Adoption of Improved Lentil Varieties among Smallholder's farmers in Gimbichu District, East Shewa Zone, Oromia Region, Ethiopia

MSc. THESIS

BY

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ADOPTION OF IMPROVED LENTIL VARIETIES AMONG SMALLHOLDER’S FARMER IN GIMBICHU DISTRICT, EAST SHEWA ZONE, OROMIA REGION, ETHIOPIA.

A Thesis submitted to the Department of Agricultural Economics and Agribusiness Management

In partial Fulfillment of the Requirements for the Degree of
MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS

BY
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DEDICATION

This Thesis is dedicated to all my family specially my beloved mother, who passed away without seeing my achievement.

STATEMENT OF THE AUTHOR

First, I declare that this thesis is my bona fide work and that all sources of materials used have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for the M.Sc. degree in Agricultural Economics at Jimma University and 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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Date of submission: **August, 2020**

BIOGRAPHICAL SKETCH

The author was born from her father Assefa Tolla and her mother Birhana Geda in Adiss Abeba, in 30 May 1995. She attended her primary and secondary school at Adiss Abeba and completed her secondary school at Adiss Ketema Perpatory School in June 2012 G.C. After successful completion of Ethiopian school leaving certificate examination, she joined Jimma University college of Agricultural and veterinary medicine in Agro-economics department and Graduate with BSc degree in June 2015G.C. After graduation, she was employed in the Ethiopian Institution of Agricultural Research, Debrezeyit Research Center in junior research until she joined the school of Graduate studies to pursue her further education for MSc in Agricultural Economics at Jimma University in October 2018G.C.

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ABBREVIATIONS AND ACRONYMS

CSA	Central Statistics Agency
CIMMYT	International Maize and Wheat Improvement Center
DZARC	Debreziet Agricultural Research Center
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization
FTC	Farmers' Training Centers
GDP	Gross Domestic Product
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
LDCs	Least developed Countries
M.a.s.l	Meter above sea level
NGO	Non-governmental organization
SNNPR	South Nation Nationality People of Representative
TLU	Tropical Livestock Unit
UN	United Nations

ABSTRACT

Lentil (Lens Culinaris Medikus) is among the oldest domesticated crop in the world. Lentil plays significant role in human and animal nutrition. It also helps in the maintenance and improvement of soil fertility. Adoption of improved technologies is one of the most promising ways to ensure food security and alleviate poverty in Ethiopia. However, the adoption and dissemination of these technologies is constrained by various factors. To this end, the aim of this study was to empirically identify the determinants of adoption and intensity of adoption of improved lentil varieties in the study area. In this study, two stage sampling procedure was followed to select the sample respondents. First four lentil growing kebeles were randomly selected from the 26 lentil producing kebeles of the district. In the second stage: 166 sample respondents were randomly selected based on probability proportional to size for the interview purpose. Semi-structured interview schedule was developed, pre-tested and used for data collection the study from the sampled households. Both primary and secondary data were used for this study. The collected data was analyzed by descriptive statistics and double hurdle econometric model. Probit model was employed for adoption decision and truncated model for level of decision. The probit model statistics shows that from the total 13 variables, 7 of them show statistically significant difference with the adoption decision at 1%, 5% and 10% level of significance depicted that sex headed household, TLU, family size; cooperative membership, extension service, total land size and education affected the likelihood of adoption of improved lentil varieties positively and significantly. The truncated model results were positively and significantly influenced the intensity of use of improved lentil varieties production in the study show that the level of adoption has significantly active labour force, TLU, family size and access to credit. Finally, the study recommends that, adoption and intensity of use of improved lentil varieties should be given due attention for enhanced by rising farm household asset formation, and providing extension and credit services.

Key words*:* Adoption, improved lentil variety, double hurdle, household, Gimbichu district, Ethiopia.

1. INTRODUCTION

1.1 Background of the Study

The economic development of Ethiopia is highly dependent on the performance of its agricultural sector. Agriculture contributes 42 % of the GDP of the country and about 85 % of the population gains their livelihood directly or indirectly from agricultural production (CSA, 2015).

