ADOPTION OF IMPROVED POTATO PRODUCTION PACKAGES, HARAMAYA DISTRICT, EASTERN HARARGE ZONE,OROMIYA REGIONAL STATE, ETHIOPIA

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DEDICATION

I dedicate this thesis manuscript to my father Wakie Berhanu and my mother Mintwab Desta for nursing me with affection and love for their dedicated partnership in the success of my life.

STATAMENT OF THE AUTHOR

First, I declare that this thesis is my real work and that all sources of materials used for the thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for MSc degree at Haramaya University and is deposited at the University library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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ACRONOMY AND ABBREVIATIONS

BOA	Bureau of Agriculture
CSA	Central Statistics Agency
EAs	Extension Agents
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GO	Governmental Organization
HABARD	Haramaya District Bureau of Agriculture and Rural Development
HU	Haramaya University
HYVs	High Yielding Varieties
IAR	Institute of Agricultural Research
CIP	International Potato Center
Masl	meter above sea level
MDG	Millennium Development Goals
MEDAP	Ministry of Economic Development and Planning
Mg/ha	mega gram per hectare
MoARD	Ministry of Agriculture and Rural Development
NARS	National Agriculture Research System
NGOs	Non Governmental Organizations
Pas	Peasant Associations
PPS	Probability Proportional to Size
RoARDs	Regional Bureaus of Agriculture and Rural Development
SARC	Sirinka Agricultural Research Center
SSA	Sub-Saharan Africa
TVs	Traditional Varieties
RAAE	Review of Agricultural and Applied Economic

BIOGRAPHICAL SKETCH

Sisay Wakie Berhanu was born in Chelenko, East Hararghe Zone Oromiya National Regional State on Jun 12, 1966. He attends his elementary and junior high school education at Chelenko junior high school, and later attends his high school education at Deder Senior Secondary School. After completion of his high school education, he was employed in Oromiya finance office as a store manager in 1998, he joined Alfa University College Distance Education Program and in 2000 completed Diploma program in Accounting After graduation he served, the Dire Dawa Administrative Council in different places at different positions). He then got an opportunity to join Addis Ababa University for the Bachelor of Art degree program in journalism and communication as full-time student and completed his study in May 2006. After completion of his first degree, he served different Mass media at different positions including Radio Fana for six years and then employed to Haramaya University as program director at fm radio station. He has been serving the radio station since May 30, 2016 as Deputy Manager at Radio.

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ABSTRACT

Potato (Solanum tuberosum L.) is one of the most important vegetable categorized under tuber crops. Potatoes are the third most important food crop in the world after rice and wheat and the leading vegetable crop in United States. Ethiopia has an enormous potential for production of vegetable crops in general and particular and it is also among the most important export crops. Potato is one the most important vegetable crops grown in the study area, Haramaya, It contributes to the major share of cash source, and food security. Currently, production and productivity of potato in Ethiopia are very low. The objectives of this study were Assess the status of adoption of improved potato production package in the study area and to examine factors limiting improved potato production package in the study area. This study interviewed 122 sample household. In this study data were collected and analyzed qualitatively and quantitatively. Quantitative data analysis method were employed mainly with chi-square, F-test and Tobit model using SPSS and Stata computer software .The result of this study revealed that respondent farmers were found to use mainly improved potato variety and fertilizer from the recommended package practices are low. Among the 122 sample respondents, 76 (62.3%) were adopter while 46(37.7%) non –adopters. Moreover, results of the econometric model indicated that sex of the household head, educational level of the household head, annual farm income, credit use, participation in extension events and farmers knowledge about improved potato production package were important variables which had positively and significantly influenced adoption and intensity of adoption of improved potato production package. On the other hand, market distance had shown negative and significant relationship with adoption and intensity of adoption of improved potato production package. The overall finding of the study underlined the high importance of institutional support in the areas of extension, credit service and market to enhance adoption of improved potato production package. Therefore, policy and development interventions should give emphasis to improvement of such institutional support system so as to achieve wider adoption, increased productivity and income to small scale farmer

Keywords: Adoption; Improved Potato production Package, Tobit

1. INTRODUCTION

1.1. Background of the Study

Potato (Solanum tuberosam L.) is among the major food crops produced in the world (Knapp 2008; Nyunza and Mwakaje 2012) in which Ethiopia is also inclusive. It is the fourth most important food crop in the world on the basis of production next to maize, rice, and wheat with annual production accounts of nearly 300 million tons (Naz et al. 2011). Out of these, over half of production occurs in developing countries (Devaux et al. 2014). In Ethiopia, for example, the total production-of potato was 943,233 tons with an average productivity of 13.5 t/ha. and it ranks first in area coverage and third in both total production and productivity among the root crops grown (CSA, 2016).

As most studies show Potato is one of the important crops in terms of its content and economical values. According to (Sen et al. 2010), potato has a significant value in ensuring food and nutrition security of since it provides more calories, vitamins, and nutrients per unit area than any other staple crops In Ethiopia, potato is becoming a prominent source of income since the crop is the most important cash crop for smallholder farmers in the mid-altitude and highland areas of the country (Mulatu et al. 2005; Gildemacher et al. 2009). Particularly , in areas like Hararghe, the economic benefit of potato production is not only limited to smallholder farmers, but also to other actors involved in the potato value chain (Jaleta 2007; Bezabih 2008; Bezabih 2010; Kebret et al. 2015).

More importantly, in East Hararghe zones, landholding is very small and as a result land use is highly intensive. Hence, potato production takes place both under rain-fed and irrigation (Kumilachew and Musa 2016). In addition to the agro- ecological potential, East Hararghe zone has a comparative advantage of producing potato due to its high domestic and export markets (Bezabih 2010). Therefore, potato production is a major source of livelihood for various value chain actors in Eastern Ethiopia where irrigation is available and farmers have better access to local and export markets due to its proximity to neighboring countries like Djibouti and Somalia.

However, potato yields are relatively low in developing countries (FAO 2013). Similarly, Mulatu et al. (2005) indicated that in Hararghe the yields of potatoes grown on the research station (30-40 metric tons ha−1) are not realized at the producer's level (11-13 metric tons ha−1). Productivity of the crop is constrained by multidimensional factors such as lack of disease resistant and high yielding varieties with desirable market qualities, limited knowledge of agronomic and crop protection management technologies, and poor post-harvest handling (Nigussie et al. 2012).

Regarding to potato Adoption, many Local and international studies have been carried out. Of these researchers such as Gebremedhin et al. (2008); Ortiz et al. (2013) and Abebe et al. 2013) found that adoption of a single technology components like improved variety adoption. However, adopting a single component of the package like improved varieties may not realize the expected benefits of potato producers. Hence, studies that take into account different technology components as a package are necessary. This study takes into account different potato technology package including improved variety, application, Di-Ammonium Phosphate (DAP) and Urea application. The objective the current study, therefore, is to assess determinants of adoption of potato technology package in selected districts of Eastern Ethiopia focusing on Haramaya, district.

1.2. Statement of the Problem

Increasing population pressure and small and decreasing land holdings necessitated intensification of production practices to meet the increasing demand for food in Haramaya woreda. One of the greatest advantages of root and tuber crops (particularly in areas where land is scarce) is the High productivity per unit of area or time. They help to insure the food security of households. Potato is one of these crops. It has high potential in terms of dry matter and edible energy per hectare that is important for the study area where population pressure and food Insecurity are increasing. A number of improved sweet potato varieties have been released by research centers over the past several years.

In Ethiopian, the Ethiopian Agricultural Research Institution (EARI) has a national mandate to conduct and coordinate research, but higher education institutions (Universities and Colleges) are also engaged in research on potato and other crops. EIAR has a strong collaborative research with international agricultural research centers such as CIP on potato and sweet potato research. 2007). However, EIAR along with Universities such as Haramaya University released considerable number of potato varieties for different regions and agro-ecologies. Haramaya University has been to undertake research on, tuber and other root crops particularly on potato. Since its establishment, several improved potato varieties have been tested and disseminated to farmers through the outreach programs of the center as well as through other organizations involved in agricultural development and extension activities.

However, the extent to which farmers has adopted these varieties has not been studied and factors affecting the adoption of improved potato production package were not yet known. Lack of adequate information on farmers' perception about new technologies, farm and farmers' characteristics often placed new technologies on wrong target regions where they failed or registered with partial success. In Ethiopia, with its mainly agriculture based economy, the development initiatives seem to be impractical if smallholder farmers are not provided with a full scope of means for increasing their productivity, income and standard of living. This would be of paramount importance when it comes to root crops producers. We know little about the kinds of situations needed to encourage farmers to use new technologies. Particularly, our understanding of rural decision-making and decision-making situations is very limited. The situation of smallholders needs to be thoroughly investigated and understood in order to design an appropriate policy. Past adoption studies conducted in Ethiopia have tried to identify factors affecting adoption of new technologies and indicated that adoption has been slow and factors affecting adoption behavior of farmers remained largely unknown (Chilot et al., 1996).

Moreover, a factor which is found to enhance adoption of a particular technology in one locality at one time was found to hinder it or irrelevant to adoption of the same technology in another locality (Getachew et al., 1993). Therefore, this study analyzed factors that affect the adoption decision and intensity of use of improved potato varieties in Haramaya woreda of

East Hararage Zone. Likewise, an in-depth and up to date understanding of a particular farming system is a Pre-requisite for any research and development interventions. However, no work has been carried out to characterize the farming system of the study area and hence important characteristics of the system remain unknown. This research activity was, therefore, initiated to bridge these information gaps by focusing on potato.

1.3. Objectives of the Study

The general objective of this study was to analyze factors that affect the adoption of improved potato production package in Haramaya woreda in order to draw important Conclusions and implications for future intervention.

The specific objectives of the study were

1. Assess the status of adoption of improved potato production package in the Haramaya woreda
2. To examine factors limiting improved potato production package in the Haramaya woreda

1.4 Research Questions

What is the status of adoption of improved potato production package in the Haramaya woreda?

What are the factors limiting improved potato production package by farmers in the Haramaya woreda?

1.5. Significance of the Study

This study has great value to extension programs, seeking to adjust strategies in technological intervention; it is further expected to give feedback to Policy makers, researchers with regard to the Performance of *package and aimed* at benefiting small holders.

1.6. Scope and Limitation of the Study

The study was carried out by surveying a sample of 122 randomly selected farm households from Peasant associations (PAs) in Haramaya woreda where the improved potato varieties were disseminated. Review of available secondary information was made from relevant Sources to supplement the field survey data. The study was confined analysis of factors affecting adoption of potato production package in Haramaya woreda of Eastern Hararge Zone because of limited resources and times to complete the study. Hence, the results of the study are thus, applicable to the study area and other areas with similar physical and socioeconomic settings.

2. LITERATURE REVIEW

This chapter seeks to give an overview of the existing literature available on the various aspects of potato production. The chapter is divided into deferent sections. The first section discusses about the origin and spread of potato; the second section reviews about potato production in Ethiopia. The third and fourth sections deal with factors affecting potato production and basic concepts of adoption, respectively while the fifth section highlights factors affecting agricultural innovation. The sixth section presents the theoretical perspectives of adoption and the seventh section deals with a review of empirical studies on the adoption of different improved technologies. Finally, section eight presents

2.1. Potato Production

2.1.1. Origin and spread of potato crop (*Solanum Tuberosum L.*)

Potato has its origin in the high Andes OF South America. It was first cultivated in the Andes in the vertically of Lake Titicaca near the present Peru and Bolivia in South America. Ones domesticated, the crop spread throughout the Andes. Then by time of Spanish conquest in the early 16th century, farmers were cultivating thousands of varieties throughout the highland areas of Bolivia, Chile, Colombia, Ecuador and Peru. Potatoes were sold in Seville as early as 1573.From Spain potato spread throughout Europe. It reached most other part of the world through colonial power, rather than directly from South America. For this reason many people think of it as a European crop and named « Irish Potato», and also assume that would trends in potato production and use directly European trends. It is also one of about 2000 species in the family Solanaceae. There are eight cultivated species of tuber bearing solanums and about 200 wild species. All this relatives of the potato are of new world (America) origin, from where it from where it spread to old world (Mathewos, 2005).

2.1.2. Origin and spread of potato crop

Potato (Solanum Tuberosum L.) has its origin in the high Andes of South America. It was first cultivated in the Andes in the vicinity of Lake Titicaca near the present border of Peru

and Bolivia in South America Calibri (Body) Calibri (Body) Calibri (Body).Once domesticated, the crop spread throughout Andes. Then by the time of Spanish conquest in the early 16th century, farmers were cultivating thousands of varieties throughout the high land areas of Bolivia, Chile, Colombia, Ecuador and Peru. Potatoes were sold in Seville as early as 1573. From Spain potato spread throughout Europe. It reached most other parts of the world through the European colonial powers, rather than directly from South America. For this reason many people think of it as a European crop and named "Irish Potato", and also assume that world trends in potato production and use directly European trends. It is also one of about 2000 species in the family *Solanaceae.* There are eight cultivated species of tuber bearing *solanum*s and about200 wild species. All these relatives of the potato are of new world (America) origin, from where it spread to old world (Mathewos, 2005).

2.1.3. Potato production in Ethiopia

Ethiopia has a wide range of micro climatic zones with varying altitudes and soil types suitable for potato production. Ethiopia's potato production has increased considerably-in the twentieth century: some empirical study show that in the year 1975 and 2001; 50,000 ha (5 ton/ha) and 160,000 ha (8 ton/ha) has been found respectively (Bezabih et al., 2011). In spite of its remarkable importance, the productivity of potato in the country has been low, and the potential attainable average yields of the potato crop on research and farmers‟ fields are 45 and 25 tons/ha respectively, while the national average production is limited to about 10 tons/ha (Beliyu and Tederose, 2014). According to (Bezabih and Mengistu, 2011), the possible causes flow productivity is: lack of improved seeds, use of sub-optimal management practices, poor storage facilities, and inadequate technology transfer efforts.

Potato production in Ethiopia is not proportional to its population .Recent information shows , Ethiopia has 93 million population and large land size.Almost double that of Texas which can able to accommodate growing 3 million hectares of potatoes (Cornell, 2014)., Ethiopian Institute of Agricultural Research (EIAR) under its different research centers has been introducing different kinds of improved potato varieties. The released potato varieties along with improved package of technologies have been disseminated through Ministry of

Agriculture (MoARD) and its regional and grassroots structures. However, some potato growing farmers do not apply some recommended technology packages. Farmers‟ current practice of technology components (improved potato production package) consists of varieties, seed rate, seed size, methods of planting, spacing, fertilizer rate, chemical spraying, weeding/hoeing and healing frequency, and number of seed in a hole, and seed storage type (Beliyu and Tederose, 2014).

2.1.4. Potato production constraints

Potato production is can be affected by different factors. Such as socio-economic, institutional and psychological factors as well as personal and demographic variables (Degu, 2012).These constraints can be explained in some details as follows:

Disease and pests are the major problems that reduce potato production in our country Late blight [Phytophthora infestans (Mont.) de Bary] is common in all potato growing areas of Ethiopia. It is the most harmful and damaging potato disease worldwide. To the use of home saved seed, use of seed potatoes of unknown origin from local markets, limited use of resistant varieties, poor storage practices like leaving potato underground un-harvested and only limited adoption of haulm killing and selection practices by farmers, the seed tubers used bymost potato producers are of poor quality (Bezabih and Mengistu, 2011). Bacterial Wilt (Pseudomonas solanacearum) is other severe production constraint of potato and other solanaceous crops such as tomato and eggplant, especially in warmer weather occurring at lower altitudes in Ethiopia. Tuber Moth (Phthorimaea operculella Zeller) is also a major pest of potatoes either in fields or storage, potentially a cause of total crop loss in the form of discards or unfitness of tubers for seed.

Farmers also suffer losses of reduced prices for damaged potatoes, or indirectly when they are forced to sell potatoes at low prices to avoid damage (Ktheisen,2009).Farmers usually suffer from problems related to selection of potato varieties. Given the great diversity of Ethiopia, it is not surprising that there are no "standard" varieties grown widely throughout the country. Local varieties are reported to be generally low yielding, susceptible to diseases and pests, and subject to rapid virus degeneration. However, farmers apparently consider many factors

in selecting varieties. In addition to the essential qualities of yield and resistance to disease (especially late blight), varieties are also selected for tuber traits considered positive, especially for commercial sale: relative smoothness of texture, shallow eyes, more attractively shaped, whiter color in preference to red, and cooking quality (Ktheisen, 2009).

Moreover, farmers usually use varieties of unknown origin and improved varieties are not available to the majority of the farmers. Long dormancy period of potato (stored for more than 3 months) and lack of well sprouted good quality seed potato tubers are also among key potato seed problems frequently raised by potato growers (Bezabih and Mengistu, 2011).

Water is the most decisive factor for potato production. According to Ktheisen (2009) the irrigated dry season potato crop can be very important because late blight is less severe during the dry season, and the limited availability of irrigation water results in a seasonal shortage of potatoes and other crops, and correspondingly high prices. Potato cultivation during this season also allows for the possibility of farmers being self-sufficient in production of seed tubers. Rainfall is similarly affected by topography, average annual precipitation generally increasing with altitude. Rains are generally concentrated in the months of June through September, but with considerable spatial and temporal variability. Ethiopian farmers distinguish long rains (meher), which generally occur from June to September and provide the main agricultural season, from short rains (belg), from January to June (Ibid).

There are also problems related to potato harvesting, storage and marketing that negatively affect potato production. According to Ktheisen (2009) determining when to harvest is based on the drying of foliage, the vegetative cycle of the varieties planted, and observations of tubers. Harvesting is usually done manually to avoid damage to tubers. Potatoes for market are harvested all at once while potatoes for home consumption are harvested as needed. Some tubers are inevitably missed and left in the ground where they act as vectors for disease and pests and compete with subsequent crops as weeds. Physical damage during harvesting that includes cuts, bruises and holes, inflicted on tubers during harvesting, storage, packaging and transportation reduces marketable tubers (Bezabih and Mengistu, 2011).Storage of both seed and ware potatoes is problematic for most farmers, as storage losses can reach fifty percent,

sometimes higher (Ktheisen, 2009). Similarly, Potato price fluctuates based on the season of harvest. When supplies become excessive, farmers in more remote locations facing high transport costs might be forced to dump their potatoes. Most of the time prices are set by the traders who increase or decrease the price considering the supply situation (Bezabih and Mengistu, 2011).

Potato production is also affected by the perception of farmers. Farmers examine the advantages from the point view of compatibility to their current situation, with labour demand, profitability, and other social necessities to adopt a technology. Farmers‟ decision for adoption or rejection of technologies depends upon their perceptions of the appropriateness of the characteristics of the technologies under investigation (Adesina and Zinnah, 1993). According to Duvel (1975) perception is a key dimension in behavioral change process. Perception about the relative advantage of different package practices was assumed to have positive effect on adoption of improved agricultural production package. Technologies are viable only when farmers use them. No matter how well the new technologies work on research stations, if farmers do not have them for use, their development would be in vain (Tadesse, 2008).

