) were female respondents. The average age of the sample respondent was 43.4 years. The average household size was found to be 6.94 family members. According to the study results indicates, the overall average year of formal schooling of the total sampled household heads had up to only 5 years of formal education, with a minimum of 0 grade and a maximum of level-2 vocational and technical course of formal education.

The average number of livestock owned by sampled households which were measured by tropical livestock unit (TLU) is 5.4 tropical livestock units. On average, the annual income from the sale of crop and livestock for sample households were 1572.07 Ethiopian birrs.

The average rate of urea used packages for barley production by sample respondents during the production year was 49.78 kg/ha. The mean of dap rates applied on barley production by sample respondents was 67.07kg/ha. Farmers in the study area were found to be used vary seeding rates of improved barley variety. Concerning variability in the amount of seed-applied per hectare of land among sample respondents, farmers on average applied 93.31kg of seed per hectare of land.

The relationships among all barley technologies were positive and significant. There is complementarity among improved barley production technologies (Urea, Dap, Chemicals, Improved variety, Manure, and crop rotation), meaning that the adoption of a given barley technology was conditional on the adoption of the others. Moreover, the results of the adoption of agricultural technologies of barley production reveal that 58 %, 75%, 65%, 66%, 75% of the respondents adopt urea, dap, manure, improved variety, and crop rotation respectively. Only 19% of the farmers practiced chemicals on barley production.

The results of a study showed that adopters of barley technologies as compared with non-adopters were characterized by better educational status, higher livestock assets ownership, and higher farm income. Moreover, higher proportions of adopters (75.99 %) were practiced crop rotation; while lower proportions of farmers (58%) adopted urea.

A multivariate probit model result has suggested that the age of the household head was negative and significantly related to urea and improved variety. This implies that younger household heads are more likely to adopt barley technologies. The sex of the household head was positive and significantly related to urea, improved variety, manure, and crop rotation. Being a male household head had a higher probability to adopt barley technologies. Education was found to have a positive and significant relationship with the adoption of urea, manure, and improved variety. Therefore, educated barley farmers are expected to be in a good position to get and use agricultural technology availability which contributes to improving their barley production practices. Family size was found to be negatively and significantly affect the adoption of the use of urea improved varieties, manure. This implies the application of more labor for other jobs will affect the adoption of agricultural technologies for barley production negatively.

Farm size was found to be negatively and significantly affect the adoption of the use of improved varieties, manure. This implies that farmers with large land would diversify more into other crops. Access to credit services was positive and strongly significantly related to the adoption of barley technologies. This implies credit utilized permits a household to enhance adoption of barley technologies by removing money constraints which may affect their ability to apply inputs, and farm management decisions on time. The training was found to be negatively and significantly affect the adoption of barley technologies. This revealed there is a promotion of inappropriate technology and adaptive research in the barley-based training section.

Farm income was found to positively and significantly related adoption of the use of improved varieties, manure. This implies income is the main source of capital for purchasing agricultural inputs. Transportation cost was negatively and significantly related to the adoption of barley technologies. This implies the rising cost of transportation farmer's consequence of being far away from market centers which might face a lack of information on the availability of the newly released barley technology provided by extension system.

5.2. Recommendations

Based on the results of a study, the following recommendations are suggested to be considered in future intervention policies.

Sex has a significant positive impact on the adoption of barley technologies. Having in mind the problem that may arise from female head households, the government should make a policy that empowers female-headed households to participate in different institutions and agents of change by considering a widespread and comprehensive development of the country where their involvement is important in all overall country's development.

Younger household heads are more likely to adopt barley technologies. Hence, the introduction of new agricultural technology in the areas may be effective if it emphasizes more on young farmers. This study provides evidence on the role of credit use in improving the adoption of barley technologies positively; therefore, efforts towards establishing and strengthening micro-finance institutions seem crucial.