Addressing food security and poverty problems in agriculture-based economies demand for substantial efforts in improving agricultural production and productivity (WDR, 2008 cited in Moti*et al*., 2013). Since the 1950s and 1960s, agricultural research centers (both national and international institutes) have been generating a number of agricultural technologies that best fit to smallholder farmers and help increasing production and productivity. Among these technologies are many improved crop varieties, widely disseminated (Maredia *et al*., 2000; Alene *et al*., 2009). Recent studies witnessed the clear contributions of these technologies to the welfare of smallholder farmers and other poor households who benefited from the enhanced adoption of technologies and improved agricultural productivity and production over time (Alene *et al*., 2009; Kassie *et al.*,2011; Asfaw, *et al*., 2011).

Pulse food like lentil crops provides nutritional security to low income consumers a sits seed contains high amounts of digestible protein, macro-and micro nutrients, vitamins, fiber and carbohydrates for balanced nutrition. Lentil straw is a valued animal feed throughout West Asia, North and East Africa regions, and sometimes financial returns to farmers equal that from seed (Sarker, 2018).According to the 2007 CSA report lentil mainly depends on soil type, altitude and agro-ecologic conditions relationship between agro-climatic conditions and pulses production. In Ethiopia, lentil grows between 1700-2400m.a.s.l. with annual rainfall ranging from 700-2000 mm. and grown on black vertisols.

The average annual total harvests of lentil for the last ten years in Ethiopia were about 90,159.63 tons of grains from about 92,998.61 hectares of land (CSA, 2004-2013). Ethiopian

Central Statistical Agency (CSA, 2017) indicates, Pulses grown in 2016/17 covered 12.33% (1,549,911.86 hectares) of the grain crop area and 9.69% (about 2,814,633.20tone) of the grain. Lentil to put fifth stage under pulse crop planted to area coverage 0.90% (about 113, 684.63 hectares) production in quintals 0.57% (166,274.220 productions in tone) compared to other major pulse crop lentil is low production (CSA, 2017)

In addition to the low rate of adoption of modern agricultural inputs, the decreasing size of farms, which resulted in shorter fallow periods and even continuous cropping, contributed to the low productivity of the agricultural sector. Technology adoption is among the most revolutionary and impactful areas in agriculture sector. Agricultural innovations also play a significant role in fighting poverty, lowering costs of production (Kassie*et al*., 2011). Improving the livelihood of rural households in the course of agricultural productivity would remain a mere wish unless the level of technology adoption is improved (Gemeda*et al*., 2007, Ajayi*et al*., 2013). In such regards, adopting agricultural technology become a concern of agricultural experts, policy makers, agricultural researcher, and other stakeholder.

In Ethiopia, evidences indicate that the adoption rate of modern farm technologies including improved seeds is low. For example, at national level, the proportion of farm land area under improved seeds in the *belg*-season (2014) is 5% (CSA, 2014).Chickpea adoption study was conducted by Teklu (1998), to monitor use of chickpea technologies in Lume and Gimbichu. He assessed the adoption of Chalew, an improved variety, by demonstration participants and non-participant farmers. The result showed that 80% of participant and 20% non-participant farmers adopted the variety in 1996/7.

Small scale farmers in Ethiopia grow various crops for own consumption and economic benefits specially for the East Shewa zone based on Agro- ecological for grown to choose among pulse the first one lentil. The national agricultural research system has generated (released) a number of improved varieties to get high yield and resistant to pests and diseases, drought tolerant and early maturing.

Breeding program is based at the Debreziet Agricultural Research Center (DZARC) of the

Ethiopian Institute of Agricultural Research (EIAR). It is aimed at developing and popularizing improved lentil cultivars, and enhancing their crop management technological packages. The breeding program released seven superior improved lentil varieties (National Pulses Value Chain Development Strategy of Ethiopia Working Document 2016-2020, August 2015). But, According to the expert pane, the strong partnership between the lentil improvement program and ICARDA are instrumental in release of 12 improved lentil varieties. Most of these varieties have been promoted for use among smallholder farmers in the major lentil production areas of the country. Only the 4 released improved lentil varieties are currently under cultivation by smallholder farmers in Ethiopia (research report, 2016).