2.2. The Meaning and the Concepts of Adoption

Adoption as defined by Rogers (1962) is the decision-making process in which an individual passes from first hearing about an innovation to final adoption. Adoption is either at a farm-level (individual) or at an aggregate level. Similarly the word diffusion is defined as dissemination or dispersion of an idea, a practice or a technology. An individual may decide to discontinue the use of an innovation for a variety of personal, institutional, or social reasons, one of which might be the availability of an idea or practice that is better in satisfying needs. Tsibuk (2013) argues that adoption is a process which passes through several mental stages on which an individual passes after first hearing about an innovation to finally deciding to accept or reject it based on its objectives and constraints as well as cost and benefit it is accruing to it. This process generally includes five stages: aware about the new innovation, creating interest on the new innovation, evaluation or weighing the advantage and

shortcomings of the innovation, trial in small scale to see the suitability of the innovation, and adoption and apply it in the large scale for further expansion if it is satisfying the needs of the local condition (Degu, 2012).

Farmers are classified according to their tendency to adopt an innovation as innovators, early adopters, followers, and laggards. It is usually measured by the length of time required for a certain percentage of the members of a social system to adopt an innovation; because farmers need time to think over things before reaching a decision to adopt an innovation–rates of adaption as the relative speed with which members of a social system adapt an innovation. The rates of adoption for innovations are determined by an individual's adopter category (Rogers, 1983 as cited in Tadesse, 2008).. In general, individuals who first adopt an innovation require a shorter adoption period (process) than late adopters. Adoption is also typically a continuous process that involves evaluation of rewards from early adopters, which may trigger bandwagon effect (Almaz, 2008), as such the positive relationship that existed between profit as a result of innovation and adoption are the motivating factors for innovation spread. The adoption pattern to a technological change in agriculture is a complex process. A large number of personal, situational and social characteristics of farmers have been found to be related to their adoption behaviour.

According to Ray (2001), adopters have a high rate of literacy and higher level of formal education, operate large sized holdings, own the land they operate, have a relatively high income and economic status, are commercial in farming operation, have relatively high level of extension contact, and belong to upper socio-economic status categories. On the other hand, non-adopters have a low rate of literacy and level of formal education, operate smallholdings, are mostly small and marginal farmers, belong to low income group, have a low level of socio-economic status categories. Dissemination of agricultural innovations to users is one of the priority areas that deserve attention in agricultural and rural development (Atakilti, 2008). The issue of agricultural technology adoption by small-scale farmers is one of the development topics in low income countries. This is due to its contribution to increase in agricultural yields that improves farmers‟ income and ensures food security. A widely accepted objective for agricultural development in Africa is to achieve sustainable

intensification with the adoption of new technologies that use purchased inputs (such as improved seeds and inorganic fertilizers) to increase land and labor productivity (Getachew, 2012).In this regard, Mulugeta (1995) and Tadesse (2008) suggest that yield could be increased through more intensive application of new technologies that include the use of improved inputs and methods. Tsibuk (2013) also indicated that the opportunity to increase production through area expansion is very limited particularly in Ethiopian highlands and sustainable increase in productivity cannot be attained unless these innovations are accompanied by complementary institutional arrangements like access to credit, extension services and marketing facilities.

Regarding to Adoption, a lot of local studies have been carried out by researchers (such as Yishak, 2005; Atakilti, 2008; Tadesse, 2008; Beliyu and Tederose, 2014) on vegetable crops. However, the results vary from area to area depend on variations in agro- climate, information and resources owned by different groups of farmers (Jemal, 2006).

Following the introduction of the potato to Ethiopia in 1858 by a German immigrant, Wilhelm Schimper, adoption of potato crop by Ethiopian farmers occurred very gradually for several decades until wider adoption of the potato occurred at the end of the-19th century in response to a prolonged famine (Ktheisen, 2009). To promote potato culture in the country, the potato research program was launched in 1975 at the then Alemaya University of Agriculture jointly by the University, the Institute of Agricultural Research (IAR) and the International Potato Center (CIP) and released a number of promising cultivars which has been dispatched to different parts of the country. But due to the absence of schematic potato production program shortage of planting material has made many potato growers not to make use of the improved materials developed at Alemaya research station (HU annual research report, 1988). Currently, in Ethiopian, a very significant progress has been made in the rapid production, promotion and diffusion of improved potato varieties that has been released from different governmental and non-governmental research stations. The target was to accelerate production and diffusions of improved varieties especially new ones that had not reached farmers because of lack of seeds. On farm promotion and diffusion activities are closely supported by researchers and technicians of the potato growers (International potato Center,

2005).Ethiopia have done different adoption studies in collaboration with other African countries in order to improve the productivity of potato crop and accelerate its adoption. For instance, the process of production of improved

potato varieties that was initiated in 2004 in Kenya, Uganda and Ethiopia has led to the remarkable improvement in the production and productivity of the crop (International potato Center, 2005).Similarly, Participatory research on potato-related innovation systems conducted in Bolivia, Ethiopia, Peru and Uganda identified the factors that influence potato innovation systems from the point of view of farmers, field practitioners and institutions (Ortizi et al., 2007).

2.3. Empirical Studies of Adoption.

Several studies have indicated that the level and determinants of adoption of improved varieties are affected by many factors such as farm size, age, family size, education, availability of credit, access to information, etc. Different people and institutions both outside and inside Ethiopia have conducted a number of empirical studies on the adoption and diffusion of agricultural innovations. But the studies are mainly concerned with major cereals and due to this reason studies conducted in the area of horticultural crops is very limited. For ease of clarity the variables so far identified as having relationship with adoption are categorized as household personal variables, economic factors, social and institutional factors.

2.3.1. Household’s personal and demographic variables.

Household’s personal and demographic variables are among the most common household characteristics, which are mostly associated with farmers' adoption behavior. Under this category, variables such as sex, age, education of household head, education of family members, family size and farmers‟ perception were considered to be the major ones. Being Male or Female has its own effect on adoption of improved agricultural technologies. Due to long lasted cultural and social grounds in many societies of developing countries, women have less access to household resources and also have less access to institutional service.

Regarding the relationship of household's sex with adoption of agricultural technologies, Degu (2012) reported that household's sex has positive effect on adoption in favor of males. For example, on his study entitled "determinants of fertilizer adoption in Ethiopia" Techane (2002) found that male headed households are more likely to adopt fertilizer than female headed households. Similarly, Mulugeta et al. (2001) reported that gender differentials among the farm households positively influenced adoption and intensity of adoption of fertilizer use at 5% significance level. They also further mentioned that being a male headed household increases probability of adoption by 5.9%.

Regarding to the influence of age on adoption, studies show different result. The study conducted by Rahmeto (2007) on determinants of adoption of improved haricot bean production package in Alaba special district indicated that farmers' age did not significantly affect improved technology adoption. However ,the result of Million and Belay (2004) show that age has negative influence on the adoption of fertilizers. On the other hand, Shivani et al. (2000) reported that, the more the experience of growing chickpea, the higher the adoption of new varieties. Such a pattern is expected because more experienced farmers may have better skills and access to information about improved technologies.

Researchers also carried out a research to see the effect of Education on adaption. Accordingly, Degu (2012), Habtemariam (2004), Million and Belay (2004), Itana(1985), Kansana et al.(1996), and Nkonya et al. (1997) found that farmers' education–has a significantly positive effect on adoption. Each additional year whenever the level of education increases, the probability of adoption of improved technology increases the ability to interpret and use new agricultural information. But Legesse (1992) and Degnet (1999) stated that though education plays a significant role in the adoption decision, this variable was not found to be significant in affecting the decision to adopt improved technology.

Family size is one of the other important household demographic variables which have influence on farmers‟ adoption behavior. Large family size usually implies availability of labor provided that majority or all of the family members are within the age range of active labor force (15-64 years). Availability of labor in the household is again one of the important

resources required in vegetable production. In most studies family size had positive relationship with adoption of improved agricultural technologies. For instance, Kidane (2001) on the study he conducted on factors influencing adoption of new wheat and maize varieties in Tigray reported positive and significant relationship of family size with adoption. Similarly, Haji (2003) reported positive effect of family size on adoption of cross-breed dairy cows. Others, for instance, Asante-Mensah and Seepersad (1992); Degnet et al (2001) have also reported similar results.

On the contrary, Million and Belay (2004) reported that family size negatively affected adoption of physical soil conservation measures. Adoption of technologies by farmers may reflect rational decision making based up on farmers‟ perceptions of the appropriateness (inappropriateness) of the characteristics of the technology under investigation (Adesina and Zinnah, 1993). Different studies have been conducted in South Africa to see the effect of perception on adoption behavior. For example, studies conducted by Duvel (1975) confirmed the positive and significant relationship between adoption behavior and perception of technology attributes. In addition, studies conducted in Ethiopia by Enderias (2003) and Taha (2007) showed that farmers‟ perception of technology attributes have positive and significant influence of adoption of technologies of their respective studies. Similarly, Abrhaley (2006) found that farmers‟ perception of technology attributes influence positively and significantly the adoption and extent of use of ISM technologies.

2.3.2. Economic variables

Economic variables influence household's adoption decision of agricultural technologies. In this study, economic related variables such as farm size, off- farm activities and livestock ownership are assumed to play a great role in determining the willingness and ability to invest in adoption of agricultural technologies. Farm related variables influence farmers‟ adoption behavior, as farm land holding is an important unit where agricultural activities take place.

Concerning farm size, the findings of Degu (2012), Huque et al. (1996), Nkonya et al. (1997), Bekele et al. (1998) and Yishak (2005) reported that farm size exerts a positive influence

on adoption of improved technologies. Contrary to this study, Rahimeto (2007) and Taha (2007) reported that land holding was not significant in adoption of improved haricot bean and onion technology package respectively. As described by Sodjinou et al. (2015), smallholder farmers are more likely to adopt organic farming because they can easily mobilize the necessary organic inputs (particularly organic manure) and labor force for their small size of operation, while the bigger the farm size the more difficult it is to appropriately handle organic farming. Off-farm and non-farm activities are the other important activities through which rural households get additional income. The income obtained from such activities helps farmers to purchase farm inputs.

Review of some of the past empirical studies shows that the findings regarding the influence of off-farm/ non-farm income on adoption vary from one study to the other. However, the majority of the studies reported positive contribution of off-farm and non-farm income to household's adoption of improved agricultural technologies. For instance, technology adoption studies conducted by Kidane (2001), Birhanu (2002); Mulugeta et al. (2001) and Mesfin (2005) indicated positive relationship between off-farm income and adoption. Contrary to this, Techane (2002) in his study on determinants of fertilizer adoption in Ethiopia reported the negative influence of participation in off-farm income on farmers‟ adoption of chemical fertilizer. The reason is that farmers who involved on off/non-farm business pay less attention to their crop production and tend to focus more on their off/non-farm operations and they do not have time to find newly introduced agricultural technologies. In rural context, livestock holding is an important indicator of household's wealth position. Livestock are also an important income source which enables farmers to invest on adoption of improved agricultural technologies.

In most cases, livestock holding has positive contribution to household's adoption of agricultural technologies. This is evident from many of the past adoption studies which have reported positive effect of livestock holding on adoption. To mention some of them, for instance, Kidane (2001); Birhanu (2002); Techane (2002); Endrias (2003); Degnet et al. (2001) and Chilot (1994) have found that livestock holding has positive influence on adoption of improved agricultural technologies. Water is the most decisive factor for potato production.

The study done by Chanyalew (2009) on capacity of public extension to facilitate the commercialization of small-scale vegetable production system in Kombolcha district reveals that access to irrigation and households‟ irrigated land had positive and significant influence in extent of participating in potato production and marketing. According to Ktheisen (2009) the irrigated dry season potato crop can be very important because late blight is less severe during the dry season, and the limited availability of irrigation water results in a seasonal shortage of potatoes and other crops, and correspondingly high prices. Potato cultivation during this season using irrigation also allows for the possibility of farmers being self-sufficient in production of seed tubers.

2.3.3. Institutional variables

Institutional factors are one category of the variables which are mostly associated with farmers' adoption behavior. From this category attendance in extension events, access to credit service, market information and frequency of listening to agricultural programs are positively related to the adoption decision of farmers. The study done by Beliyu and Tederose (2014) on Knowledge gaps in adoption of potato technology in central highlands of Ethiopia underlined the high importance of institutional support in improving seed rate, DLS (Defused Light Store) construction, spacing, fertilizer rate and chemical application. Likewise, the study conducted by Jabbar and Alam ,1993; Chilot et al.,1996; Huque et al., 1996; Nkonya et al., 1997; Degnet,1999; Tesfaye et al., 2001; Habtemariam (2004) and Kansana et al.(1996) reported that the availability of reliable information sources will enhance communication process and had significant associations with adoption of improved technologies. Sources of information such as mass media and neighbor farmers in the particular rural area are also important in diffusion of agricultural innovations. Particularly, interpersonal communication networks among farmers are important and reported in many studies to have significant influence on farmers‟ adoption decision.

Mass media also play the greatest role in provision of information in shortest possible time over large area of coverage. Many studies reported the positive and significant relationship of mass media with adoption of agricultural technologies. In line with this, Yishak (2005) in his

study on determinants of adoption of improved maize technology in Damote-Gale woreda, Wolaita, Ethiopia indicated that ownership of radio and participation in demonstration had positive influence on adoption of improved maize technologies. Credit service (credit utilization) is also the other institutional variables that farmers need to get to improve production and productivity is. Initial working capital is key factor that limit the adoption of high value crops by small scale farmers because these crops generally are much more costly to produce than the traditional crops and most growers require credit to finance their production. In line with this, the study conducted by Legesse (1992), Chilot et al.(1996), Kansana et al. (1996) and Tesfaye et al. (2001) reported that access to credit had a significant and positive influence on the adoption of improved technologies. Unlikely, Jabbar and Alam (1993) found that access to credit was not significant in their study of adoption of rice technology. Similarly, Sodjinou et al. (2015) revealed that access to credit will negatively influence the adoption of organic cotton. Other institutional factor is attendance in extension events like involvement in training and participation on field days. They are also crucial in improving farmers‟ experience, building capacity and developing confidence on the advantages of improved agricultural technologies. Tesfaye and Alemu (2001) and Tadesse (2008) reported that participation in demonstration and attendance of training contributed positively to farmers‟ adoption decision. In the same line, Yishak (2005) in his study of determinants of adoption of improved maize technology in Damote Gale woreda found that farmers‟ participation in demonstration and field days had positive and significant relationship with adoption. Many of the studies which have considered distance to the nearest market reported their significant relationship with adoption behavior. To mention some, the results of research by Largesse et al. (2001) showed that distance to market, which is determining the adoption and intensity of use of technologies and found to be negative with significant effects. In addition Ebrahim (2006) on his study on the adoption of dairy innovations in Adami Tulu found negative and significant relationship between adoption and distance to market. The results of many other researchers who reported that market distance as negatively and significantly associated with the adoption of crop technologies, namely, Mesfin (2005) and Yishak (2005).

2.3.4 Psychological Characteristics

Many of the studies which have considered psychological variables reported their significant relationship with adoption behavior. To mention some, a study conducted in Sera-Leone by Adesina and Zinnah (1993) showed that farmers' perception of specific characteristics of technology significantly condition adoption decision. Adesina and Zinnah also further indicated that the omission of such variables in adoption model might bias the result of factors determining adoption decision of farmers by ignoring their possible and important influence on adoption behavior.

Some other studies also conducted in South Africa to see the effect of perception on adoption behavior .For example, researchers such as Botha (1986) and Duel and Botha (1999) studies conducted a research and as a result they confirm the positives and significant relationship of perception with adoption behavior. In line with this, the study on the effect of knowledge on adoption behavior carried out by Botha (1986) indicated that farmers' technical know-how of the innovation is important in adoption. Likewise, a study conducted by Abd-Ella et al., 1981 on adoption behavior in family farm system in Iowa indicated that the knowledge about the recommended farming practice is positively related with adoption. Moreover in his analysis on smallholder wheat production and technology adoption in south eastern highlands of Ethiopia, Mulugeta (1994), also found out that farmers' knowledge of recommended fertilizer application rates was critical variable influencing the decision to use higher rates fertilizer per hectare. Study by Degent (1999) also reported that adopter were found to have better knowledge on fertilizer application than non- adopter did.

As far as risk perception associated with crop production is concerned, a limited research has been made so far. According to Belayneh (2001), multiple perception of cause of risk on crop and livestock production was identified. In this study, the prime purpose is to identify weather risk perception associated with wheat production affect adoption decision or not. Accordingly, these risks were perceived to come from unreliability of rainfall in terms amount and distribution, water lodging, pest and disease incidence and others. Schultz (1995) suggested

many testable hypotheses: that the probability of adoption of a new technology will depend on the ability of farmers to perceive the advantage and efficiency utilize the new technology.

2.4. Conceptual Framework

Adoption of new innovation is the outcome of behavioral change processes which interim involves decision making (Koch, 19860. In addition, Rogers (1962) indicted that adoption is a mental process of deciding on whether to adopt a given technology or not the literature reviewed in the previous section al so proved that adoption is not an instantaneous act, rather it is a processes. It involves a serious decision-making stage involving a cognitive engagement in the processes.

The analytical frame work of this study was developed based on assumptions and theoretical models of adoption and diffusion discussed earlier. As clearly illustrated in figure 1 below, different factors supposed to affect adoption behavior of farmers particularly those which contribute to the variation to adoption in the adoption and the intensity of adoption of improved potato production package among respondent were taken in to consideration. The conceptual framework highlighting the relationship of explanatory variable with dependent variable will be summarized in the following figure.