Supporting adequate and effective basic educational opportunities for the rural farmers in Ethiopia is more crucial. The results of the study also revealed that farm income has a positive effect on the adoption of barley technologies; consequently, distribution and scaling up of barley technologies in Ethiopia should be expanded.

Enhancing the current livestock production system through supplying improved livestock feed, health services, targeted credit, and adopting high-yielding breeds in the areas to improve adoption packages of barley technologies.

Transportation costs were negatively and significantly affected the adoption of barley technologies. Therefore, concerned bodies need to launch a market center for the producers around their home which boosts the likelihood of adoption of barley technologies.

The study was set suggestions for future research; it has certain limitations, which originate primarily from a shortage of time. Secondly, the study was done using cross-sectional data, which only reveals farmers' statuses in a given year. Furthermore, the results of cross-sectional data do not express the change over time that may be important for a follow-up development strategy. Finally, the study was limited to the only adoption of barley crop, however; the separate analyses of different crops will give a clear picture of the farming sector in the area that couldn't touch in this particular study. This is merely due to the limitation of time and other resources.

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7. APPENDICES

Appendix Tables 1: Results of multivariate probit regression for urea

Urea	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Age	-.0049467	.0022711	-2.18	0.030	-.0094167	-.0004766
Sex	.34019	.1154483	2.95	0.003	.1129573	.5674227
HHEDU	.0304199	.0123915	2.45	0.015	.0060302	.0548097
FamliySize	-.0116183	.0066106	-1.76	0.080	-.0246298	.0013932
SoilQuality	-.1391567	.0410579	-3.39	0.001	-.2199694	-.058344
FarmSize	-.0210695	.0129565	-1.63	0.105	-.0465714	.0044324
Irrigation	-.0969709	.1191989	-0.81	0.417	-.3315859	.137644
ExtContact	.2073055	.1161954	1.78	0.075	-.0213978	.4360088
CreditServices	.4881132	.1649367	2.96	0.003	.1634742	.8127523
Training	-.5993512	.1831273	-3.27	0.001	-.9597942	-.2389083
OxenPower	-.0226263	.0210383	-1.08	0.283	-.0640352	.0187826
LandFragmantation	.0036992	.0040021	0.92	0.356	-.0041779	.0115763
CropInsurance	.0934559	.0906775	1.03	0.304	-.0850213	.2719331
Erosion	.0832271	.0538115	1.55	0.123	-.0226882	.1891423
TLU	.0119673	.0081416	1.47	0.143	-.0040576	.0279922
TotalIncome	.0000254	9.92e-06	2.56	0.011	5.87e-06	.0000449
TransportationCost	-.0008203	.0002807	-2.92	0.004	-.0013727	-.0002679
_cons	1.075425	.2762509	3.89	0.000	.5316902	1.61916

Appendix Tables 2: Results of multivariate probit regression for Dap

Dap	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Age	-.0012965	.002168	-0.60	0.550	-.0055638	.0029707
Sex	.20606	.1102102	1.87	0.063	-.0108628	.4229828
HHEDU	.0031409	.0118293	0.27	0.791	-.0201423	.026424
FamliySize	-.0099364	.0063107	-1.57	0.116	-.0223575	.0024848
SoilQuality	-.0045154	.039195	-0.12	0.908	-.0816615	.0726307
FarmSize	.0007788	.0123687	0.06	0.950	-.023566	.0251236
Irrigation	-.12585	.1137907	-1.11	0.270	-.3498201	.09812
ExtContact	.1713486	.1109234	1.54	0.124	-.046978	.3896753
CreditServices	.5093854	.1574532	3.24	0.001	.1994758	.819295
Training	-.5395152	.1748185	-3.09	0.002	-.8836043	-.1954262
OxenPower	-.03569	.0200838	-1.78	0.077	-.0752201	.0038402
LandFragmantation	.0062677	.0038205	1.64	0.102	-.001252	.0137874
CropInsurance	.0888291	.0865633	1.03	0.306	-.0815503	.2592084
Erosion	.0600231	.05137	1.17	0.244	-.0410866	.1611328
TLU	.0166128	.0077722	2.14	0.033	.001315	.0319107
TotalIncome	.000024	9.47e-06	2.54	0.012	5.39e-06	.0000427
TransportationCost	-.0006726	.0002679	-2.51	0.013	-.0011999	-.0001453
_cons	.7477435	.2637169	2.84	0.005	.228679	1.266808