In East Showa Zone the national agricultural research system has generated a number of improved technologies and recommendations such as crop variety, agronomic practices, crop protection measures as well as other technical advises and practices. In Gimbichu district improved lentil technologies are being promoted by research center. The technologies promoted include improved lentil varieties, recommended fertilizer rates and types, improved agronomic and weed control practices.

The adoption and intensity of use of agricultural technologies are not yet assessed in the study area. This study provided primary information on the factors affecting adoption and intensity of adoption of improved lentil technologies in the study area. It also addressed the constraints of improved lentil production.

1.2 Statement of the Problem

In Ethiopia, adoption of improved agricultural technologies has been a long term concern of agricultural experts, policy makers, and agricultural research and many others linked to the sector. However, evidence indicates that adoption rate of modern agricultural technologies in the country is very low (Kebede *et al.*2009).

Lentil, among other food legumes, plays a significant role in human and animal nutrition and in soil health improvement (Abraham, 2015).Use of improved seed holds the key to sustainable food crop production across the globe because seed is the basic agricultural inputs that brought improvement of agricultural productivity (Pelmer, 2005). Ethiopia experienced chronic poverty and food insecurity problem for a sustained. One of the reasons for the prevalence of food insecurity is low rate of adoption of improved farm inputs. In fact different agricultural technologies have been released to improve productivity of smallholder farmers in the country (Hailu, 2008) but according to CSA 2014/15 recent data indicated that out of total pulse crop less than 1% of pulse land in annually covered with improved seed. As result the production and productivity of lentil crops in the study area decreased due to the use of low yielding local cultivars, biotic and a biotic constraints, and poor management practices (Mussema, 2016).

In Gimbichu district, improved high yielding lentil varieties have been popularized by stakeholders in which was tested by the Ethiopian National Seed Industry and Ethiopian Institute of Agricultural Research (EIAR). However, farmers' adoption is very low due to different factors (WoARD, 2016). Several studies analyzed the determinants of improved (cereal and pulse) variety adoption in Ethiopia (Feleke and Zegeye, 2006; Tura *et al*., 2010; Legese *et al*., 2011; Masresha *et al*., 2017). However, none of these researchers conduct to assess the farmers' perception on lentil technologies, which is the focus of the present study.

To promote higher adoption and understand of the reasons, why farmers adopt or reject the recommended technology is an important concern for the people dealing with agricultural development. Most commonly studied internal factors that affect adoption and use of agricultural technologies are farmers' attitude towards risk (Feder *et al.,* 1985), household characteristics that affects the level of production and consumption, resource endowments, etc. External factors could be access to technologies, in particular through a well-developed seed system (Byerlee and Heisey, 1996; Croppenstet *et al.*, 2003; Alemu *et al*., 2008;Shiferaw *et al*., 2008; Asfaw *et al*., 2011), infrastructure, institutions (Beke, 2011) markets and enabling policy environments (Maredia *et al*., 2000; Smale *et al*., 2011),

Therefore, this study was proposed to identify the determinants of the adoption and intensity of use of improved lentil varieties and exploring farmers' perception towards the varieties in Gimbichu district. Smallholder farmers' participation in lentil production is far below the available potential and the current demand for its product. This indicates that there are external and internal (household specific) factors that constrain some households from participation in the activity. Therefore, this study attempts to fill the gap of information's on production.

1.3 Research Question

This study was tried to address the following research questions:

1. What are the determinants of adoption and intensity of use of improved lentil varieties in the study area?
2. What are the constraints of the lentil production?

1.4 Objectives of the Study

1.4.1 General Objective

The general objective of this study was to assess smallholders' adoption of improved lentil varieties in Gimbichu district of Oromia region, Ethiopia.

1.4.2 Specific objectives

- ❖ To identify the determinants of adoption and intensity of improved lentil varieties in the study area and
- ❖ To identify the constraints of lentil production in the study area.

1.5 Significance of the Study

A complete understanding of farmers' behavior on adoption of improved varieties in a different environment is necessary to design appropriate strategies to harness their potential benefits in target domains (Shiyani *et al*., 2000). The information about decisions on matters of new agricultural technologies is important for designing more productive research and extension programs. Researchers and extension workers engaged in development and transfer of lentil production technologies can utilize the results of this study in setting research and extension agenda. Information on farmers' perception about technology characteristics were gives a feedback and enables researchers to modify and redirect research activities towards the most pressing problem.