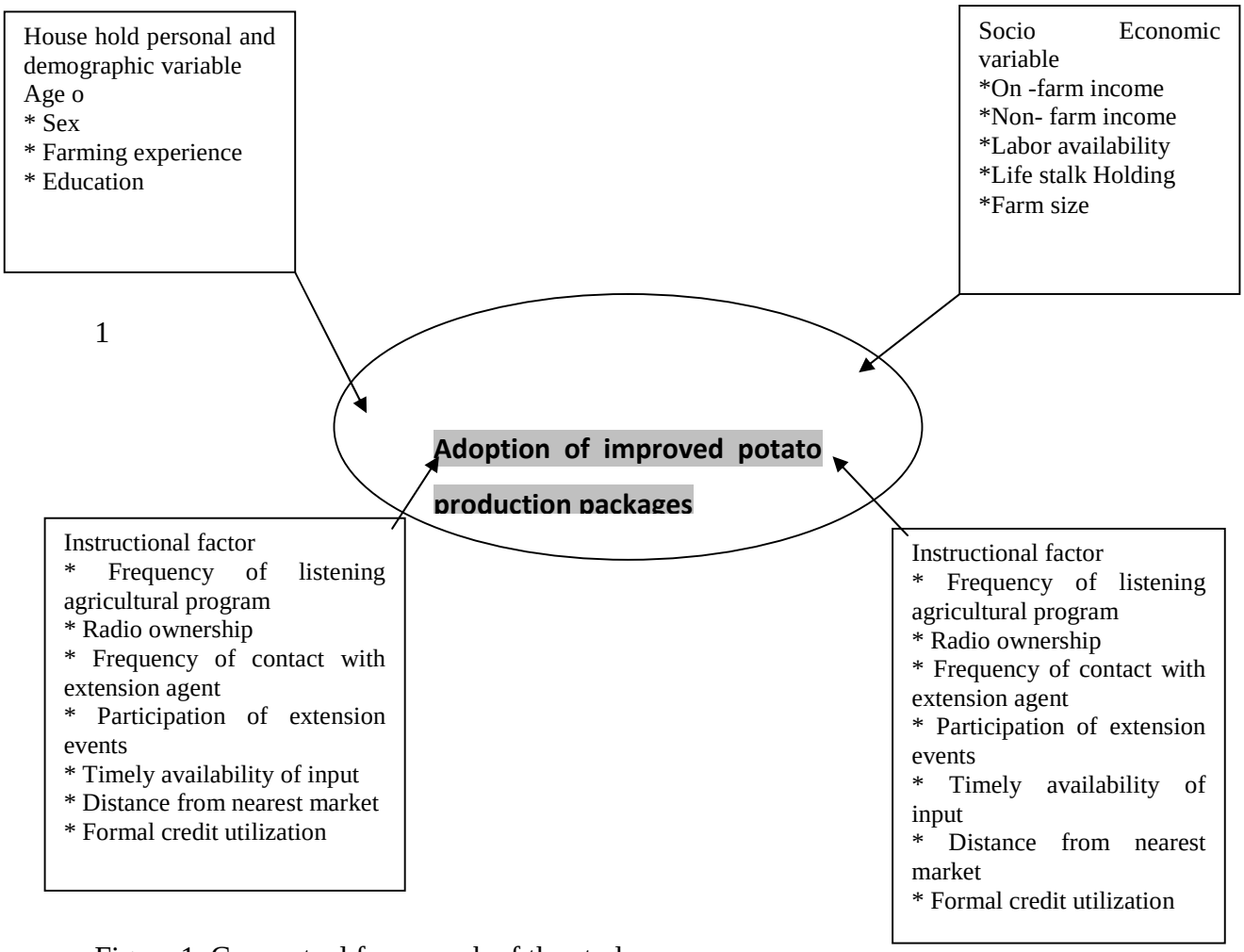

Figure 1. Conceptual framework of the study

3. RESEARCH METHOLOGY

3.1. Background of the Study Area

Haramaya district is one of the 18 districts in East Hararghe Zone. The capital town of the district is known as Haramaya which is 520 kms from the Capital 19 kms south of Harar,-and 32 kms away west of Dire Dawa Administrative Council. The district is geographically situated between 42°3'E longitude and 9°26'N latitude with its altitude ranging from 1,400 to 2,340 meters above sea level (masl). It is bordered by Kurfa Chale in the south, by Kersa to the west, to the north by Dire Dawa, to the east by Kombolcha, and by the Harari National Region State to the southeast (Nigussie *et al.*, 2014).

The district is part of the Ethiopian highland system, and lies in the semi-arid tropical belt of eastern Ethiopia. It is, therefore, representative of a sub-humid mid-altitude agro-climatic zone. Rainfall is bimodal, and the mean annual rainfall received ranges from 600 to 1,260 mm. The short season (*Badheessa*), rain usually starts in March and ends in May, and the long season (*Ganna*) rainfall occurs between June and September. Relative humidity varies between 60 and 80%.Minimum and maximum annual temperatures range from 6°C to 12°C and 17°C to 25°C, respectively (Nigussie *et al*., 2014).

The district comprises 33 rural and three urban kebeles (HARDO, 2015). It has an area of 52,163 hectares, out of which 38,407 hectares is used for farming/cultivation/, 825 hectare is covered by forests and bushes, and 324 hectares is used for grazing. Based on the altitude above sea level the district is categorized into two agro- ecological zones, *woinadega* 59.3 % and *kola* 40.7 % (Haramaya District report, 2008/09). The district has an estimated total population of 236,601(Nigussie *et al.*, 2014).

The topography of the district varies from flat land, gentle undulations, plateaus, to hills. Most of the land is observed suitable for agriculture. Agriculture is the main stay of the districts economy and nearly 90% of the population directly or indirectly depend its livelihoods up on this sector. Mixed farming system is considered as the most common practice across all agro-ecological zones, which cash crops (chat and vegetable crops), food crops (sorghum, maize,

pulses and other cereals), and livestock production are the main source of livelihoods. Land holding size is small and fragmented and, hence, the average land holding size is found to be less than half a hectare. Among vegetable crops, potato is the most cultivated and has covered a larger area in this district. Out of 33 rural *kebeles* potato is grown in 17 *kebeles* and it covers a total area of 1532 hectares. In the district, 7591 households were involved in the production of potato in 2014/015 production season. In the study area, potato is cultivated twice a year. The first round starts in September and ends in January where vegetables and root crops are produced using irrigation, whereas the second round starts in February and ends in June where horticultural production is practiced using irrigation and rainfall (HARDO, 2015).

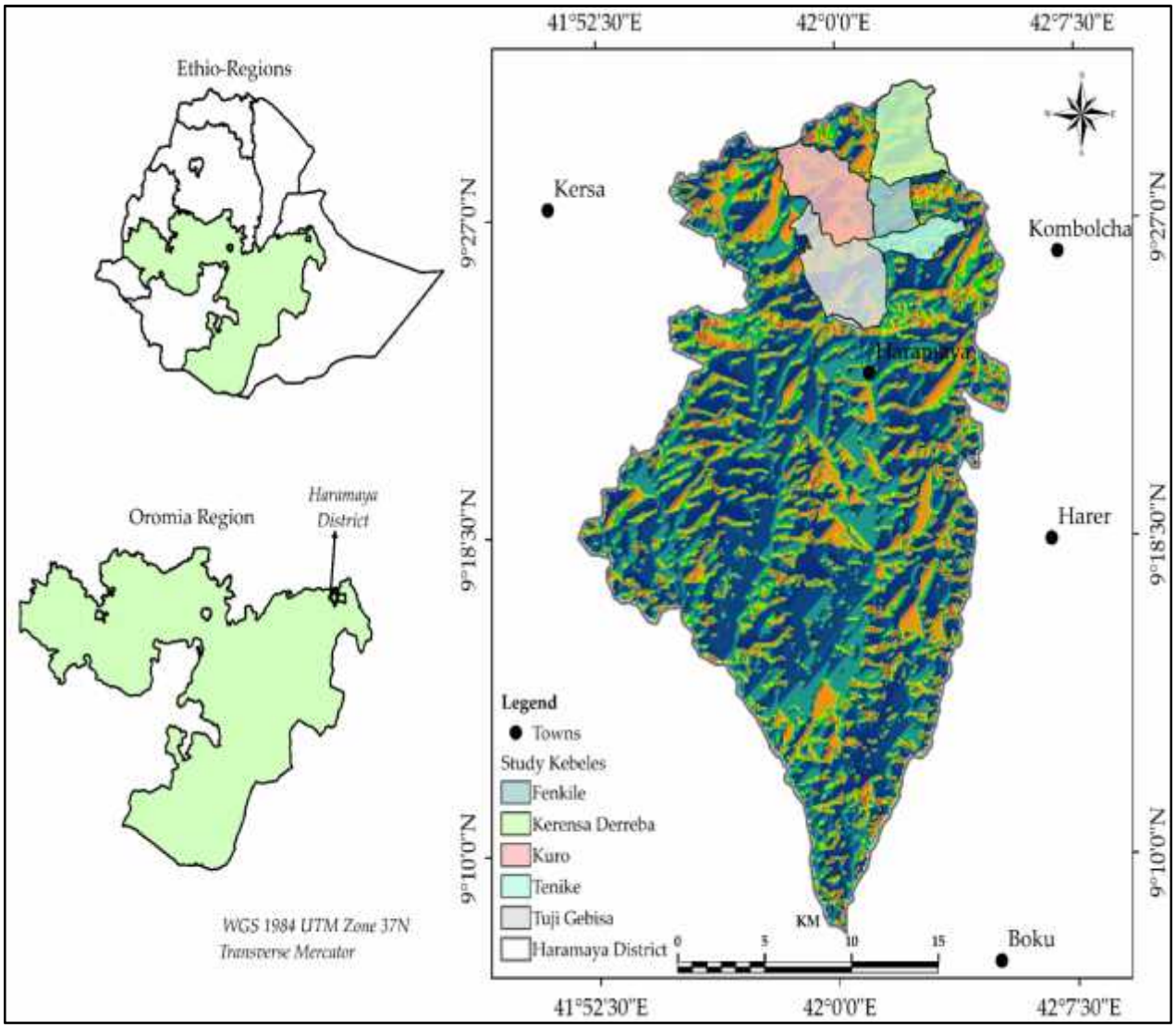

Figure 2. Map of Haramaya District

3.2. Sampling Procedure

A multi-stage sampling procedure was employed to select *kebeles* and the required number of sample households. First, Haramaya district was purposively selected because the area is among the potential potato growing areas in East Hararghe zone as well as in the region. Secondly, out of 17 potato producing *kebeles,* five *kebele*s were purposively selected with the consultation of Haramaya district Agriculture Office based on the maximum area coverage under potato crop

As the evidence obtained from the district Agricultural Development Office shows, almost all potato growing *kebeles* in the district are relatively homogenous in terms of agro ecology, access to resources, history of extension and others. Thus, all potato growers in the selected *kebeles* formed the sampling frame for this study. From this fresh list of the sampling frame, 122 potato growers were randomly selected as sample of the study using probability proportional to size sampling techniques from four *kebeles* as presented in Table1.

All potato farmers were listed and used as sample frame unit in each kebele, that is Ni.
Lastly, a total of 122 sample farmers were selected randomly based on pps.

$$n = \frac{N \times n}{N}$$

n= total sample size, N=TOTAL HHH in 5 kebeles,

Ni=each kebeles HHH frame unit

Table 1: Proportion of sample respondents from each kebele

Name		Total potato grower HH size of the kebeles	sample respondent
Tuji Gabsa	1574	867	28
Kurro	1239	350	12
Tinkee	1063	860	28
Finkle	1667	1201	40
Qesensa Deraba	1324	435	14
Total	6867	3713	122

Source: Haramaya distinct.

Sampling procedure chart

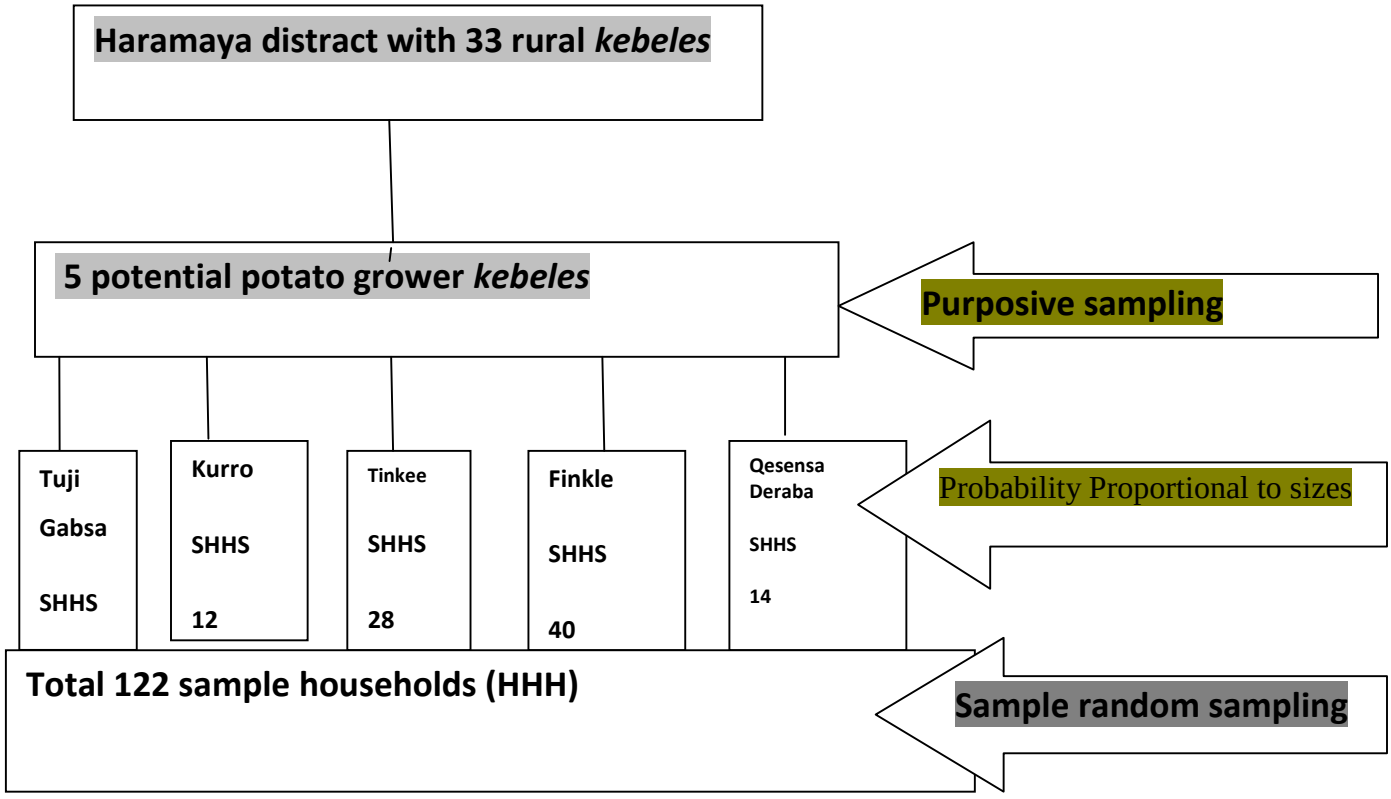

Figure 3 Sample size selection procedures

3.3. Data Types, Source and Methods of Data Collection

Both primary and secondary data were used for this study. Primary data related to personal, socioeconomic, institutional variables, farm characteristics, farmers' perceptions of potato production package attributes and other relevant variables were collected. Secondary information from published and unpublished documents and reports from relevant organizations were gathered. Primary data were collected through individual interviews and group discussions. Secondary data were collected through reviewing published and unpublished documents and discussions with agricultural experts and researchers. The questionnaire was pre-tested before actual data collection and amendments were made on some of the questions to make them fit to the context. Five experienced enumerators were recruited. They were briefed on the objectives of the study and contents of the questionnaire. The researcher with the five enumerators conducted the interview in September, 2016.

3.4. Data Analysis

The data was analyzed using software SPSS version 20 and STATA software appropriate techniques and procedures were used in the analysis to identify the influence of personal, socio- economic, institutional and psychological variables on the adoption decision process of the technology. Descriptive statistics were used to provide a summary statistics related to variables of interest. Chi-square and F- test were used to identify variables that vary significantly across adopter categories and to test the hypothesis. Cramer's V, Gamma and Pearson correlation were used to see the strength and direction of association between dependent and independent variables. Post hoc multiple comparisons were also run to see if there is statistically significant difference among the mean of the respective adopter categories with respect to continuous variables. The Tobit model was employed to see the effects of explanatory variables on the probability of adoption and intensity of use of potato production package.

3.5. Analytical Technique

The quantitative data analysis and presentation involves the use of descriptive statistics such as frequency distribution, measures of central tendency, Chi-square test and F-test. Tables and charts were also used to illustrate and facilitate the analysis. This helps to assess and analyze farmers' adoption and intensity of adoption behavior of improved potato production packages. Cramer's V and Pearson correlation were used to see the strength and direction of association between variables. Moreover, Tobit model were used to determine the relative influence of various explanatory variables on the dependent variable.

Adoption is a decision to make full use of an innovation at best appropriate course of action available (Rogers, 1983:176). For multiple practices (package), there are two options of measuring adoption; Adoption index: Measures the extent of adoption at the time of the survey. It is used in the case of adoption study of multiple practices to measure adoption and intensity of adoption of improved potato production package at the time of the survey. Adoption quotient: measures the degree or extent of use with reference to the optimum possible without taking time into consideration.

In this study, the first option was employ accordingly, adoption index which shows to what extent the respondent farmer has adopted the whole set of package will be calculated using the following formula. In order to know the intensity of adoption of improved potato production package, adoption index of individual farmer was calculated as follows:

$$A = \frac{\sum_{n=1}^{n}\left[\frac{A}{A} + \frac{S}{S} + \frac{F}{F}\right]}{N}$$

Where,

i	1, 2, 3……n, and n = total number of respondent farmers
NP	Number of practices
AIi	Adoption index of the i^{th} farmer
AVi	Area under improved variety of potato of the i^{th} farmer

ATi Total potato production Area (improved variety + local, if any) of the i^{th} farmer

SRAi Seeding Rate Applied per unit area of improved potato of i^{th} farmer,

SRR Seeding Rate Recommended per unit area,

FRAi Fertilizer Rate Applied per unit area in improved potato variety production of the i^{th} farmer

FRR Fertilizer Rate Recommended.

On the basis of adoption index score, adopter farmers were classified as low, medium, and high adopter. Adoption index is thus a continuous dependent variable which is affected by different factors to be investigated.

Tobit model was used to identify factors affecting farmers' adoption and intensity of adoption of improved potato production package.

The Tobit Model

Tobit model is an extension of probit model and it is one of the approaches dealing with the problem of censored data (Johnston and Dandiro, 1997). Some authors call such model limited dependent variable model, because of the restrictions put on the values taken by the regressed (Gujarati, 1995). Tobit model is superior over the other dichotomous regression models in that the later only attempts to explain the probability of adoption of agricultural technologies by the farm households rather than the extent of adoption. However, adoption of improved technology alone is not sufficient enough since improvement in production and productivity of farm households depends not only on adoption but also on the intensity of use of the technology. Strictly dichotomous variable often is not sufficient for examining intensity of adoption (Feder et al, 1985). In such cases, Tobit model, which has both discrete and continuous part, is appropriate as it handles both the probability and intensity of adoption at the same time.

Many researchers have used Tobit model to identify factors affecting adoption and intensity of adoption of improved agricultural technologies. To mention some, for

instance, Nkonya et al. (1997) used Tobit model to identify factors affecting adoption of improved maize seed and fertilizer in Northern Tanzania. He used area planted with improved seed and area receiving fertilizer as continuous dependent variables for running Tobit model.