Appendix Tables 3: Results of multivariate probit regression for chemicals

ChemicalF	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Age	.0011223	.0017889	0.63	0.531	-.0023987	.0046432
Sex	.1562887	.0909354	1.72	0.087	-.0226962	.3352736
HHEDU	-.0246195	.0097604	-2.52	0.012	-.0438307	-.0054084
FamliySize	.0065373	.005207	1.26	0.210	-.0037115	.0167861
SoilQuality	.012981	.0323401	0.40	0.688	-.0506729	.076635
FarmSize	.0124643	.0102055	1.22	0.223	-.0076228	.0325515
Irrigation	.1732458	.0938897	1.85	0.066	-.0115539	.3580454
ExtContact	-.2584018	.0915239	-2.82	0.005	-.438545	-.0782585
CreditServices	.1222135	.1299161	0.94	0.348	-.1334957	.3779226
Training	-.1144317	.1442443	-0.79	0.428	-.3983426	.1694792
OxenPower	.023374	.0165713	1.41	0.159	-.0092427	.0559907
LandFragmantation	.005861	.0031523	1.86	0.064	-.0003436	.0120656
CropInsurance	.0098242	.0714241	0.14	0.891	-.1307573	.1504057
Erosion	.0835187	.0423858	1.97	0.050	.0000922	.1669452
TLU	-.0020272	.0064129	-0.32	0.752	-.0146495	.0105952
TotalIncome	7.89e-06	7.82e-06	1.01	0.314	-7.49e-06	.0000233
TransportationCost	.0000346	.0002211	0.16	0.876	-.0004005	.0004697
_cons	1.492518	.2175951	6.86	0.000	1.064233	1.920803

Appendix Tables 4: Results of multivariate probit regression for Manure

Manure	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Age	-.0036526	.0022374	-1.63	0.104	-.0080564	.0007512
Sex	.2459242	.1137362	2.16	0.031	.0220612	.4697871
HHEDU	.0372216	.0122077	3.05	0.003	.0131935	.0612496
FamliySize	-.0137415	.0065126	-2.11	0.036	-.02656	-.0009229
SoilQuality	-.1055273	.040449	-2.61	0.010	-.1851416	-.025913
FarmSize	-.0254461	.0127644	-1.99	0.047	-.0505698	-.0003224
Irrigation	-.0029206	.1174312	-0.02	0.980	-.2340563	.2282151
ExtContact	.0662942	.1144723	0.58	0.563	-.1590175	.2916059
CreditServices	.5230784	.1624908	3.22	0.001	.2032536	.8429031
Training	-.5524709	.1804116	-3.06	0.002	-.9075686	-.1973732
OxenPower	-.0264589	.0207263	-1.28	0.203	-.0672538	.0143359
LandFragmantation	.0008125	.0039427	0.21	0.837	-.0069479	.0085728
CropInsurance	.0312596	.0893327	0.35	0.727	-.1445709	.20709
Erosion	.0959343	.0530135	1.81	0.071	-.0084102	.2002789
TLU	.0160094	.0080209	2.00	0.047	.0002221	.0317967
TotalIncome	.0000256	9.78e-06	2.62	0.009	6.35e-06	.0000448
TransportationCost	-.0006512	.0002765	-2.36	0.019	-.0011954	-.000107
_cons	1.099209	.2721542	4.04	0.000	.5635381	1.634881

Appendix Tables 5: Results of multivariate probit regression for improved variety