Therefore, the study enabled us to identify important factors which hinder success in the adoption and intensity of use of improved lentil varieties in the study area. Research and extension specialists can utilize the results of this study in modifying research and extension activities. Also development policy makers can benefit from the result of this study since they require micro level information to formulate suitable policies.

1.6 Scope and limitation of the Study

1.6.1 Scope of the Study

The study focused only on adoption of improved lentil varieties production. This study was undertaken in one district, namely Gimbichu district, which is found in the Oromia regional state. The study focused only on smallholder farmers, the adoption of new technology is influence by many factors. A factor which is found to enhance adoption of a particular technology in one locality at one time might be found to hinder it or to be irrelevant for adoption of the same technology in another locality at the same or different time for the same or different crops.

1.6.2 Limitation of the study

In data collection was used cross-sectional data due to the bound of time and thus, unable to explore the dynamic nature of the process of adoption by households. The study focused only on smallholder farmers that of adopters and non-adopters of improved lentil varieties. In addition, the study had confined to only one district in terms of area coverage and it focused on lentil growing farmers. The information was ex- post facto (reports of past events), and the farmers in the study sites may not have given accurate information due to memory lapse, since most of the farmers are don’t keep records of operations.

2. LITERATURE REVIEW

2.1 Concepts and basic Definition

Rogers (1983) defines the adoption process as "the mental process an individual passes from first hearing about an innovation to final adoption". Adoption is the degree of use of a new technology in the long-run equilibrium when the farmer has full information about the technology and its potential uses, whereas the aggregate adoption is measured by the aggregate level of use of a specific new technology within a geographic area or within a given population. As Feder *et al*. (1985) defines adoption is classified into individual and aggregate adoption according to its coverage. Individual adoption stands for the farmer's decisions to introduce a new technology into the production process. Aggregate adoption on the other hand is the process of transmission of a new technology within a region or population as a whole.

Egge*et al*.(2002) as cited by Ray(2001) Adoption is viewed as a variable representing behavioral changes that farmers undergo in accepting new ideas and innovations in agriculture. The term behavioral change refers to: desirable change in the knowledge, understanding, and ability to apply technological information; changes in feeling behavior such as changes in interest, attitudes, aspirations, values and the like; and changes in overt abilities and skills.

Tegegne(2017)as cited by Roger, (1983) defines the aggregate adoption as the process by which a technology is transferred through certain channels over time among the members of social system. The author brought four elements of adoption; the first one is technology that represents the new idea, practice, or object being diffused, the second communication channels which represent the way information about the new technology flows from change agents (extension, technology suppliers) to final users or adopters (e.g. farmers), the third time period over which a social system adopts a technology, and the fourth social system itself.Final adoption at the individual farmer's level is defined as the degree of use of a new technology in long-run equilibrium when the farmer has full information about the new technology and it's potential.

Many studies on the adoption of technology have been conducted in developing countries. However, because of natural resources, cultural, political, socioeconomic, and institutional differences, the importance of factors affecting technology adoption differs across countries. Technology adoption studies showed that factors influencing adoption differed by location. Therefore, there is a need to conduct specific studies on technology adoption in areas where extension and research programs are implemented to understand the important factors affecting adoption in these areas (NKonya, Schroeder & Norman, 1997).

Diederen (2003) as cited by Feder *et al*.(1982) Adoption of technological innovations in agriculture has attracted considerable attention among development economists because the majority of the population of less-developed countries (LDCs) derives its income from agricultural production and because new technology apparently offers opportunity to increase production and income substantially. Agriculture progresses technologically as farmers adopt innovations. The extent to which farmers adopt available innovations and the speed by which they do so determines the impact of innovations in terms of productivity growth.

2.2.Stages of Adoption Process

The five stages for the innovation-decision process of classical adoption process model which was formulated by the North Central Rural Sociology Committee (1961) was the dominant model until it was modified by (Rogers and Shoemaker, 1971). According to Campbell (1966), the classical five-stage of adoption process model was developed from the recognition that adoption of an innovation often is not an instantaneous act. Rather, it is a process that develops over a period of time and influenced by a series of actions. The model composed of the following five stages adoption process: awareness stage (first hear about the innovation), interest stage (seek further information about an innovation), evaluation stage **(**weigh up the advantages and disadvantages of using it), trial stage (test the innovation on a small scale), and adoption stage (apply the technology on a large scale in preference to old methods). Sometimes adoption is defined as the proportion of farmers using a technology, in other cases; it is the actual proportion of field or crop area under the new technology (CIMMYT, 1993).