From adoption studies conducted in Ethiopia, Legesse (1992) and Chilot (1994) used Probit and Tobit model to identify factors affecting adoption of improved varieties, fertilizer and herbicide. Both of them used Probit model to identify factors affecting adoption of improved variety and Tobit model to identify factors affecting intensity of fertilizer and herbicide use. On the other hand, Techane (2002) used Tobit model to identify determinants of adoption and intensity of use of fertilizer in Ethiopia. In the same line, Endrias (2003) and Getahun (2004) used Tobit model to assess factors affecting adoption and intensity of adoption of sweet potato varieties and wheat technologies respectively.

Model Specification The econometric model applied for analyzing factors influencing adoption and intensity of adoption of improved potato production package will be the Tobit model shown in equation (1). This model will chosen because; it has an advantage over other adoption models (LPM, Logistic, and Probit) in that it reveals both the probability of adoption and intensity of use of improved potato production package. Following Maddala (1992), Amemiya (1985) and Johnston and Dandiro (1997), the Tobit model for the continuous variable adoption index, can be defined as:

AIi = B0 + BiXi + Ui

AIi = AIi if B0 + BiXi +Ui>0..... (1)=0 if B0 BiXi +Ui ≤0

Where:

AIi = is adoption index for i^{th} farmer

AIi = is the latent variable and the solution to utility maximization problem of intensity of adoption subjected to a set of constraints per household and conditional on being above certain limit,

Xi= Vector of factors affecting adoption and intensity of adoption, Bi= Vector of unknown parameters, and

Ui= is the error term which is normally distributed with mean 0 and variance ∂^2.

The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, 1997 and Amemiya, 1985).

$$L=\prod_{\delta}^{1} f\left[\frac{A \quad -A}{\delta}\right] \prod F\left[\frac{-\beta i \times i}{\partial}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (Z)$$

Where:-

f is the density function

F is cumulative distribution function of

$\prod$ is the product over those i for which AI≤ *0, and

$\prod$ is the product over those i for which AI >0.

Limdep (NLOGIT) software was employed to run the Tobit model. It may not be sensible to interpret the coefficients of a bit in the same way as one interprets coefficients in an uncensored linear model (Johnston and Dinardo, 1997). Hence, one has to compute the derivatives of the estimated To bit model to predict the effects of changes in the explanatory variables.Maddala (1997, citing Johnston & Dinardo 1997; Nkonya et al. (1997, and McDonald & Moffit , 1980) proposed the following techniques to decompose the effects of explanatory variables into adoption and intensity effects.

Thus; change in Xi (Explanatory variables) has two effects. It affects the conditional mean of AIi in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. Similarly, in this study, the marginal effect of explanatory variables was estimated as follows. The marginal effect of an explanatory variable on the expected value of the dependent variable is

$$\frac{\partial (A)}{\partial} = F(z)\frac{\beta}{\partial} \text{----------} (3)$$

Where, $\frac{\beta}{\partial}$ is denoted by z, following Maddala, (1997)

The Change in the probability of adopting a technology as independent variable

$$\frac{\partial (z)}{\partial} = f(z)\frac{\beta}{\delta} \qquad \text{----------} (4)$$

3. The change in the intensity of adoption with respect to a change in an explanatory Variable among adopters is:

$$\frac{\partial (A \quad >0)}{\partial} = \beta \left[1 - z\frac{f(z)}{F(Z)} - \left(\frac{f(z)}{F(z)}\right)^{2}\right]$$

Where ,F (z) is the cumulative normal distribution of Z,

f(z) is the value of the derivative of the normal curve at a given point,

Z is the z-score for the area under normal curve,

β is a vector of To bit maximum likelihood estimates and

∂ is the standard error of the error term.

Before running the Tobit model all the hypothesized explanatory variables were checked for the existence of multi-co linearity problem. There are two measures that are often suggested to test the existence of multi-co linearity. These are: Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for dummy variables. In this study, both measures were used to test multi-co linearity problem.

According to Maddala (1992), VIF can be defined as: VIF (X_i)=$\frac{1}{1-R_i^2}$, R_i^2 Where is the squared multiple correlation coefficient between Xi and the other explanatory variables. The larger the value of VIF, the more would be the problem. As a rule of thumb, if the VIF of a variable exceeds 10 (this will happen if R_i^2 that variable is said to be highly collinear (Gujarati, 1995).exceeds 0.95), Similarly, contingency coefficients were computed for dummy variables using the following formula:

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

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

3.6. Definition of Variables and Working Hypothesis

3.5.1. Dependent Variable

The dependent variable in this study is adoption index (AI) which indicates intensity of adoption of improved potato package. Adoption index in this case is a continuous dependent variable. Intensity of adoption refers to adoption index indicating farmers' level of use of multiple practices from the recommended improved potato production package.

the Tobit model for the continuous variable adoption index, can be defined as:

AIi= B0 + BiXi + Ui

AIi=AIi if B0 + BiXi +Ui>0..... (1) =0 if B0 BiXi +Ui ≤0 Where:

AIi = is adoption index for i^{th} farmer

AIi = is the latent variable and the solution to utility maximization problem of intensity of adoption subjected to a set of constraints per household and conditional on being above certain limit,

Xi = Vector of factors affecting adoption and intensity of adoption, Bi= Vector of unknown parameters, and

Ui = is the error term which is normally distributed with mean 0 and variance ∂^2.

The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, 1997 and Amemiya, 1985).

$$L = \prod \frac{1}{\delta} f\left[\frac{A - A}{\delta}\right] \prod F\left[\frac{-\beta i \times i}{\partial}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:-

f is the density function

F is cumulative distribution function of

$\prod$ is the product over those i for which AI≤ *0, and

$\prod$ is the product over those i for which AI >0.

3.5.2. Independent Variables and Hypnotized relationship

The independent variables of adoption study are those which are expected to have influence on the dependent variable. Adoption literatures provide a long list of factors that may influence the adoption of agricultural technologies. Based on Feder et.al, (1985) that extensively reviewed factors affecting adoption of agricultural technologies in low income countries, and on the brief literature review in this study, the combined effect of variables mentioned below are hypothesized to influence farmers' decision to use improved potato production package and use intensity of the same.

Age: - It is a continuous variable measured in number of years from birth. The influence of farmers' age on the decision to adopt an innovation or technology is not clear. Because, some authors found that older farmers are more likely to adopt an innovation, while others found that young people are open to adopt new technologies (Sodjinou et al, 2015). Thus, in this study, it is assumed that adoption of improved potato technology is affected positively or negatively with the increase in age of farmers**.**

Sex: **-** is nominal variable used as dummy (1 if male, 0 female). Gender difference is found to be one of the factors influencing adoption of new technologies. Due to many socio-cultural values and norms, male have freedom of mobility and participation in different extension programs and consequently have greater access to information. Therefore, it is hypothesized that male farmers are more likely to adopt potato production package, (Taha 2007) and (Mesfin 2005**).**

Education (EDUHHH): formal education of household head in the family (a continuous variable and measured in terms of number of grades attended in school) will increase the farmer's ability to obtain process and use information relevant to the adoption of improved technologies (Berhanu, 2002; Almaz, 2008). Household head's educational level is thus expected to influence the adoption of improved potato technology positively**.**

Farming experience (EXRCFARM): measured in number of years since a respondent started farming on his own. Experience of the farmer is likely to have a range of influences on adoption. Experience will improve the farmer's skill in production operations. Higher skill increases the opportunity of not undertaking the traditional enterprise. Farmers with higher experience appear to have often full information and better knowledge and are able to evaluate the advantage of the technology, (Chilot 1994).In this study, a positive relationship between experience in farming and the probability of adoption and intensity of use of improved potato production package was hypothesized. Farming experience among farmers was measured in years of farming.

Labor availability (MANEQUI): those farmers who have access to labor are expected to adopt innovation more than those who lack labor accessibility since improved technologies required more labor. The variable has been treated as continuous variable measured by man equivalent of the family labor. As labor accessibility increases, adoption is also expected to increase and correlate positively, (Yishak 2005).

Non- farm income (NONFARINC): Additional income earned from agricultural activities outside the farm and from activities that are not related to agriculture improves the farmers' financial capacity and increases the probability of investing on new technologies (Paulos, 2012). It is therefore, expected to affect adoption positively. It is treated as a dummy variable which takes the value 1 if a household head participated in off/non-farm income generating activities; and 0 otherwise.

Size of land owned (FARMSIZE): Landholding size: - This variable is a continuous variable and it refers to the size of farm land possessed by the farm household, measured by hectares. Large farm size is usually hypothesized to affect positively the area allocated to any technology applied. This is because of the fact that household with large farm size is expected to have better asset accumulation and risk taker than those who have not (Greek, 2011). Therefore, it is hypothesized that this variable would have positive influence on farmers' adoption of improved potato technology.

LIVE STOCK OWNED (TLU): Households that have more large number of livestock are likely to adopt more innovations than others who have less number of livestock because the farmers with more number of livestock have better opportunity to get credit. In this study it was assumed that livestock ownership and adoption would be related positively. As livestock ownership increases adoption/intensity of adoption is expected to increase and correlate positively (Birhanu 2002) and (Endrias 2003).

Radio exposure (RADIOWN): Radio plays an important role in the adoption of agricultural technology. Access here is defined as an ownership of any radio. A person who has an access to Radio will be given a value of 1 and similarly the one who has no access to radio will be

given a value of 0. Access to Radio is expected to have positive .Influence on the adoption and intensity of adoption of improved potato variety by the farmers, (Kidane 2001).

Radio ownership is not an end by itself unless farmer's ability to receive broadcast of agricultural program is accounted. In this study, frequency of listening to agricultural program is measured by giving values as 1, if the respondent rarely listens to agricultural programs. It takes the value 2 and 3 if the respondent listens' agricultural programs sometimes and frequently respectively. Therefore, it was hypothesized to have positive influence on adoption and intensity of adoption of improved potato production package by the farmers, (Kidane 2001)

Frequency of extension contact (EXTENS): Frequency of extension contact is the number of times the household received extension personnel contact within a year. The effort to disseminate new agricultural technologies is mainly successful if there is smooth and frequent contact between development agent and the farmer at the grass root level. Here, the frequency of contact between a farmer and development agent has the potential force to accelerate effective dissemination of adequate agricultural information that in turn enhances farmers' decision to adopt agricultural technologies (Kidane, 2001). Therefore, agricultural extension services provided by agricultural development offices are believed to be an important source of information for improved agricultural technologies. Moreover, extension services are helpful in increasing awareness among farmers about new farming techniques. Frequent contact between the target group and development agent, and different extension services such as training, visiting and demonstration serve as the major sources of agricultural information and build decision making skill. Therefore, a household who has a frequent contact with extension personnel and service has a potential to adopt valuable extension advises and improve productivity of agriculture. Therefore, this variable was expected affected positively the adoption and intensity of adoption of potato production packages.

Participation in extension service (EXTPART): It is an aggregate variable which is measured by giving score value to respondent households' participation in training, demonstration, and field day, which are used as a proxy for participation in extension. A value

1 was given if the farmer participated in each of the above mentioned extension events during last five cropping seasons, 0 otherwise. Accordingly, a composite participation index was taken as the sum of status of participation in each extension activities divided by the number of activities**.** Participation in field days is expected to positively influence farmers' adoption level of improved potato production package, (Edlu 2006).And participation in training is expected to positively influence farmers' adoption behavior, (Dereje 2006).

Farm in put (INPUTAVAI): Farm inputs refer to use of chemical fertilizer such as DAP, UREA and high yielding varieties (HYVs). It is measured by rating the availability of inputs on five point scale. In line with this, a continuous input availability index was developed by dividing the summation of scores given to each input by the number of inputs. Households using fertilizer/HYVs are expected to have better food production capacity than non-users. Use Farm input improves productivity per unit area; which is intensification of agricultural strategy and helps the household to meet food needs. The adoption of improved farm technologies such as fertilizer and improved variety can result in significant income increase for the adopters (Beyene *et a*l, 2000).Thus, in this study, it was hypothesized that to have negative impact on decision of household to diversify livelihoods. In other words, a household who could have used farm inputs (chemical fertilizer and HYV) hypothesized to have negative relation with diversifying strategies.

Access to credit (CREDUSE): Access to credit enables in the farmers to adopt the technology which Otherwise may not be affordable for him. It is a dummy variable, which takes the value 1 if the farm household uses credit and 0 otherwise. Use of credit will influence adoption of vegetable Production package positively, (Teresa 1997) and (Legesse1992).

Accuse to market (MKTDIST): Access to market was hypothesized to be positively related to the probability of adoption of innovation. If the households located near to market tend to buy improved agricultural inputs and they can have easy access to sell their product in the market. Therefore, the variable was treated as a dummy variable in that if the household has

an access to market has coded as 1and 0, otherwise. As market distance increases adoption and intensity of adoption was expected to decrease, (Dereje 2006) and (Rahimeto 2007).

Risk perception associated with Potato production (RISKPERC): Knowing about people's perception of risk is important as people respond according to what they believe to be the case, rather than looking for scientific solution (Blayneh, 2001).

Farmer's perception of these risks is expected to affect adoption decisions. The variable is measured on five point scale. A score value of 1 (very low) was given for the farmer who perceives that the source of risk under consideration is not a threat for potato production. The farmer who perceives that the specified source of risk is a threat was given the value 5(very high). Accordingly, risk perception index was taken as the sum of the farmers perception of each sources of risk divided by the number of sources of risk.

Knowledge on improved production package (KSCORE): Acquaintance with the knowledge of the production package is a precondition of its adoption. The more sample respondents are knowledgeable about the technology practice, the more will be their confidence to adopt new practices. Legesse,(1992),Getcachew,(1993) and Degnt and Bely,(2001) ,Knowledge level of sample respondent about the improved potato production packages was hypothesized to positively influence the adoption and intensity of use of potato production package.

Teacher made type of achievement examination was applied by developing suitable questions in order to test farmer's responses for the variable under consideration. Accordingly, knowledge is measured by scoring in such a way that respondents know how about seeding rate, fertilizer rate, naming of improved potato varieties and other was assessed.

Perceived relative advantage (PRELADV): It is a continuous variable measured on five-point scale and refers to the superiority of the technology in terms of its advantage and compatibility with farmers circumstances. Respondents will rate the advantage of each package practices on five point scale based on their perception about the relative advantage of

each package practices. The total perceived relative advantage of the package will be the sum of the scores for each package components. Therefore, total perceived relative advantage of improved potato production package was supposed to positively and significantly influence adoption and intensity of use of improved onion production package,(Ibrahim 2005).

Table 2 Summary of independent variable (nature, measurement and effect)

Variable	Variable type	Measurement	Expected sign
Age	Continuous	Age of household head(in years)	=/-
Sex:-	Dummy	1 if male & 0 otherwise	+
Education	Continuous	Highest grade attend	+
Farming experience	Continuous	Number of years	+
Labor availability	Continuous	Man equivalent	+
LIVE STOCK OWNED	Continuous	TLU	+
Accesses radio	Dummy	1 if Accessible &0 otherwise	+
Frequency of listing agricultural progrm	Dummy	Rarely, sometimes, always	+
Participation in extension service	Dummy	1 if participated& 0 otherwise	+
Contact with extension agent	Continuous	number of contacts annually	+
Farm in put availability	Dummy	five point scale	+
Access to credit	Dummy	1 if Accessible & 0otherwise	+
Distance to the nearest local market	Continuous	Actual distance in kilo meter	-
Risk perception	Continuous	five point scale	+
Knowledge on improved production package	Dummy	1 if yes & 0 otherwise	+
Perceived relative advantage	continuous	five-point scale	+

4. RESULTS AND DISCUSSIONS.

4.1. Introduction

Since this chapter is the nucleus of the thesis work, it will consist of the overall findings of the study. Discussion on the status of adoption and intensity of adoption potato production package is presented at the beginning. Then, the influence of different personal, demographic, socio-economic, and psychological factors on the adoption and intensity of adoption of improved potato production package were discussed consecutively.

Improved potato production package involves the use of different package practice recommended by research system and being promoted by extension. These includes the use of improved variety, seeding rate, fertilizer rate, pest control chemicals, land preparation i.e.).recommended date planting, recommended frequency of weeding. In any case significant improvement of farm household in potato production and productivity depends on his/her adoption and level of adoption of this package practice.

In this study out of the recommended potato production package practice mentioned above, only variety use, seeding rate and fertilizer rate were included for calculating the adoption index. Due to absence of variation among farmers and difficulty in getting reliable data, the remaining package components were excluded from adoption index calculation.

The category as, low adopter, medium adopter and high adopter was identified based on the result of adoption index score. Adoption index score was calculated by adding the adoption quotient of each practice and dividing it by the number of practice adopted. This helps to know level of adoption of each farm households. The adoption quotient of each practice was also calculated by taking the ratio of actual rate applied to the recommended rate, which indicate the extent to which an individual farmer has adopted the package practices. The final adoption index scores of sample adopter groups were categorized into three as low, medium, and high. The non adopter group was given 0 and kept as separate category to investigate

factors limiting adoption of improved potato production package. Towards this end, for identification of determents of adoptions and intensity of adoption, respondents were categorized in to four adopter categories.

The adoption index score ranges used to classify respondents as non-adopter, low, medium and high adopter were 0.01-0.61, 0.62-0.83, 0.84-0.87 respectively. The actual adoption index score range from 0 to 0.87.Adoption index score of 0 point implies non-adoption of the overall improved potato production package and 1 implies as per the recommendation adoption. In addition, adoption index scores greater than one clearly indicted adoption of improved potato production packages above the recommended practice. Distributions of sample respondents by adoption category are illustrated in Table 2.

Table.3. Distribution of respondents by level of adoption of Potato production package

Adoption Category	N	Percent	Adoption Index range	F	Sig.
Low	45	36.9	0.01-0.61		
Medium	19	15.6	0.62-0.83		
High	12	9.8	0.84-0.87		
Total	122	100.0	0-0.87	3.48	.000

Source: Own Survey Data. the mean difference is significant at .01 levels

In addition, from the total sample respondents,37.7 had adoption index score 0 which indicates there over all package non- adoption while the remaining proportion(62.3 of adopters) had adoption index score between 0.01-0.87 indicating adoption at different level. Among the practice, fertilizer application rate was used beyond the recommended rate by the majority of sample adopter households. Farmers' devotion from the recommended rate could be discussed in the coming section.

4.2. Current Status of Adoption and Intensity of Use of Improved Potato Production Package Recommendations

New technologies are usually recommended in a set or a package form for use to farmers. However, for several reasons farmers usually adopt only certain components of the package. Moreover, in most cases there is variation in intensity or level of use of a given technology. Diversity among farmers in their level of package adoption could be related to many factors. Understanding why farmers adopt one component of the package was rejecting the other as well as the underlying reasons for the variation is of paramount importance.