ImprovedV	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Age	-.0045319	.0021889	-2.07	0.039	-.0088402	-.0002236
Sex	.2617739	.1112698	2.35	0.019	.0427656	.4807822
HHEDU	.0390063	.011943	3.27	0.001	.0154994	.0625133
FamliySize	-.0140748	.0063714	-2.21	0.028	-.0266153	-.0015342
SoilQuality	-.1011859	.0395718	-2.56	0.011	-.1790737	-.0232982
FarmSize	-.0258176	.0124876	-2.07	0.040	-.0503965	-.0012387
Irrigation	-.0563714	.1148846	-0.49	0.624	-.2824947	.169752
ExtContact	.0905497	.1119899	0.81	0.419	-.1298759	.3109754
CreditServices	.5368254	.158967	3.38	0.001	.2239363	.8497144
Training	-.5474123	.1764992	-3.10	0.002	-.8948093	-.2000152
OxenPower	-.026256	.0202768	-1.29	0.196	-.0661662	.0136542
LandFragmantation	.0021104	.0038572	0.55	0.585	-.0054816	.0097025
CropInsurance	.0537228	.0873955	0.61	0.539	-.1182945	.2257402
Erosion	.0827276	.0518638	1.60	0.112	-.0193542	.1848093
TLU	.0177118	.007847	2.26	0.025	.0022669	.0331567
TotalIncome	.0000255	9.56e-06	2.67	0.008	6.69e-06	.0000443
TransportationCost	-.0005935	.0002705	-2.19	0.029	-.0011259	-.0000611
_cons	1.065051	.2662523	4.00	0.000	.5409959	1.589106

Appendix Table 6: Tables Results of multivariate probit regression for crop rotation

CropRotation	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
Age	-.0004694	.0021048	-0.22	0.824	-.0046122	.0036734
Sex	.2329236	.106995	2.18	0.030	.0223293	.4435179
HHEDU	.0044006	.0114842	0.38	0.702	-.0182033	.0270045
FamliySize	-.0094764	.0061266	-1.55	0.123	-.0215352	.0025823
SoilQuality	-.0296771	.0380515	-0.78	0.436	-.1045726	.0452184
FarmSize	.0014933	.0120078	0.12	0.901	-.0221413	.0251279
Irrigation	-.1058881	.110471	-0.96	0.339	-.3233241	.111548
ExtContact	.2058864	.1076874	1.91	0.057	-.0060709	.4178436
CreditServices	.5191611	.1528598	3.40	0.001	.2182927	.8200294
Training	-.610434	.1697184	-3.60	0.000	-.9444847	-.2763833
OxenPower	-.0187334	.0194978	-0.96	0.337	-.0571103	.0196435
LandFragmantation	.0042541	.003709	1.15	0.252	-.0030463	.0115544
CropInsurance	.0596838	.0840379	0.71	0.478	-.1057249	.2250926
Erosion	.0415378	.0498713	0.83	0.406	-.0566221	.1396977
TLU	.008615	.0075455	1.14	0.255	-.0062366	.0234665
TotalIncome	.000033	9.20e-06	3.59	0.000	.0000149	.0000511
TransportationCost	-.0006308	.0002601	-2.43	0.016	-.0011428	-.0001189
_cons	.7876129	.2560233	3.08	0.002	.2836915	1.291534

Appendix .Table 7. Conversion factors used to estimate Tropical Livestock Unit equivalents

Animal category	TLU
Calf	0.25
Weaned Calf	0.34
Donkey (Young)	0.35
Donkey (adult)	0.70
Camel	1.25
Heifer	0.75
Sheep and Goat (adult)	0.13
Caw and Ox	1.00
Sheep and Goat young	0.06
Horse	1.10
Chicken	0.013

Source: Storck et al. (1991)

Appendix .Table 8 Result from Variance Inflation Factor (VIF)

VIF =	**1.23**

Appendix. Table 9 Result from model test

Number of obs	**693**
Wald chi2 (102)	787.98
Log likelihood	-1892.60239
Prob > chi2	0.0000*
Joint probability(success)	0.171
Joint probability(failure)	0.042

Thank you!