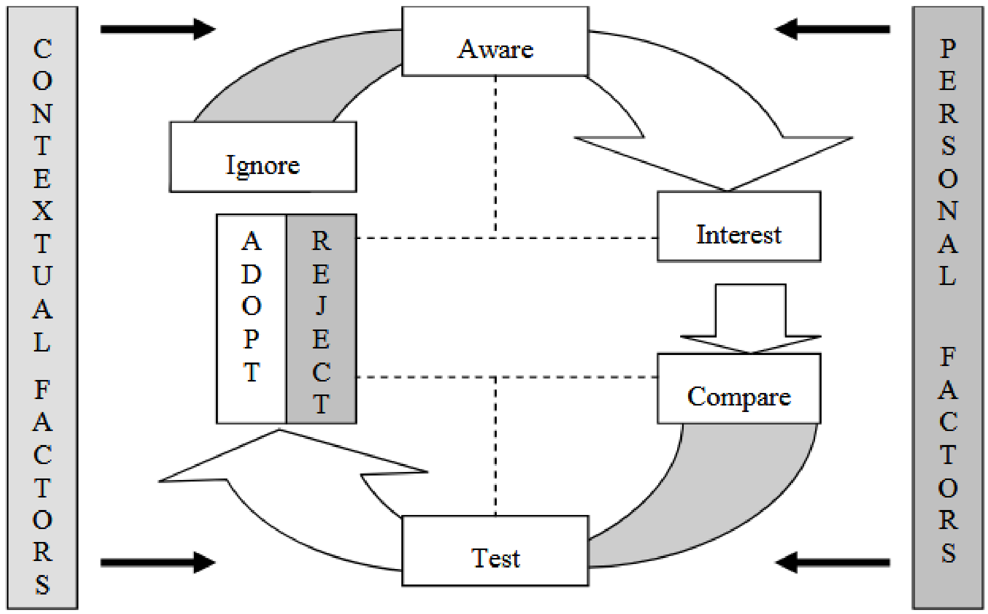

Figure 1. Stage of adoption process (Botha and Atkins, 2005)

During this stage the individual may also want, as part of the test phase, to compare the innovation with other available or possible options. They may reject it, because it failed the test. However, if the innovation passes this test, they will adopt the innovation. Once adopted, discontinued application or use is also a possibility, e.g. rejection after adoption.

According to Rogers (1962), developed a technology adoption model, generalized the use of it in his book entitled as "*Diffusion of Innovations*". He used the model to describe how technology spread in the social system. The technology adoption model describes the adoption or acceptance of a new product or technology. The process of adoption over time is typically illustrated as a classical normal distribution or bell-curve and use the mean and standard deviation to divide the normal adopter distribution categories. The model indicates that the first group of people to use a new product or technology is called innovators, followed by early adopters. Next come the early and late majority, and the last group to eventually adopt a product are called laggards. While explaining each of the categories the study defined as:

Innovators: These are the first individuals to adopt a given technology and hence they are willing to take risks, youngest in age, have the highest social class, have great financial liquidity, are very social and have closest contact with scientific sources and interacting with other innovators.

Early adopters: These are those groups of individuals who are typically younger in age, have a higher social status, have more financial liquidity, advanced education, and are more socially forward than late adopters, which means more discrete in adoption choices than innovators.

Early majority: Individuals in this category adopt technology after a varying degree of time. This time of adoption is significantly longer than the innovators and early adopters. Early majority tend to be slower in the adoption process, have above average social status, contact with early adopters, and seldom hold positions of opinion leadership in a system.

Late majority: Individuals in this category will adopt technology after the average member of the society. These individuals approach technology with a high degree of skepticism, and after the majority of society has adopted the technology. Late majority is typically skeptical 13 about technology, have below average social status, very little financial lucidity, in contact with others in late majority and the early majority, very little opinion leadership.