With regard to the study area, the finding revealed that 37.7% of the sample respondents were found to be non-adopters. The mean adoption index score of the sample respondents were found to be0.3911.One way analysis of variance also revealed that there is significant mean difference(f=348.288,p=000) among three categories in the adoption index score at 1% level. This indicates that there is variation in the level of adoption among the three adoption categories. In addition, post hoc multiple comparison test shows existence of significant mean difference between each adoption index score at 1% probability level (Table 2).

4.2.1. Adoption and intensity of adoption of improved potato production package.

Out recommended potato production package, improved varieties are the principal component introduced in the study area. In line with this, a lot of efforts have been made by the research system to generate improved varieties of potato. As a result many varieties have been recommended to the study area by different research centers. Besides the recommended cultivars, four varieties have also been released by Haramaya University where the study area being the trial site under Haramaya University' mandate area for potato improvement. Among the potato varieties Bubuu, Gabissa, Zeman Badissa ,Batee, Chiroo and Shantem were the major ones promoted and entered in to production system.

Beside such intervention, adoption of improved potato varieties is still low in the study area, the intensity of potato varieties adoption which is measured as area covered with improved

potato varieties was found to vary across potato grower house hold. The result on intensity of variety adoption is presented in table 3 below

Table.4. Mean area coverage, tube ring rate and fertilizer rate used by sample farmers

Statistics	**Area coverage(ha)**	tube ring rate **(** Kg/ha)	Fertilizer **(kg/ha)**
N	122	122.	122
Mean	. 0.733	18.852	120.962
S.D	.209	4.50091	35.41836
F-value	5.689	19.024	21.705
Sig.	.001	000	.000

Source: Own survey data.2016;*. The mean difference is significant at the 0.1 level

According to the finding in table 3, out of the total average area allotted for potato production).The mean area coverage of improved of improved potato verities was found to be 0.733ha. This shows there was significant difference among adoption categories (f=5.89,p=0.0001) in adoption and intensity of use of improved potato variety at 1% significance level. Post hoc multiple comparison test result illustrated that variability is observed between adopter and non-adopter categories than within adopter categories at 1% probability level.

4.2.2. Seeding tuber rate

Seed Tuber rate is another important component of potato technology package .Applying the recommended seeding rate is good practice which results in efficient potato production .Excessive or underutilization of tuber will result in poor production performance. Usually research recommends specified level of tube ring rate for a given variety or crop with a given range of tuber viability. Extension also advices farmers based on this research recommendation. The recommended tube ring potato rate of improved potato variety in the study area is 150-200 kg/ha. (Depend on the size of potato).Farmers' adoption of recommended tuber ring rate however depends among several things on the appropriateness

of recommended rate itself. Availability of quality seed tuber and other household related socio-economic problems

4.2.3. Fertilizer application rate

With the current sense of urgency to increase production and productivity, farmers prefer to use chemical fertilizer than organic fertilizer than organic fertilizer (compost) because the impact of using compost will be realized after 2-3 cropping seasons compared to the use of chemical fertilizer where by its effect is immediate. Moreover, preparation of compost for the potato farm was found to be labor intensive. above premises coupled with loss of soil fertility through frequent cultivation, the trend showed an alarming increase in the rate of fertilizer use On the other hand, the use of crop rotation system is common practice in the study area planting potato after onion, maize, sorghum and cabbage production season enables farmers to reduce the use of chemical fertilizer to lesser extent

Unlike any other crops, improved potato production in the study area requires the use of chemical fertilizer. In addition, farmers use chemical fertilizer even on local potato varieties. Even though location specific fertilizer recommendation for potato is released recently by the research system, extension is still promoting the blanket fertilizer recommendation rate of100 kg/ha DAP and 100kg/ha urea in the study area This recommendation is the same across all improved potato varieties. The average fertilizer application rate is shown in Table 3 above and the result discussed consequently.

According to table 3, analysis of mean variance indicated that there was significant mean difference (F=21.705, P= .000) in fertilizer application rate among adoption categories at 1% level of significance (Table 3). Moreover, the average rate of fertilizer application for potato production by sample households during last production season was 120.96 kg/ha fertilizer. This value is almost coinciding with the research recommendation revealing that majority of adoption categories use fertilizer almost equivalent to the research recommendation. However, there are also farmers using fertilizer above the recommendation and apply fertilizer even on local potato cultivars. This is related with the loss of soil fertility of the area

through frequent cultivation. Result of focus group Discussion (FGD) also added that 100 kg/ha of fertilizer rate is not enough to get required amount yield implying the need to promote the recent location specific fertilizer recommendation released by the research system)

4.3 Farmer's Variety Preference Criteria

The other important issue in variety adoption is to understand farmer's variety preference criteria. In most cases, varieties fail to adopt by users due to mismatch in preference criteria between breeders and farmers. In general, sample respondents have selected Yield advantage, earliness in maturity, Ease of adaptability, market demand, Water lodging Tolerance, storability, food making quality, Cooking time, Frost resistance, Disease resistance, Tuber size, eye depth, shape and Taste as criteria for choosing the variety adaptable to them. Finally, based on the aforementioned attributes, the type of improved potato variety preference of sample respondents is displayed in Table 4 below

Table 5 Potato variety preference criteria ranking by sample house holders (%)

Variety name	Attributes										
	Yield advantage	Earliness in maturity	Market demand	Water lodging Tolerance	Storability	Eye depth	Taste	Tuber size	Disease resistance	Percent	Rank
Bubuu										40.12	1st
Gudanee										27.16	2nd
Chirro										16.66	3rd
Badissa										8.02	4th
Shantem										3.70	5th
Gabisa										2.47	6th
Zeman										1.85	**7th**

Source: own survey Data

4.3. Influence of Independent Variable on Adoption and Intensity of Use of Improved Potato Production Package

In this study, the independent variables thought to have the relationship with adoption and intensity of adoption of improved potato production package are grouped as household's personal and demographic variables, farm related variables, household economic variables, household psychological related factors and institutional variables. The relationship of these variables with adoption and intensity of adoption of improved potato production package is discussed under the flowing sub topic

4.3.1. Personal and Demographic Characteristics

Age is one of the household characteristics important to describe households and can provide a clue as to age structure of the sample and the population too. The result of one-way ANOVA indicated that there was significant mean age difference among adopter categories. The finding of this study is in agreement with the one conducted by Tesfaye et al, (2001) on the adoption of improved bread wheat varieties and inorganic fertilizer by small- scale farmers indicated that there was no significant difference in age between non-adopter and adopter of improved bread wheat varieties

The chi-square result indicates that there is significant relationship between age among adopter categories at 1% significant level ((x^2 =0.91, p = 0.423).

Sex of the household head was one of the demographic characteristics hypothesized to limit the adoption of potato technology in such way that male-heeded households were expected to make a decision to adopt more than female headed households. The survey result shows that male respondents (59.8.1%) take larger proportion than female respondents (40.1%) as it's presented in Table 5 below.

The chi-square result indicates that there is significant relationship between sex and among adopter categories at 1% significant level (X^2=2.151, P =..542).

Table.6.Age, sex and Educational level of sample farmers by adopter category

Variable			Adopter category					
			low	medium	high	total	x^2	p
Age		N	44	19	13	76	.941	.423
Sex of household head	M	N	42	19	12	73		
	F	N	3	0	0	6	2.151	.542
Educational level household head	Illiterate	N	34	9	8	87		
	1-8	N	11	10	1	31		
	9-12	N	0	0	3	3		
	Total	N	45	19	12	122	36.77	000

Source: Own Data 2016;**, significant at 5%

4.3.2 Educational status of household head

Adoption of a given technology is a behavioral change process, which is the result of a decision to apply that particular innovation. Farmers need enough information about the technology to make the right decision. Education enhances the capacity of individuals to obtain, process, and utilize information from different sources. As indicated in Table 5. In this study, the educational range of the sampled respondent farmers was lied between grade 9-12 while the second lowest range was 1-8 (Table 5. Whereas out of 87 illiterate respondents about 36 (41.38%) are none-adopter and the remaining 51 (58.62%) respondents are adopters ranging from low to high.

The chi-square result indicates that there is significant relationship between education level and among adopter categories at 1% significant level (X^2=36.77, P = =.000).

4.3.3. Potato experience in farming

Experience in farming will improve the farmer's skill on produce of crop in general and potatoes produce in particular. A more experienced grower may have a lower level of uncertainty about the innovation's performance. Farmers with higher experience appear to have often full information and better skill and are able to evaluate the advantage of the technology considered. Therefore, it was hypothesized that farmers with higher experience in farming would have positive relation with the adoption of improved potatoes production package. As depicted in table 6 the result of this study in contrast to the assumption, where farming experience was expected to have positive relationship to the adoption of potato production package. Farming experience has no significant mean among adoption categories (F=.574, P=.633). The result is in line with the finding of Rahimeto (2007) and Chilot. (1994).

Table.7 Potato experience in Farming by sample respondent

Adoption category	Farming experience			f	sig
	N	Mean	Std,		
Non-adopter	46	24.48	8.919		
Low	44	25.52	5.663		
Medium	19	25.05	6.151		
Hhigh	13	22.52	6.721		
Total	122	25.54	7.203	.574	.633

Source: Own Data 2016;**, significant at 5%

4.3.4. Socio-economic characteristics

4.3.4.1. Livestock holding

In the study area mixed farming is practiced with crop and live stock production. Each house hold owns at least one or more types of live stock and piece of land for crop and livestock production, Livestock in the study area provides traction power, manure and serves as source of income through sale of animals and their products.

Table 8.The relationship between live stockholding with the adoption of improved potato production package

			Medium	High	Total	X^2	p
Livestock ownership	Yes	N	19	12	119		
		%	100.0%	100.0%	98.3%		
	No	N	0	0	2		
		%	0.0%	0.0%	1.7%		
	Total	N	19	12	121		
		%	100.0%	100.0%	100.0%	3.316	.345

Source own data, 2016;

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As it is indicated in table 7 above about 36.97% of the ownership livestock of the respondents are None-adopters whereas the remaining 63.03% of the ownership livestock of the respondents are adopters. Contrary to the hypothesis, the Chi square analyses of the study was found to be insignificant (X^2=3.316, p=.345) among adoption categories.

The plausible reason for the absence of significant difference can be attributed to the decrease in grazing land holding size because of extended family size and other contributing factors. As more grazing land has been converted into crop land, the remaining marginal land which is not suitable for raising livestock animals prohibit farmers from keeping more number of animals.

4.3.4.2. Size of land holding

Farm size is also another important proxy indicate of wealth and social status within the farming community. However, land shortage caused by population pressure is acute in the study area. In line with this, increasing potato productivity depends on increased crop intensification. Based on the above premises, total cultivable land holding size was hypothesized to influence negatively the probability and intensity of use of improved potato technology and the survey result is illustrated in Table 8 below.

In this study, the average cultivable land of sample population for non adopters was found to be 0.418 ha with standard deviation of 0.194. Whereas the average area allocated for potato of sample population for non adopters was found to be .0204 ha with standard deviation of .046. On the other hand, the average cultivable land of sample population for Low, Medium and High Adopters was found to be 0.431, 0.4853 and 0.479 ha with standard deviation of 0.1629, 0.208 and 0.2432 respectively. Contrary to the proposed hypothesis, the results of one way ANOVA (F = .769, P = .513) shows that there was insignificant mean difference among adopter categories with regard to total cultivable land holding. Similar result has been found regarding the relationship of total area allotted to potatoes with the adoption and intensity of adoption (Table 8).

Table 9.Sample respondents by land holding and the adoption of improved potato production package

Adoption Category		Cultivated land	Area allocated for potato
Non Adopters	Mean	.417948	.020380
	SD	.1935484	.0457468
Low	Mean	.430722	.035625
	SD	.1629144	.0530936
Medium	Mean	.485395	.023553
	SD	.2077095	.0368680
High	Mean	.479167	.017045
	SD	.2432809	.0404169
Total	Mean	.439185	.026167
	SD	.1899303	.0469858

Source own data, 2016;

The result is justified with chi-square test regarding sharecropping system in the study area. According to the result from Table 9 below; there is no statically significant mean difference (x^2 =1.96, df =3. P=0.58) in the status of sample respondent's to lease-in crop land and the use of potato production package across adopter categories. This implies that there is no difference between farmers who rented –in land and who do not in the use of improved potato technology explaining the importance of land holding size to adoption being little. The result of the study confirms the earlier finding of Gethaun (2004) and Mesfin (2005).

Table 10 Sample respondents by the status of land rented-in and intensity of use of potato production package

Variables			Adoption Category				Total
			Non Adopters	Low	Medium	High	
Land Rented-in	Yes	%	7.9%	16.3%	11.1%	27.3%	13.6%
	No	%	92.1%	83.7%	88.9%	72.7%	86.4%
	Total	%	100.0%	100.0%	100.0%	100.0%	100.0%

x^2 =1.96, df =3. P=0.58

Source: own survey data.2016

As indicated in the table above, the total land lease for both Adopter and Non-Adopter category share 13.6% whereas the remaining 86.4% sample household respondents do not lease land for potatoes production.

Specifically speaking, non-adopters category who leases land for potatoes production accounts 7.9% while the remaining 92.1% sample household respondents do not lease land for potatoes production. As the survey result indicates the adopter of low category who lease land for potatoes production accounts 16.3% while the remaining 83.7% do not lease land for potatoes production. The Medium Adopters who lease land for potato production account 11.1% whereas 88.9% of the sample household respondents do not lease land for potato

production. The High Adopters who lease land for potatoes production account 27.3% and the remaining 72.7% sample respondents do not lease land for potatoes production

Table **11.** Distribution of respondents by the status of land rented in and the adoption and intensity use of potato production

Land rented in	Adoption Category	df	Sum of Squares	Mean Square
Cultivated land	Between Groups	3	.084	.028
	Within Groups	118	4.281	.036
	Total	121	4.365	
Area allocated for potato	Between Groups	3	.007	.002
	Within Groups	116	.256	.002
	Total	119	.263	

Source Own Data, 2016**, Significant at 0.05 level

4.3.4.3 Family size and household labor availability

Large family size will able to provide the labor that might be required for timely operations especially during land preparation, planting, and harvesting periods. In addition, large working force within the household means, the house hold may not need to hire labor during peak seasons and the money saved could be used to purchase improved potato production inputs. Consequently, active labor availability was assumed to have positive and significant relationship with the adoption and intensity of adoption of potato production package. It was measured in Man Equivalent.

According to the result from table 13 below, the average active labor force availability in term of man equivalent for sample household was 2.69. The average labor force of adopter groups Was 2.81 while that of non- adopters groups was 2.44 explaining mean difference (f=3.15,p=.027) across adopter categories at 5% significant level. With regard to the direction of relationship, the correlation result showed that household labor availability had positive and significant relationship (r=.232, p=.003) with adoption and intensity of adoption of improved potato production package at 0.01 significant level

Table 12 Family size and household labor availability

Adoption Category	Man Equivalent	
	Mean	SD
Non-adopter		
	2.441	.83
Low	2.56	1.02
Medium	2.87	1.11
High	3.01	1.15
Total	2.69	1.03
F-value	3.151	
P-value	.0027	
r	.232	

Source: Own Data, 2016;*, significant at 0.05 level

Hicks and Johnsion (1974) reported that a higher labor requirement explained the non adoption of improved rice varieties in Taiwan and that a shortage of family labor explained of high yielding varieties in India.

Respondents were also interviewed to describe the type of labor demanding agricultural activates. According to table 11 from total respondent about 22.1%, 28.1546.1%, and 3.5% reported that planting, weeding, harvesting, and threshing were the major farming activates that demand more labor in potato production respectively. Respondent farmers in the study area revealed that they have different coping strategies during those peak seasons. These include use of family labor, hiring and use of traditional labor pooling system (*wenfel or guuza*). Accordingly, 35.9%, 29.3% and34.7% of respondents has reported that they have used family labor, hired labor, and *guzza* respectively.

4.3.4.4. Annual on-Farm Income

Crop production and livestock rearing are the major components of farming as main source of income. Improved potato production often requires an intensive input use specially fertilizer

in the study area which has great implication on cost of production. Due this, improved potato growers need to have the required amount of financial resources to purchase inputs. In this study, annual farm income was measured as the amount of birr received from crop, livestock animal and livestock products sell during last cropping season. For Non-adopter was 12,472.78 birr with the standard deviation of 11,663.200. On the other hand the average annual farm income of the sample households for Low, Medium and High Adopters were 35856.77, 30488.00 and 22500.00 birr respectively with the standard deviation of 14733.816, 20781.946 and 17191.930.

Table 13. Mean off farm/non-farm, farm, and total income by adopter category

Variable	Adopter category					F	P
	Non	Low	Medium	High	Total		
OFF/non-farm income	12472.78	35856.77	30488.00	22500.00	101317.55	11.316	.000
Cash from crop	5400.00	14491.25	10920.00	43110.00	73921.25	5.704	.003
Total income	17872.78	50348.02	41408	65610	175238.8	6.804	.003

Source: own Data; significant at 5% level,

One-way ANOVA had also indicated that there was significant mean difference (F= 5.704, p=0.003) in their farm income among sample respondents at 5% level implying the relationship between farm income and Potatoes adoption being significant. Bivariate correlation analysis was also conducted those strength and direction of relationship between farm incomes and adoption of improved potato production package. Accordingly the result indicted that the farm income was positively and significantly related with adoption and intensity of adoption of improved potato production package at the 0.1 level (r=0.220) (Table15). From the findings, it can be concluded that lower income group of the society face difficulty to adopt potato production package.

This implies the need to support lower income groups through different mechanisms such as strengthening credit schemes specific to improved potato technology under consideration. Majority of empirical studies shows that the effect of farm income on household's adoption

decision is positive and significant. To mention some of them for example, Kidane, 2001; Degent et al., 2001 and Getahun, 2004 reported positive influence of household's farm income on adoption of improved technologies.

4.3.4.5. Non-Farm income

Mostly during slack periods many farmers can earn additional income by engaging in various non-farm activities. In the study area grain trading, livestock trading, casual labor and petty trading were found to be major nonfarm activates in which sample respondents were participating. Participation of sample respondent in such activities in such activities helped them in generating diversified income in addition to farm income and increases the farmer's ability to adopt technology.

Regarding the non-farm income, Table 12 above reveals that the average non-farm income of sample respondent is 29570.74 Birr. The average nonfarm income adopter and non- adopter groups was found to be 8642 and 28496 birr respectively.

However the mean difference across the three adopter categories was not significant. The result suggests that non-farm income does have important role in the adoption of potato production package.

4.3.5. Institutional characteristic

4.3.5.1. Radio exposure

Radio plays the greatest role in provision of information in shortest possible time over large area of coverage than other communication channels. Hence, since a farmer who owns radio can have a better access to agricultural information and use technology than the farmer who doesn't, radio ownership was hypothesized to positively influence the adoption of improved potato technology. The result from the survey has been summarized in the table 13 below.