Laggards: Individuals in this category are the last to adopt a technology. Unlike some of the previous categories, individuals in this category show little to no opinion leadership. These individuals typically have an aversion to change-agents and tend to be advanced in age. Laggards typically tend to be focused on “traditions”, likely to have lower social status, lowest financial fluidity, older of all other adopters, in contact with only family and close.

2.3.Basic Concepts of Intensity of Agricultural Technology Adoption

Intensity of adoption is defined as the level of use of a given technology. When technology is adopted it is important to understand the extent to which the technology has been used by the intended group. Shiferaw *et al.* (2008) stated intensity of adoption as a measure of depth of adoption in terms of parameters such as the number of hectares planted with improved seed or the amount of fertilizer applied per hectare. The concept is necessary as adopters may claim that they have adopted the technology but comparatively they have not met the required standards (CIMMYT, 1993). Similarly, as Kisusu (2003), points out intensity use normally provides a correct measure on policy reform. For instance, low intensity may indicate that the technology introduced is not effective although it has been adopted. This avoids the generalization of technology having been adopted but in actual fact only a small amount is actually being used.

2.4.Lentil Production and its Economics Importance in Ethiopian

According to National Pulses Value Chain Development Strategy of Ethiopia Working Document 2016- 2020 selection of priority pulses for the total of the twelve pulse species grown in the country, lentil (Lens cultinaris Medik) to put the fourth ranked, in the order of their importance in terms of area coverage and volume of production. The criteria used for prioritizing these pulses were area coverage and economic benefits for market size. Faba bean, chickpea, grass pea, and lentil are the most important crop within the crop livestock production system across the East African country (ICARDA, 2017) and leguminous crops in general has better market price and hence 70-80 percent of the production is for market. The quantity grain supplied to market accounted to more than90% in some legumes crops like chickpea lentil, and pea (Tegegne, 2017).

Table1. Lentil production in Ethiopia

Year	Total area	Total production of lentil	Yield (q/ha)
2005/06	84,895	576,032	6.79
2006/07	97,110	810,494.22	8.35
2007/08	107,427	941,027	8.76
2008/09	94,946	947,734	9.98
2009/10	105,956	1,237,772	11.68
2010/11	77,334	809,517	10.47
2011/12	109,895	1,280,087	11.65
2012/13	123,718	1,514,999	12.25
2013/14	125,830	1,591,212	12.65
2014/15	98,869	1,373,542	13.89
2015/16	100,692	1,339,336	13.30
2016/17	113,684	1,662,742	14.63

Source: CSA (2005/06-2016/17)

Lentil research in Ethiopia was formally started in 1972 at Debre Zeit Agricultural research center, which is National Program coordinator and has released E1-142, R186, Chalew (NEL-358),Chekol (NEL-2704), Gudo (FLIP 84-78L), Adaa (FLIP 86-41L), Alemaya (FLIP 88-63L), AlemTena and Teshale. Among these EL–142, Chekol and Alem Tena were released for the lowland dry areas. Varieties R186, Chalew, Gudo, Adaa and Alemaya were for the central, northern and south eastern highlands of Ethiopia (Bejiga and Anbessa, 1998).

Production of pulses and relative share of specific crops in Ethiopia during 2007 – 2013 among the individual pulses, faba bean accounts for the greatest portion of production, 36 %, followed by common beans (17 %), chickpea 16%, field pea (13%), grass pea (11%), lentils (6%) and soybean (1%) when seen the lentil to get benefit for consumption is high, but the production very low compared to other pulse crop. According to FAOSTAT (2015), the average world pulse production was 70 million tons during the period 2007-2011. The major producers of pulses in the world were India, Canada, Myanmar and China with a share of 25, 8, 7 and 6% in 2013, respectively. Ethiopia share in the global pulse production in 2013 was only 1.8%.

During the period 2010-2014, the total amount of pulses traded globally was 14 million tons per year. Canada is the largest exporter of pulses in the world, with market share of 29%, followed by Australia, with market share of 7.8%. Russia, Madagascar and Brazil have been entering the market aggressively in the past years. Ethiopia's share in the global market was less than 2.4% during the period 2010-2014. While pulses are grown throughout the country, and account for 13 percent of cropped land, production is concentrated in Amhara and Oromia regions, which together account for 87% of faba bean production, 95% of chickpea production, 77% of common bean production, 78% of field pea production and 93% of lentils production.