Table 14. Relationship between radio accuse and adoption of improved potato production package

Variables			Adoption Category				
			Non Adopters	Low	Medium	High	Total
Farmers	Yes	%	87.2%	88.4%	78.9%	100.0%	87.6%
response	No	%	12.8%	11.6%	21.1%	0.0%	12.4%
	Total	%	100.0%	100.0%	100.0%	100.0%	100.0%

X^2=3.038, df=3, Cramer's V= .386, P=.386

Results of chi-square test revealed insignificant relationship ($\chi 2$ = 3.038, P = .386) across adopter categories between radio ownership and Potatoes adoption.

4.3.5.2. Frequency of Listening Agricultural program

The adoption process of agricultural technologies depends primarily not only on the availability of radio. Rather, farmer's willingness and ability to listen radio as a major source of information is also another issue. Accordingly, frequent exposure to radio is anticipated to improve farmer's listening ability and gain agricultural related information. Therefore, it is not uncommon to say that frequency of listening to radio in general and agricultural programs in particular has paramount importance. Based on the aforementioned premises, frequency of listening to agricultural matters was hypothesized to positively and significantly influence the adoption and intensity of improved potatoes technology. It was measured by giving scores to respondent farmers in such a way that a farmer who rarely listens was given a value 1, and who sometimes and frequently listen was given a value of 2 and 3 respectively, (Appenex.1)

Table 15. Distribution of sample respondent's frequency of listing agricultural program

Listening Frequency		Adoption Category				
		Non Adopters	Low	Medium	High	Total
Rarely	%	11.9%	20.0%	17.6%	0.0%	14.4%
Some times	%	78.6%	60.0%	64.7%	75.0%	69.4%
Frequently	%	9.5%	20.0%	17.6%	25.0%	16.2%
Total	%	100.0%	100.0%	100.0%	100.0%	100.0%

Source own survey Data, 2016

Regarding radio listening habit of sample respondents in the study area, Table 14 suggests that 14.4% of sample respondents rarely listen radio on agricultural matters. On the other hand about 69.4% of sample respondents sometimes listen to radio on agricultural matters while the last category accounts 16.2%.

Table 16 frequencies of listening agricultural information with adoption of potato production package

Adoption Category	Listening Frequency		F	Sig.
	Mean	Std. Deviation		
Low	2.00	.641		
Medium	2.00	.612		
High	2.25	.452		
Total	2.02	.556	.792	.501

Source: Own survey data, 2016

This study has also found out that there is no significant mean variation (F=.792, P=.501) between adoption categories in the frequency of radio listening. The plausible reason may be in convenient transmission of agricultural radio program and farmer's lack of interest. The finding of this study is consistent with Kidane (2001),Getahun (2004), Tesfaye and Alemu (2001), Ibrahim(2006), and Kebede (2006).

4.3.5.3. Frequency of contact with extension agents

According to diffusion theory, there are multiple sources of information to farmers. The most important source of information in the study area was provided by government Bureau of Agriculture and Rural development through Extension Agents (EAs) residing in their respective areas. For this reason, contact with EAs was hypothesized to increase the likelihood that a farmer will adopt improved Potatoes technologies. In this study, the variable was measured in number of contacts the farm household had with EAs and survey result is presented in Table 16 below and discussed accordingly.

Table 17. Relationship between frequency of extension contact and adoption of potato production package

Adoption Category	Mean	Std. Deviation	F	Sig.
Non Adopters	4.00	1.893		
Low	2.99	1.625		
Medium	3.39	2.004		
High	3.67	1.826		
Total	3.41	1.815	1.759	.160

Source Own survey data, 2016;*** ,significant at 10%

As indicated in table16 above, the average frequency of extension contact for the sample households was 3.41with standard deviation of 1.815. On average adopter groups had better frequency of extension contact than non-adopters.

The result of one way ANOVA revealed that there was insignificant mean difference (F=1.759, P=0.160) among adoption categories.

4.3.5.4. Participation in extension

Various extension methods are being used by the national agricultural extension system as a means of influencing and transferring agriculture related messages. The common extension events that were used as a proxy for participation in extension in the study area include

demonstration, field day, and training. These extension activities are the major source of agricultural information that equips farmers with the necessary knowledge and skill about the new technology and as a result farmers would be more likely to adopt new innovation. Therefore, farmer's participation in extension was hypothesized to influence positively the decision to adopt and intensity of adoption of improved potato production package. The survey result is illustrated in table 17 below:

Table 18. Relationship between participation in extension and improved potato technology adoption

Variables			Low	Medium	High	Total
Extension participant	Yes	N	44	17	12	119
		%	100.0%	89.5%	100.0%	97.5%
	No	N	0	2	0	3
		%	0.0%	10.5%	0.0%	2.5%
	Total	N	44	19	12	122
		%	100.0%	100.0%	100.0%	100.0%
S o s d			X^2= 6.589, df=3, Cramer's V= .086, P=.086			

The chi square result indicate that there is insignificant relationship X^2= 6.589, P=.086 across adopter categories between Extension participation and Potatoes adoption. This may indicate that the more a farmer participated in extension activities, the more he will be experienced in managing his/her farm and develops confidence to adopt new potato related innovations.

4.3.5.5. Access to credit

Adoption of improved potato production package by farmers is motivated by the income gained from the sale of produce. Farmers grow the potato crop not for the consumption purpose only but to fetch cash income which allocated for purchasing farm inputs and met out other family needs. But constraints to adoption of improved potato production are numerous: the cost of seed, high labor requirements and technical skill need for of crop management, are some of the constraints that hinder the adoption of this crop.

Farmers without cash and no access to credit will find it very difficult to adopt new technologies. Previous authors verified this preposition (Legesse,1992;Teressa,1997).Ii is expected that access to credit will increase the probability of adopting improved potato production package.

In this study, the hypothesized preposition is not supported by the significant relationships which exist between access to credit and adoption of potato production package (X^2=2.915, df=3, Cramer's V= .405, P=.405) as shown in table 17.

Table 19. Relationship between accuse to credit and adoption of improved potato adoption

Variables			Adoption Category			
			Low	Medium	High	Total
Response	Yes	%	44.8%	50.0%	66.7%	41.2%
of farmers	No	%	55.2%	50.0%	33.3%	58.8%
	Total	%	100.0%	100.0%	100.0%	100.0%

Source own survey data X^2=2.915, df=3, Cramer's V= .405, P=.405

The result of chi square indicated that there is no significant relationship X^2=2.915, P=.405 across adopter categories between Credit and Potatoes adoption.

4.3.5.6. Input use

The minority (very poor farmers) of farmers in the study area obtains improved seed and chemical fertilizer on credit basis through district level bureau and service cooperatives. In the previous section, it was shown that credit in kind would not only relax farmer's cash constraint currently existing, but also improve their access to inputs.

Result showed that out of the total sample respondent, 97.5% (APPENDX 1) used chemical fertilizer on either improved potato variety or local variety while the remaining proportion did not use. In addition, the number of adopters was higher compared to non-adopter groups.

In a similar manner, the proportion of sample respondents who have used improved Potato variety was almost equivalent to those who didn't. Therefore, Chi square test has shown that the use of chemical fertilizer (χ2=.940, P=.816) makes insignificant difference across the District in general and within the adoption categories in particular (Table 18).

As indicated in the table 19 below, about 97.7% of Low adopter category has used improved potato varieties during the last two cropping seasons, the medium adopter who have used improved potato varieties during the last two cropping season's accounts 100.0% and the high adopter who have used improved potato varieties during the last two cropping seasons. The Chi square result indicated that there is significant relationship (X^2=94.784, P=.000) across adopter categories between cropping seasons and Potatoes adoption.

Table 20 Adoption characteristics of farmers on fertilizers and improved potato verities

Status of inputs		Adoption Category				X^2	P
Fertilizer		Low	Medium	High	Total		
	Yes	97.7%	94.7%	100.0%	97.5%		
	No	2.3%	5.3%	0.0%	2.5%		
	Total	100.%	100.0%	100.0%	100.0%	**.940**	**.816**
Improved	Yes	97.%	100.0%	91.7%	64.7%		
potato	No	2.3%	0.0%	8.3%	35.3%		
	Total	100.%	100.0%	100.0%	100.0%	**.784**	**.000**

Source Own survey data, 2016

4.3.4.7. Distance to market

Input-output markets are communication centers for producers, consumers and traders. Market accessibility is important for farmers to influence the decision to adopt improved agricultural inputs. If farmers are closer to market centers, they can easily purchase improved

agricultural inputs without moving long distances. Moreover, farmers will be motivated to sell their outputs in fair price if they have access to attractive input-output market. To this end, since households near to input-output market centers tend to have easier market access to dispose their production, distance to the nearest market center was hypothesized to be negatively correlated with the adoption of improved Potato varieties,. The variable was measured in kilometers. The result on mean distance traveled by sample households across each adopter categories is presented in Table 23 below and discussed subsequently.

Regarding the distance to reach the nearest market center, sample respondents reported that they had to travel on average 10.19 km with a SD of 10.120. On average, non-adopter groups travelled 7.83 km to reach to the nearest market center. Among the adopter, the low category travelled 12.94 km to reach to the nearest market center. The medium and the last category travelled 7.64 and 13.68 km respectively.

The result of one way ANOVA revealed that there was significant mean difference (F=2.859, P=.040) among adoption categories. This implies that there is strong relationship between Distance to Market and potato production.

Table 21 Distance to nearest market center and adoption of potato production package

Adoption Category	Mean	Std. Deviation	F	Sig.
Non Adopters	7.83	10.004		
Low	12.94	8.632		
Medium	7.64	8.970		
High	13.68	14.643		
Total	10.19	10.120	2.859	.040

Source Own survey data, 2016

4.3.6. Psychological characteristics

4.3.6.1. Knowledge about the technology package

Knowledge about the technology package is precondition for technology application in particular and technology adoption in general. Farmer's knowledge level about improved potato production package practices was hypothesized to influence adoption of technology. Knowledge of farmers' increase awareness about improved potato was measured by scoring. Accordingly, farmers were asked whether they know the recommended rate, fertilizer rate, time of planting, frequency of weeding and cultivation etc and responses were summed up for each question and total score of the respondent was recorded 0 and 10 being the minimum and maximum score respectively.

Table 22. Farmer's knowledge level about improved potato production package practices

Adoption Category	Mean	SD	F value	P value	r
Non	7.21	2.48			
Low	8.51	2.28			
Medium	9.21	0.86			
High	8.29	1.80			
Total	8.12	2.16	7.736*	0.000	0.242

Source: own survey data, *, Significant at 1%

As it was clearly indicated in the table 21 above, the average score of farmers on the knowledge about the improved potato technology were 8.13 with SD of 2.16 across all adopter categories.

The mean difference of knowledge score between adopter categories was significant (F=7.736,p=0.000).This implying that awareness about the technology package affect

adoption of improved potato technological package positively. In addition, the correlation (r=0.242, p=0.002) revealed significant and positive association of respondents' knowledge level and adoption and use of intensity of the same at 0.01 level. Therefore, the more sample respondents are knowledgeable about the technology practice, the more will be their confidence to adopt new practices. This result confirms the findings of Legesse,(1992),Getcachew,(1993) and Degnt and Bely,(2001).

4.3.6.2. Farmer's perception of technology attributes

Farmer's perception of certain technology is interwoven result of personal, socioeconomic, instructional and technical factors, technology Characteristics like relative advantage and its compatibility with farmers situational circumstances are important factors in deterring adoption and level of adoption of technology. The relative superiority of the technology in terms of its advantage enables farmers to have favorable perception about the technology, which in turn enhances decision in favor of adoption technology.

According to Duvel (1975) perception is a key dimension in behavioral change process. However, major adoption studies have not considered this analysis of the determinants of adoption decisions. The omission of farmer's evaluation of technology specific attributes may bias the result of factors conditioning adoption choices. Therefore, there is a need for adoption studies to consider farmers perception of technology specific attributes in the assessment of technology decisions (Adesina, et al.1993). Based on the above argument, perceived relative advantage and compatibility were expected to influence the adoption and intensity of adoption of improved potato production package.

In this study, since improved potato variety is principal component of the package, 7 variety attribute were taken to infer the effect of relative advantage on the adoption and intensity of adoption of the same. These include Yield advantage, earliness in maturity, Ease of adaptability, market demand, Water lodging Tolerance , storability, food making quality, Cooking time, Frost resistance, Disease resistance, Tuber size, eye depth, shape and Taste

Presetting and FGD were applied to establish and set these evaluation and selection criteria of improved potato verities.

Perceived relatives advantage was measured by rating variety attributes over the local sample respondents were asked to rate the varieties in terms of the above attributes where 1 refers to not preferred attribute, 2 refers to indifferent between the local and improved cultivar and 3 refers to a preferred attribute. Then perceived relative advantage index was taken as the sum of the scores of each attribute. The average summation of each attribute shows how far the variety is superior or inferior to the local one. (APPEDNX 1)

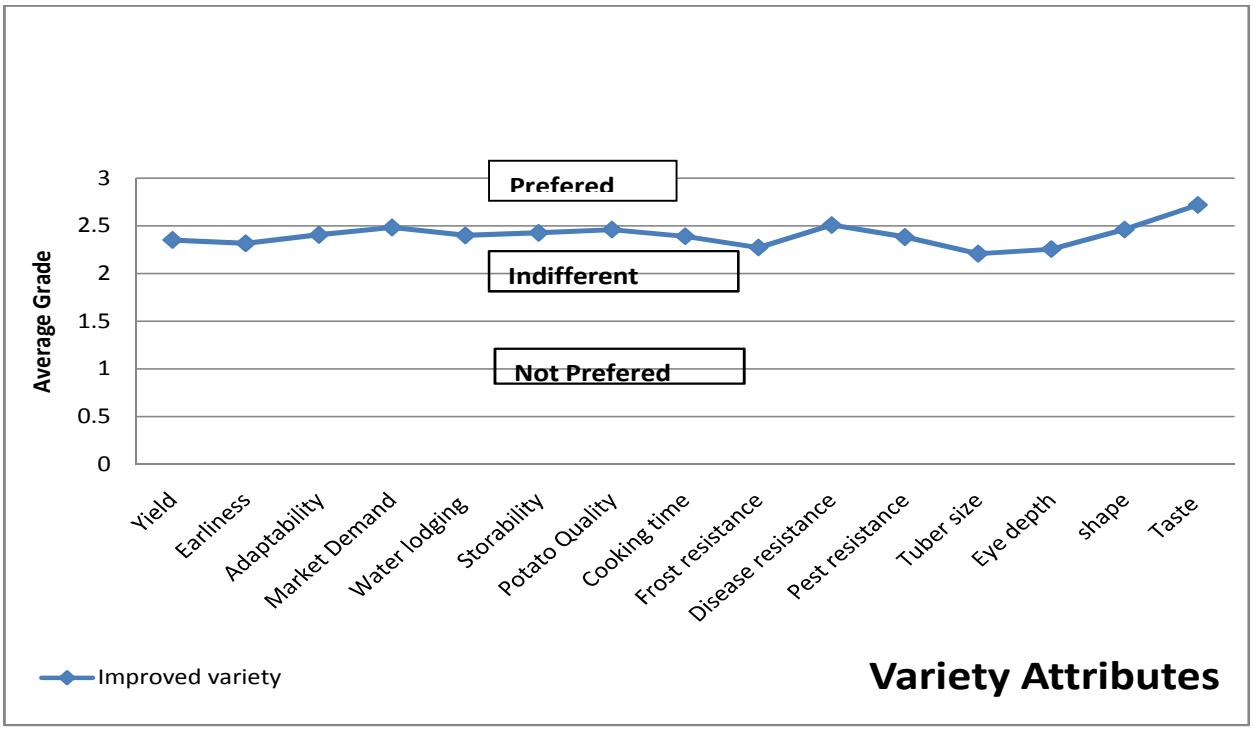

Figure 3 Average grade of farmers improved potato variety Attribute Preference

The result of figure 3 depicts that sample respondents replied that they preferred improved potato varieties over the local ones taking into account most of the aforementioned attributes. On the other hand, the majority of the respondents preferred the local varieties in terms of water lodging, frost, disease and pest resistance than the improved ones. Despite such variability in farmer's perception towards these variety attributes.

According to the survey result shown below in table 22 revealed that statistically significant relationship (F=9.023, p=0.000) between perceived relative advantage and technology adoption categories.

Table 23. Relationship between perceived relative advantage and adoption of improved potato production package

Adoption Category	N	Mean	SD	F value	P value	r
Non	45	1.9333	.68755	9.023	.000	.189
Low	44	2.4318	.58658			
Medium	19	2.5263	.69669			
High	12	2.8333	.57735			
Total	122					

Source: Own Survey data, 2016

4.3.6.3. Perceived Compatibility of the technology

In this study, it was expected that perceived technology compatibility would have significant effect on improved potato technology adoption. The same procedure was used to measure compatibility of improved potato cultivar and fertilizer with that of relative advantage where 1 is less compatible, 2 is medium 3 is highly compatible. The level of compatibility of technology practice was assessed in comparison with the existing income of sample respondent, farmers past experience and physical environment (soil condition)

In line with this, sample respondents were evaluated whether they perceive the improved potato production practices are compatible or not. Accordingly, analysis of one way ANOVA shows that there is insignificant difference (F=0.686, p=0.562) between adoption categories. The average perceived compatibility score of technology was 2.52625 with SD of o.6071325.Adopter groups (2.41) have higher mean score of perceived technology compatibility than non adopter groups (2.36). This justifies that adopter groups have favorable perception about compatibility of the recommended potato technology practice and adopt technology better than non adopter groups.

Table 24 Relationship between perceived compact ability of technology and adoption of improved potato production package

Adoption Category	N	Mean	SD	F value	P value	r
Non	47	2.3617	.60525	.686	.562	.017
Low	44	2.4091	.54210			
Medium	19	2.5789	.60698			
High	12	2.5000	.67420			
Total	122	2.52625	0.6071325			

Source: Own survey data,2016 *, Significant at 1%

The correlation (r=0.17,p=0.005) significant at the 0.01 level.

Of course, FGD substantiated the result that compatibility of improved potato technology with farmers' situational characteristics especially the house hold income varies from year to year. The more the income generated from the use of potato technology in a given production season, the favorable would be farmers' perception on the compatibility of technology for consequent seasons. With regard to improved potato cultivar, participant farmers in the discussion replied that compatibility of the variety also depend on agronomic advantage condition in the area. Most of the time potato variety is perceived as compatible on early maturity, drought tolerant, and beast suitable to the area, better yield in poor soil fertility, require low count of fertilizer, disease resistance, tolerant frost and pest.

4.3.6.4. Risk perception in Potato production

Perception of risk is essential to formulate effective risk management and mitigation programs and policies and to target poverty reduction programs (Blayneh, 2001). Knowing about people's perception of risk is important as people respond according to what they believe to be the case, rather than looking for scientific solutions. Farmer risk orientation and capacities to absorb the negative or a side effect of any adoption of innovation is different. This difference emanate from several political. Socio-economic conditions and institutional dynamics of single individual and hence individual are different in many ways. In this study,

perception of farmers risk associated only to potato farming was considered. Toward this end, farmer's perception of risk in farming was expected to vary significantly across adoption categories.

With regard to potato production, water lodging, frost, and pest incidence, and disease unreliability or rainfall and decline of soil fertility were the major source of risk in the study area .Farmers risk perception was measured on five points scale at the farmer who perceive that the source of risk under consideration is not threat for potato production was given the value 1(very low). On the other hand, the farmer who perceive that the specified source of risk is threat was given value 5(very high).Then, farmers risk perception index was taken as the sum of farmer's perception of each source of risk divided by the number of source of risk.

Table 25. Risk perception of the technology and adoption of improved potato production package

Adoption Category	N	Mean	SD	F value	P value	r
Non	46	3.9130	.55080	2.299	.081	.056
Low	44	3.5227	1.06724			
Medium	18	3.8333	.85749			
High	12	4.0833	.79296			
Total	122	2.209	0.817			

Source: Own survey data, 2016

In line with this, this sample respondents were asked to rate their degree of perception about water lodging, frost, and pest incidence, and disease, unreliability of rain fall and decline of soil fertility as threat or not for the adoption of improved potato production.

Accordingly-test shows in table 24 that there is no significant mean difference (F=2.209,P=0.081) across adoption category in the risk perception index. The mean risk perception index i.e. 2.209 implies that sample respondent were indifferent. That means farmers perceive neither sources of risk as a threat nor not for the adoption of improved potato technologies.

4.4. Summary of Results of Descriptive Statistics

Before passing to the econometric part of the analysis it is important to summarize the results of the descriptive statistics. The overall respondent's personal and demographic, socio-economic, intuitional and psychological variables were discussed using descriptive statistical techniques. The results on each variable were demonstrated using table and percentage. In doing so, respondent were treated in four adoption categories.

The difference between adoption categories were assessed using F-test and Chi- square test statistics for continues and discrete variable respectively. The mean and SD were used to discriminate the four adoption categories for continuous variable. Out the hypothesized continues variables, participation in extension events, knowledge of the technology and perceived relative compatibility of technology were found to significantly differ across households at less than 1% level, Similarly, out the three discrete variable considered, the effect of sex of the household head and credit use were found to be significant at less than 1% and 10 % level respectively. There were also variable in both continues and discrete variables which fail to discriminate between adoption categories. Therefore, summery of the overall findings is presented in the subsequent tables

Table 26. Summary statistics of results of continuous Explanatory variable

		Adoption Category					
Variable		**Non**	**Low**	**Medium**	**High**	**F Value**	**Sig.**
EXPECFARM	**Mean**	**25.37**	**25.64**	**25.05**	**22.58**	**0.584**	**0.627**
	SD	**8.893**	**5.702**	**6.151**	**6.721**		
CULTLAN	**Mean**	**.417**	**.432**	**.485**	**.479**	**.782**	**.506**
	SD	**.193**	**.1623506**	**.2077095**	**.32809**		
total land holding	**Mean**	**.426**	**.4889634**	**.4130714**	**.598**	**2.033**	**.114**
	SD	**.223**	**.209299**	**.22517249**	**.173**		
MKTDIST	**Mean**	**10.004**	**12.94**	**7.64**	**13.68**	**2.859**	**.040**
	SD	**7.83**	**8.632**	**8.970**	**14.643**		
FARMINC	**Mean**	**17021.76**	**67218.25**	**31150.00**	**49840.00**	**11.316**	**.000**
	SD	**12178.156**	**39546.298**	**19132.99**	**13392.65**		
NONFARMINC	**Mean**	**12472.78**	**35856.77**	**30488.00**	**22500.00**	**5.704**	**.003**
	SD	**11663.200**	**14733.81**	**520781.95**	**10606.60**		
DACONT	**Mean**	**4.00**	**2.99**	**2.20**	**3.67**	**1.759**	**.160**
	SD	**1.89**	**1.625**	**1.18**	**1.826**		
Land allocated for local and improved potato	**Mean**	**.263**	**.249942**	**.236184**	**.241**	**.084**	**.968**
	SD	**.319**	**.1175462**	**.0821684**	**.068**		
Frequency of listening agricultural program	**Mean**	**1.98**	**2.00**	**2.00**	**2.25**	**.792**	**.501**
	SD	**.468**	**.641**	**.612**	**.452**		
Frequently weeding potato farm	**Mean**	**2.3404**	**2.1591**	**2.4211**	**2.4167**	**2.103**	**.104**
	SD	**.47898**	**.36999**	**.60698**	**.51493**		
Participate in extension activates	**Mean**	**1.02**	**1.02**	**1.11**	**2.4167**	**2.245**	**.087**
	SD	**.146**	**.146**	**.315**	**.51493**		
Age of the household head	**Mean**	**2.04**	**2.11**	**2.11**	**2.11**	**.941**	**.423**
	SD	**206**	**.321**	**.321**	**19**		

Source: survey result, 2016.

Source Model output *, ** and*** significant at 1%, 5% and 10% levels respectively.

4.5 Result of the Econometric Model

Descriptions of the sample population and test of the existence of association between the dependent and explanatory variable to identify factors limiting adoption of improved potato production package have been discussed thoroughly in the previous section. Identification of these factors alone is how ever not enough to stimulate policy actions unless the relative influence of each factor known for priority based intervention. In this section the econometric (Tobit) model was used to see the relative influence of different personal, demographic, socio-economic, intentional, and psychological variable on adoption and intensity of adoption of improved potato production package.

Before running the model, it was also found necessary to see the problem of multi co linearity or association among the variables. In this case the VIF (Variance Inflation Factor) was applied. VIF was used for testing the association between the hypothesized continuous variables. According to Maddala (1992), VIF can be computed using the formula

$$\text{VIF } (X_{j)} = \frac{1}{1-R_1^2}$$

Where R_1^2 is equal to the squared multiple correlation coefficient between Xi and the other explanatory variables. A statistical package known SPSS was employed to compute the VIF values. To avoid the problem of multi co linearity, it is essential to exclude the variable with the high VIF value (10) which usually happen when R_1^2 exceed 0.9 or highly correlated. Once VIF values were obtained R_1^2 value can computed using the formula. The VIF value displayed in table 31 have shown that all continuous explanatory variables have no serious multicollineartity problem. Similarly, there might also be association between discrete variable. In order to test multicollineartity problem, contingency coefficient was computed for dummy variables and the result was displayed in Table 25 below.

CC = $\sqrt{\frac{X^2}{n+X^2}}$ **Where CC = contingency coefficient = sample size and** X^2 **= Chi square value**

Table 27Summary of results of continuous Explanatory variable

Variable	Co linearity Statistics	
	Tolerance	VIF
(Constant)		
farming experience	.891	1.122
size of family in the productive age	.808	1.237
total income from crop	.788	1.270
participate in extension activates related to potato production	.904	1.106
participate in field day	.888	1.126

Source: Survey data 2016

Table 28 Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.159[a]	3	.540
Likelihood Ratio	3.629	3	.304
Linear-by-Linear Association	1.464	1	.226
N of Valid Cases	122		

4 cells (50.0%) have expected count less than 5. The minimum expected count is .59.

4 cells (50.0%) have expected count less than 5. The minimum expected count is 1.24.

Based on the above tests, both the hypothesized continuous and discrete variable was included in to the model.

4.5.1 Determents of adoption and intensity of adoption of improved potato production package

These section presents and discuses empirical findings of econometric analysis, estimates of parameters of the variable expected to determine the adoption and intensity of adoption of improved potato production package are displayed in Table 26. A total of 11 explanatory

variables were included in econometric model out which 8 variables were found to significantly influence adoption and intensity of improved potato adoption. These include sex of house hold head, education status of the house hold head, distance to the nearest market center, total annual farm income, credit use, participation in extension events, radio accuse and knowledge of about the improved potato production package.

Table 29 Maximum Likelihood Estimate of the Tobit Model

Tobit regression	Number of obs	= 122				
	F(10, 38)	= 1.49e+07				
	Prob > F	= 0.0000				
Log pseudo likelihood = -12.818331	Pseudo R^2	= 0.3280				
Variable	Estimated Coefficients	Std. Err.	t-ratio	P>|t|	Interval]	95% Conf.
Sex hhh	.1883297	.0359169	5.24	0.000	.1156197	**.2610397**
Education level hh	-.1540401	.0292686	-5.26	0.000	-.2132912	**-.0947889**
Farming expense	.0014757	.0015384	0.96	0.344	-.0016387	**.00459**
Market distance	-.0156823	.0023389	-6.71	0.000	-.0204171	**-.0109475**
Radio access	-.1547905	.0331235	-4.67	0.000	-.2218455	**-.0877355**
Farm credit use	-.0124852	.0230231	-0.54	0.591	-.0590929	**.0341226**
Frequency to contact with DA	-.006742	.0080461	-0.84	0.407	-.0230305	**.0095465**
Participate in extension activities	-2.315116	.0417859	-55.40	0.000	-2.399707	**-2.230525**
Access to market	.0524022	.0179212	2.92	0.006	.0161227	**.0886817**
Rainfall situation	.1954615	.0104987	18.62	0.000	.174208	**.216715**
/cons	2.347476	.0417859	56.18	0.000	2.262884	**2.432067**
/sigma	.3137388	.0010804		.3115516		**.315926**

Log likelihood function = -128.18331, ANOVA based fit measure = .237468,

Source Model output *,** and*** significant at 1%, 5% and 10% levels respectively.

Sex of Household head: The coefficient of this variable was found to be positive and statistically significant at less than 5% probability level. This explanatory variable accounts 1.83% of the variation in adoption and intensity of improved potato production package. This shown that male-headed house households were more likely to adopt potato production package than female-headed house hold heads. The possible explanation might be male-headed households have better access to information, agricultural inputs resource endowments. This result is in conformity with the prior hypothesis.

Educational level of the Household Head: As expected, education was positively influencing the probability of adoption and intensity of use of improved potato less than 10% probability level. The model result revealed that educational level of the house hold head account for 1.54% of the variation to the adoption of improved potato production package and to use intensity of the same. This suggests that farmers with higher educational back ground would have better opportunity to access information can easily understand the benefit of improved potato use. This result supports the findings of earlier researches on technology adoption (e.g. Konya et al., 1997).

Market Distance: Distance from nearest market center was assumed to influence potato technology adoption. The finding agrees with the hypothesis in the market distance to input output is negatively and significantly associated the probability of adoption and extent of use of improved potato production package less than 5% probability level. The model result revealed that distance to nearest market of the house hold head account for 1.567% of the variation to the adoption of improved potato production package and to use intensity of the same. The negative association suggests that the likelihood of adopting improved potato production package declines as the distance from market center increases. The possible reason might be farmers farmer nearer to market center have access to production inputs and the incentive to output market than those at far distant. As market distance increase, farmer initiation for adoption of new potato technology would diminish. The result is in consistence with the finding of Yisak(2005)and Legesse et al(2001).

Off/On Farm Income: Cash is the immediate source of capital for small holder farmers to faience their farming operations. Similar to the hypothesis made in the study, the finding of Hossain and Croch(1992) in Bangladeash reported that farmer's technology adoption decision is influenced by annual farm income. The result in revealed that annual farm income was positively related with adoption and intensity of use of improved potato production package less than 5% probability level.

According to the model result, household's farm income accounted for 0.064% of the variation in adoption and intensity of adoption of improved potato production package. This is in line with the hypotheses that households who managed to earn more off/on-farm income are more likely to adopt new potato production package. This means that a farmer who has better income will be more likely to adopt and increase level of adoption of improved potato production package. On the contrary, low income and resource poor farmers face difficulty to adopt and increase level of use.

This suggests the need to support resource poor farmers to enhance the adoption process. Regarding the influence of farm income on adoption, many other studies have also found similar results. For instance, Kidane, 2001; Degent et al, 2001 and Gethaun, 2004 reported positive influence of household's farm income on adoption of improved technologies.

Access to radio: The coefficient of this variable was found to be positive and less than10% probability level, the model result revealed that access to radio of the house hold head account for 1.547% of the variation to the adoption of improved potato production package and to use intensity of the same. This result indicated those farmers who have exposure to radio are more likely to adopt improved potato technology as compared with those who did not have any accuse to radio. This study done by Yisak (2005) and Tadesse (2008) reported positive and significant relationship of mass media with adoption of agricultural technologies.

Credit Use: Credit use was also other institutional variable that was found to influence significantly the probability of adoption and intensity of use of improved potato production package less than 5%. The model result shows that credit use was found to have contribution

like other independent variable i.e. the variable accounted for a 12.48% of the variation in adoption and intensity of adoption of improved potato production package. This has an implication that credit use helps farmers to relax their limited resources for purchasing agricultural inputs. Service cooperatives distribute fertilizer and improved seed on cash basis that require 100% down payment. In this case, only those farmers who have no cash at hand will be devoid of the opportunity. Therefore improving performance efficiency of actors which are dealing with credit services is pertinent and looks for solutions to correct the defects associated with credit system. Earlier study made by different researchers also reveals the same result (Legesse 1992; Teressa, 1997; Mulugeta, 2000; Getu,2004 and Million and Belay, 2004; Tesfaye and Shiferaw, 2001).

Access to extension services (PEXTSION): The coefficient of this variable was found to be positive and statistically significant at less than 5% probability level in explaining adoption and intensity of adoption of potato technology package**.** The variable accounted for a 23.15% in the adoption and intensity of use of potato production packages. This shows that farmers who have opportunity to participate in different extension events are more likely to use improved potato than those farmers who have no similar opportunity. This is possibly because improved potato production practice would have been included in those extension events. The implication is that emphasis has to be given to farmers training, participations in demonstration and field days to enhance adoption of improved potato production package. Similar results were reported by Taha (2007), Bezabih (2000), and Nkonya et al. (1997).

Knowledge: The knowledge which farmers might have acquired earlier is important in influencing their preference to technology.. In this study, farmers who had adequate knowledge of awareness about improved potato production practices were expected to use improved cultivar and fertilizer than those who lacked this knowledge. According to the result from econometrics model, sample respondents were found to differ positively and significantly in their knowledge of awareness about improved potato production package less than 1% probability level. The variable accounted for a 6.6% variation in the adoption and intensity of use of potato production package. So, this calls for due attention to improve farmers knowledge prior to package promotion .this implies that the importance of extension

to small holder farmer, who lack sufficient education and media exposure, was found crucial in the adoption of potato production package. The finding is in agreement with Legesse (1992), Getchew (1993) and Mulugeta (2000).

Rain fall situation. Irregular rainfall patterns results in high risk of drought and intra seasonal dry spell, leading to low crop yields and sometimes total crop failure (Kinoti et al., 2010). Variability of rainfall leads to variation of potato yield, as rainfall is the main source of water for potato growth. The coefficient of this variable was found to be positive and statistically significant at less than 5% probability level in explaining adoption and intensity of adoption of potato technology package. The variable accounted for a 1.95% variation in the adoption and intensity of use of potato production package. This argument is supported by Ogola et al. (2011).

4.6. Effect of Change in the Explanatory Variable on probability of Adoption and Use of Intensity of Improved Potato production package

All variables that were found to influence the adoption and intensity of use of potato technologies might have no similar contribution in influencing the decision of farm household. Hence, using a decomposition procedure suggested by McDocnald and Mofffitt (1980), the result of Tobit model can be used to assess the effect of change in the explanatory variable in to adoption and intensity of use of improved technologies. Based on this fact, the effect of changes in the explanatory variables on the probability of adoption and intensity of use of improved potato production package was computed and the results are summarized in Table 30

The marginal effect of Tobit model analysis showed that male-headed households were better in the use of improved potato technology as compared to female-headed households. Accordingly, as the status of sex of the household head being male, the probability of adoption of improved potato production package and use extent also increase by 18.83% and 11.79% respectively.

With regard to the level of education of the house hold head, on the average, a unit increase in years of schooling of the household head increase the probability of adoption and use of extent of potato production back age by 15.4% and 21.1% respectively. A unit increase in the market distance from farm household residence reduces the probability of adoption and intensity of use of improved potato production package by about 1.568% and 2.026 respectively.

According to marginal effect analysis, a unit increase in annual farm income increase the probability of adoption and intensity of improved potato production package by about0.0064% and 0.0060% respectively. This implies that lower income group and resource poor farmers may find it difficult to adopt improved potato production package and hence they need to get support through schemes.

The marginal effect of credit use on the overall improved potato production package adoption was 3.2%. Showed that credit use increased the probability of adoption among non-adopter and adopters by 12.48% and 5.76% respectively

Table 30. Effect of changes in probability of adoption and intensity of use due to change explanatory variables

Average marginal effect number of obs = 122
Model: Robust
Expression: Leaner Prediction, Predict ( )

	Delta method					
	dy/dx	Std. error	z	p>|z|	95% Conf.	Interval
Sex hhh	.1883297	.0359169	5.24	0.00	.1179339	.2587256
Education Level hh	-.1540401	.0292686	-5.26	0.00	-.2114054	-.0966747
Farming experience	.0014757	.0015384	0.96	0.337	-.0015396	.0044909
Market distance	-0156823	.0023389	-6.71	0.00	-.0202664	-.010982
Radio access	-.1547905	.0331235	-4.67	0.000	-.2197113	-.0898696
Farm credit Use	-.0124852	.0230231	-0.54	0.588	-.0576095	.0326392
Frequency to contact with DA	-.006742	.0080461	-0.84	0.402	-.0225121	.0090281
Participate in extension activities	-2.315116	.0417859	-55.40	0.000	-2.397015	-2.233217
Access to market	.0524022	.0179212	2.92	0.003	.0172774	.087527
Knowledge recommended input	0	omitted				
Rainfall situation	.1954615	.0104987	18.62	0.000	.1748844	.2160385

Sample respondent's participation in extension events increase probability of adoption and intensity of use improved potato production package by 23.15 % and 23.97 % respectively The implication is that more emphasis should be given to strengthen instructional supports in improving farmers' participation in extension so as to enhance adoption of improved potato production package. Similarly a change in knowledge level of sample respondents' about improved potato production package brings about 5.85% increases in probability of adoption and 3.6% increase in intensity of use of the technology by adopter.

5. SUMMARY, CONCLUSIONAND RECMMONDATION

This chapter presents summary, conclusions and recommendations of the study. The conclusions were made and recommendations were pointed out based on the results of the study.

5.1. Summary and Conclusion

The study area, Haramaya district, is one of the potential potato producing districts found in eastern part of the Oromiya regional state. The main theme of this study was examine adoption of potato production package and determines different factors affecting adoption and intensity of use potato production packages**.** A total of 122 sample households drawn from 5 kebeles of the district were interviewed using structured interview schedule. Qualitative data were collected using group discussion among selected potato growers and extension development agents who were working in the respective *kebeles.*

The analysis was done with the help of descriptive and econometric tools employing SPSS and STATA software. Mainly Chi-square test and F-test were used to test the variation of the sample group they have towards adoption of Potato production package. The econometrics model Tobit was employed to estimate the effects of hypothesized independent variables on dependent variable. The summary of the study results are discussed here under.
All recommendation practices of the potato production package are not practiced in the study are, Such as Chemical fertilizer application. Further there is a variation in the adoption of package components; some practices like seed rate and fertilizer application are below and above the recommendation. The variations in adoption of the package practices among the households were assessed from the point view of various factors which influence farmers' adoption behavior. These influencing factors are categorized as social and economic, personal and demographic institutional and psychological factors. Most of the variables assumed to influence the adoption behavior were significantly associated with the adoption and intensity of adoption of improved potato production package.

Among the personal and demographic factors educational status and sex of the household head were significantly related to the intensity of adoption of improved potato production package. From a total of 122 sample households 6 were female households. Among these women households 3 of them were categorized under the low level of adoption category the other four female respondents were non adopters. This implies that male farmers were given more attention for potato production as compared to female counter parts. Education status of the household head was also having positive relationship with the intensity of the adoption of the potato production package**.** Besides, adopter groups constitute larger proportion of farmers with longer years of farming experience than non adopter groups. With regard to the households' Scio-economic variables, adopter groups have relatively larger man equivalent and annual farm income compared to non adopter groups indicating that labor availability and farm income was found to be positively and significantly related with adoption and intensity of adoption of improved potato technology.

Moreover, among psychological factors, knowledge level of the household head about the technology package and perceived compatibility of technology package practices with farmer's circumstances were found to be positively and significantly related with adoption and intensity of adoption of improved potato production package.

In the case of institutional variables, frequency of contact with extension agent, participation in extension events, access to radio and access to credit were also have positive and significant relationship with adoption and intensity of adoption of improved potato production package. In contrast, distance to the market centers was found to have negative and significant relationship with adoption of the same. This shows that the adopter groups have high frequency of contact with extension agent, better participation in demonstration, field day and training, better access to credit and are located nearer to market centers compared to non-adopter group.

The farmers' selection and evaluation criteria of improved potato verities were also conducted through the group discussions. In this respect ,Yield advantage, Earliness in maturity, Ease of adaptability, Market demand, Water lodging Tolerance, Storability, potato Quality, Frost

resistance, Disease resistance, Pest Resistance, Tuber size, eye depth, shape, Taste, Cooking time, were the most important characteristics selected by farmers. Based on this selection criteria onion growers in the study area choose Babuu variety among the seven varieties disseminated to the study area.

Then again, results of econometric model pointed out the relative influence of different variables on probability and intensity of adoption of improved potato production package. Thus, sex, educational level, annual farm income, credit use, participation in extension events, and knowledge level of the household head were found to have significant influence on adoption and intensity of adoption of improved potato production package .Contrary to this, distance to market center had shown negative and significant relationship with adoption and intensity of adoption of the same.

5.2. Recommendation

In areas like Haramaya district were ever-increasing population pressure, land fragmentation and the impossibility of sustaining farm families' livelihoods from cereal production it is wise to intensively utilize existing farm land efficiently through the use of technology by growing high value crop like potato. Potato production highly profitable business. Its contribution to household’s nutrition, income and food security is very high. It is also provides job opportunities particularly for young farmers and landless poor. Regardless of its contribution, however, the emphasis given nationally to the sector is relatively low compared to other crops. As a result of this, institutional support provided to this sector, such as credit service and participation in extension event were not to the expected level. These factors coupled with other household personal, demographic, socio-economic and psychological factors greatly affected the adoption and intensity of use of improved potato production packages and productivity of the sector. Based on the research findings of this study, following points are recommended to improve farmers’ adoption of improved potato production so as to increase production and productivity

- In this regard, research and extension effort need to be linked and strengthened to increase the flow of information to and from farmers
- To facilitate the diffusion of improved potato production package it is important to develop suitable agricultural program for broadcasting on community based FM radio
- Inputs supplier organizations should distribute timely the same to end users.
- Farmers´ participation in extension service related to improved potato production package has to be enhanced before technology distribution.
- Opportunities for equal access of woman and resource poor farmers should be provided through provision of credit and empowerment intervention
- Poor farmers should be supported through special arrangement of credit service
- Adaptive measures like expanding of irrigation, use of high yielder and, drought-tolerant variety of potato has to be adapted

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7 APPENDIX

Appendix 1. Conversion factor used to compute Man- Equivalent

Age Group (years)	Male	Female
Less than 10	0	0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1.00	0.8
Greater than 50	0.7	0.5

Source Storck, *et at*. (1991)

Appendix 2. Conversion factor used to estimate Tropical live stock Unit

Animal Category	TTLU	Animal category	TTLU
Calf	0.25	Donky(YOUNG)	0.35
Weaned Calf	0.34	C amel	1.25
Heifer	0.35	Sheep&Goat(adult)	0.13
Cow &Ox	1.00	Sheep&Goat(young)	0.06
Horse	1.10	Chiken	0.013
Donkey(adult)	0.70		

Source Storck, *et at*. (1991

Appendix 3. Questioner used to collect data

Interview Schedule

PART I: Household General and Demographic Characteristics

Respondents Demographic Characteristics

Name of the hold head of house hold

NO	Name of head of house numbers	Sex	* Age category	Age	Educational level
1			<10		
2			10-14		
3			10-14		
4			4) >50		
5	Total				

2. Name of the house hold head……

3. Marital Status: - 1. Married 2. Single 3. Divorce 4. Widowed

4. Religion: - 1. Orthodox 2. Muslim 3. Protestant 4. Others

5. How long have you been in farming activity (in years)? ……

6 How long have you been in potato production (in years)? ……

7. Are you a member of any organization? 1. Yes 2. No

8. If yes, mention the type of organization.

1) Cooperatives 2) Farmers Group 3) Idir

PART II: Farm Characteristics

9. Do you own land? 1. Yes 2. No

10. If yes, when do you own Land? ---------- E.C

11. From the total land owned, how many ha was allotted for the following?

SN	Farm Data	Size in hectare
1	Cultivated land	
2	Grazing land	
3	Forest land	
4	Homestead land	
5	Total land holding	

12. Do you lease in land for potato production? 1. Yes 2. No

13 If yes, why did you rented in land? ……

14. Land size rented in? ---------- (in ha)

15. Do you lease out land? 1. Yes 2. No

17. Why did you rented out land ……

18. Land size rented out? ---------- (in Ha)

PART III: Socio-Economic Factors

A. LABOUR AVAILABILITY

20. What are the sources of labor for potato production?

1. Family labor 2. Hired labor 3. Relatives 4. Exchange labor 5 Others, specify

21. Family labor situation

Age	Male in number	Female in number	Total
<10			
10-14			
15-50			
>50			

22. Do you face labor shortage in potato production? 1. Yes 2. No

23. If yes, how do you solve labor shortage?----------

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1. Family labor 2.by hiring 3. Labor pooling mechanism (Guzza) 3. Others, specify ,Exchange labor

24. For which activities do you demand more labor?

1) Land preparation 3) Weeding 5) cultivation 7) Marketing

2) Planting 4) harvesting 6) transportation 8) others, specify

B. MARKET INFORMATION

25. Did you sell farm produces during last cropping season? 1. Yes 2. No

26. If no, why? ----------

---

27. If yes, where did you sell farm products?

1. at farm gate 2. Markets 3. District town 4. Others/specify----------

28. To whom did you sell? 1. Traders 2 Consumers 3. Others/specify

29. How far is your residence from the nearest market place (in km)? ----------

30. How long will it take to reach to the nearest market (in minutes)? ----------

31. Do you feel there is transportation problem in your locality? 1. Yes 2. No

32. If yes, what do you think is the problem?

1. No favorable road 2. No transport vehicle 3. High cost of transportation 4. Long distance nearby market 5. Lack of pack animals 6. Others (specify)

33. How do you see access to market in your area? 1. Poor 2. Medium 3. Good 4,No

34. How does poor market access affect potato production? Put choice(possible) --------

C. SOURCES OF INCOME

35. Cash income from crop sale during last cropping season.

Type of crop	Amount sold in quintal		Unit price	Total Birr Received
	improved	local		
Potato				
Onion				
Maize				
sorghum				
khatat				

36. Cash income from sales of livestock during last cropping season

Item	No of Animals Sold	Unit price	Amount of Birr Received
Oxen			
Bulls			
Calves			
Cows			
Heifers			
Sheep			
Goats			
Mule			
Donkey			
Chicken			
Beehive			
TOTAL			

37. Income generated from the sale of livestock products during last cropping season

Item	Amount in Sold	Unit measure	Unit price	Total birr in 20114/15 E.C
Milk				
Butter				
Egg				
Hides				
Skins				
Other income source				
Total				

38. Mention the Non-farm activities the farm family participated and estimated income from the respective activities during last cropping season?

SN	Non-farm Activity	Status of engagement(v)		If engaged in, amount of income in Birr/year
		Engaged in (1)	Engaged in(2)	
1 Shopping				
2 Grain trading				
3 livestock trading				
4 Casual labor				
5 Charcoal making				
6 Salary employment				
8 Brewing				
9 Pottery				
10 Carpentry				
11 Remittance				
12 Gift				
13 Other, specify				

39. Reason for not participating in off farm activities

1. I do not have extra time for non-farm activity
2. Non-farm income is less attractive
5. I lack the skills required
6. No starting capital

3. There is no employment opportunity 7. Have enough farm

4. Town is where the opportunity exists, It is far from our village

8, Other reasons, specify

40. Do you have a radio? 1. Yes 2. No

41. If yes, How Often do you listen agricultural program?

1. Rarely 2. Some times 3. Frequently

42. If you don't listen to agricultural program, why?

1. No time to listen 3.It is not important 4,I don not have Radio

2. Not aware about the program 4. Transmission Time is not convenient 5. Others

43. If you don't not have radio, what are your sources of information on improved potato technologies?

1) Research Center 3) NGO 5) Key informants 7) Market

2) Development Agent (DA) 4) Cooperatives 6) Fellow Farmer 8) Others

PART IV: Institutional Factors

A. UTILIZATION OF CREDIT

44. Is credit service available in your area? 1. Yes 2. No

45 If yes, have you ever used farm credit? 1. Yes 2. No

46. If you used credit, what is your source of credit?

1. Bank 4. Local organizations 7. Merchants

2. NGO 5. oromiya Credit & Saving Institute 8. Relatives

3. Friends or neighbor 6. Office of Agriculture and RD 9, cooperative society.

10. Others

47. Did you take credit during last cropping (2007) season? 1. Yes 2. No

48. If no, why? ----------

1. Lack of awareness 4. Lack of collateral 7. No access

2. No money for dawn payment 5. High interest rates 8. Others

3. Fear of crop failure 6. No need b/c I've enough money

49. If yes to qo.no.48, on what basis did you y take credit? 1. kind 2.cash 3.both

50. What amount of credit in kind did you take?

Credit in Kind	Unit	Amount Received in 2014/15 E.C	
		2014	2015
Improved seeds			
Chemicals fertilizer			
Pesticides			
Others, specify			

51. If you take credit on cash basis, for what purpose did you take and amount received?

Purpose	Amount Received i*n 2014/15 E.C* (in Birr)	
	2014	2015
Improved seeds		
Chemicals fertilizer		
Pesticides		
Others, specify		

B. EXTENSION SERVICE

52. Have you ever consulted Development Agent (EA) i*n 2014/15 E.C*?

1. Yes 2. No

53. If no, why

1. No EA nearby 2. Possessed the required information

3. EA office is far from my residence 4. I am not happy with the EA

5. No need for service 6. Others

54, did you get advice about improved potato production? 1. Yes 2. No

55. If yes, to Q 54, how frequently did you make contact with the DA last year? ----------

1, Ones weekly 5, during land preparation

2, monthly 6, during harvesting

3, Quartile

4, during planting of time

56. How far is the DA center from your house? ---------- Km --------- hrs on foot.

57. Indicate your participation in extension activities related to potato production?

Extension activities	Status of participation during last 2 cropping seasons? From 2014-2015 EC (√)		If Yes, No of times participated in the last 2 years	* If yes, status of potato production	If no, Why?
	1,yes	2.no			
Demonstration				1 .Decreasing 2.Same as before 3. Increasing	
Field day				1 .Decreasing 2.Same as before 3. Increasing	
Training				1 .Decreasing 2.Same as before 3. Increasing	

* 1. Decreasing 2. Same as before 3. Increasing

PART VI. Adoption of potato Production Package, Potato variety

58. Have you ever used improved potato varieties? 1. Yes 2. No

59. If no, why?

1. Not available on time 4. Too expensive 7. Not aware of the benefits
2. Not better than local 5. Cash shortage 8. Others (specify)
3. Not relevant to my farming 6. Not available in required quantity

60. Have you used improved seed during last two cropping seasons? 1. Yes 2. No

61. If yes to Q. 61, status of use during last two cropping seasons?

Variety	Status in 201 4		Status in 20115	
	Yes	NO	YES	NO
Bubu				
Gudane				
Badhasa				
Chirroo				
Zeman				
Gabisa				

62. Land allocated to local and improved POTATO varieties

Varieties	Area coverage (in Ha)	Total Yield obtained (in Ql)
Improved potato varieties		
Local		
Total		

63. How would you rate the following improved potato varieties over the local varieties?

Criteria	Rate as 1. Not Preferred, 2. Indifferent, 3. Preferred							LOCAL
	Bubuu	Gabisa	Badsa	Chiro	Zeman	Gudane	Bate/624	
Yield advantage								
Earliness in maturity								
Ease of adaptability								
Market demand								
Water lodging Tolerance								
Storability								
potato Quality								
Cooking time								
Frost resistance								
Disease resistance								
Pest Resistance								
Tuber size								
Eye depth								
shape								
Taste								
TOTAL								

64. Among the improved POTATO varieties, which one do you prefer most? ----------

65. Why? ----------

---

66. Take five most superior characteristics and rank them in order of importance

No	Criteria	Rank
1	Yield advantage	
2	Earliness in maturity	
3	Ease of adaptability	
4	Market demand	
5	Eye depth	
6	Resistance to water lodging	
7	Storability	
8	Test food	
9	Cooking time	
10	Frost resistance	
11	Disease resistance	
12	Pest Resistance	
13	Tuber size	
14	shape	

ii. FERTILIZER USE

67. Have you ever used chemical fertilizers for potato production? 1. Yes 2.No

68. If no, why?----------

1. Not available on time 2. Lack of knowledge of application 3. Not relevant to my farm 4. Too expensive 5. Cash shortage

6. Market problem 7. Not aware of the benefits 8. Others (specify) ----------

69 If yes, did you use fertilizer for potato growing last cropping season? 1. Yes 2. No

70. If yes, mention the amount you used

Type of fertilizer	Amount used (Kg)	Area fertilized (Ha)
DAP		
UREA		

iii. **PESTICIDES USE**

71. Was there any pest problem in potato production? 1. Yes 2. No

72. If pest is a problem, have you use pesticide in the last two cropping seasons?

1. Yes 2. No

73. If no to 73, what measures did you take to control? Mention some traditional method ------

---

74. If yes to 73, mention your practice on pesticide rate of application. ----------Lt/Td

75. Mention at least one type of pesticides you used? ----------

v. FREQUENCY OF CULTIVATION AND WEEDING

76. Is weed a major problem for potato production? 1. Yes 2. No

77 How frequently did you cultivate your potato farm?

1. Once 2.Twice 3.Three times

78. How frequently did you weed (if any) your potato farm? During one cropping season?

1. Once 2.Twice 3.Three times

79. Where did you get inputs ?

1. Minister of natural resource and Agriculture 2. Market

3. Research centers. 4, Cooperatives society 5. Neighbor 6. NGO 7. Universities 8, Others, specify

80. If inputs are not available on time, why? ----------

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vi. PERCEPTION RELATED VARIABLES

81. How do you perceive compatibility of the recommended rate of the following components of potato production package over the consistency of the three criteria?

Compatibility of		Rating (√)		
		1.Less compatible	2. medium	3.Highly compatible
Improved potato	existing house hold income			
	Past experience			
	Physical environment			
Fertilizer rate with	existing house hold income			
	Past experience			
	Physical environment			
Planting date with	existing house hold income			
	Past experience			
	Physical environment			
Frequency of cultivation with	existing HH house hold income			
	Past experience			
	Physical environment			
Frequency of weeding with	existing house hold income			
	Past experience			

	Physical environment	
Total Score		

KNOWLEDGE

82. Do you know the recommended seeding rate for potato production 1? Yes 2. No
(1 point if the answer is yes, 0 otherwise)
If yes, what is the amount of seed per hectare in quintals?
83. Do you know the recommended fertilizer rate (DAP) for potato production rate? In KG
1. Yes 2. No

If yes, what is the amount of DAP fertilizer rate per hectare for potato production? kilo gram?
84. Do you know the recommended fertilizer rate (UREA) fertilizer rate per hectare for potato production?

1. Yes 2. No

If yes, what is the amount of UREA per hectare in kilo gram?
85. Do you know the recommended planting date for improved potato production?
1. Yes 2. No
If yes, what is the interval of planting date of potato production?
86. Do you know the recommended frequency of weeding for improved potato to be 2-3 times?
1. Yes 2. No
If yes, mentions the frequency of weeding.

87. Do you know the recommended frequency of cultivation for improved potato production?
1. Yes 2. No
If yes, mention the number times for potato production
88. Do you know that spacing is recommended for improved potato farming? 1. Yes 2. No

If yes, mention the spacing between raw in cm and between tubes……..in cm

89. Mention the name of three improved potato varieties. (3 point)

1.---------- 2. ---------- 3. ----------

90, Do you know types of major diseases that affect potato crops?

If yes, Mention some…….

91, Do you know the symptom these disease show?

Yes No, If yes, Mention some ……

92, Do you know the types of controlling methods of the above disease? Yes No,

If yes, what are the controlling methods? a) Modern one b) chemical c)others

If the above is chemical what type of chemicals?.....

Risk perception in potato production

93 . Indicate your degree of feer of environmental risk in potato production

Physical environment	Rating environmental risk conditions ((√)				
	Very low(1)	Low (2)	medium(3)	high(4)	Veryhigh(5)
Drought w					
Water loading					
Pest incidence					
Disease incedece					
Rainfall situation					
Total score					

94. In general, from your experience, what are the limiting factors in improved potato production?

1. High production cost
2. Low selling price of potato
3. Lack of marketing information
4. Shortage of fertilizer
5. Lack of enough extension support
6. Water lodging
7. Lack of credit
8. Lack of knowledge on improved potato production