Table 1. Area coverage, production and productivity of lentil in 2015/16-2016/17

Location	2015/16			2016/17		
	Area Hectares	Production Quintals	Yield (q/ha)	Area Hectares	Production in Quintals	Yield (Q/H)
Oromia region	36,478.72	554,620.56	15.20	47,782.46	783,546.83	16.40
East Shewa Zone	12,917.78	234,484.84	18.15	20,514.27	401,895.45	19.59

Source: CSA 2016/17

Official estimates from the CSA show that while the total quantity of improved pulses seed supplied nationally has been increasing, improved pulses seed covered only <0.5% or 8060 hectares of 1,742,602.19 hectares of pulses area (CSA, 2013/14). According to 2012/2013 CSA main season report moreover, most farmers face great shortage of high yielding, disease resistant varieties because of low access to improved seed. Despite the release of large number of improved pulse varieties by the national research system that are adapted to wide range of rainfall, soil and altitude regimes. Currently, less than 1% of pulse land is annually covered with improved seed while for cereals the coverage is 8%. Similarly, the use of chemical fertilizer and pesticides for pulses is negligible. Among the pulse crops, common bean and chickpeas have a relatively better seed use than the other pulses while faba bean, field pea and common enjoy a higher fertilizer application than the other pulses. Hence, the level of use of improved seed is much lower for pulses compared to cereals with important differences across pulses.

Pulses accounted for 6% of export earnings in Ethiopia, and contributed more than USD 200 million to the country's hard currency reserves in 2013. The export earnings from pulses have been growing at an annual growth rate of 18%. Among the pulse crops, common bean is by first the first in export volume and foreign currency earnings, followed by chickpea, soybean, faba bean and lentil (ERCA, 2013).

2.5.Constraints of lentil Production

Smallholder farmers a number of constraints, which increase risk and uncertainty and act as disincentives for increased production, consequently preventing them from accessing agricultural markets Low production of lentil and chickpea leads farmers to poverty because the crops are commercial crops and all expenses of farmers depend on the crops including production and productivity of other crops are depend on income from lentil and chickpea to purchase agricultural inputs.

Average productivity of lentil in West Asia, North and East Africa is low due to use of predominantly local cultivars. Local cultivars have the limited yield potential and are also vulnerable to an array of stresses (Sarker and Kumar, 2011). The yield limiting factors are lack of seedling vigour, slow leaf area development, high rate of flower drop, low pod setting, poor dry matter, low harvest index, lack of lodging resistance, low or no response to inputs, and subject to various biotic and a biotic stresses.

Lentil productivity particularly in Ethiopia remains low mainly due to cultivation of low yielding, disease susceptible landraces (Geletu and Yadeta, 1994, Asnake and Bejiga, 2003). Low productivity per unit area and low grain quality (small seeded, undesired color, low plumpness) were typical features of Ethiopian lentils (Korbu, 2009 and MOARD, 2003). Lentil has been under-utilized relative to other pulses. Breeders have developed very few improved varieties in Ethiopia, in addition the uptake of these has been limited and there has been little research outside breeding.

The production constraints include both biotic (insects, diseases and weeds) and a biotic (temperature, soil fertility and drought) stresses affecting the vertical or horizontal production of lentil (Korbu, 2009; Asnake and Bejiga, 2003; Bejiga, Tsegaye and Tullu, 1996). There are about ten important lentil diseases in Ethiopia, among which rust, root rots and Fusarium wilt are the major ones. Usually rust causes about 25% yield loss in the normal year while 100% crop loss seldom occurs. Pea aphids are an important insect pest threatening the crop starting from early seedling to maturity stage. Adzuki bean beetle (Bruchids) is the most serious post-harvest pest (under storage conditions) (MOARD, 2003). Coming up with resistant varieties, such as Alemaya for rust (*Uromycesfabae*) was a breakthrough in the breeding program and relieve to the subsistence farmer who have been suffering from losing their products of the whole field due to this particular disease.

2.6.Empirical Studies on Adoption

A number of empirical studies have been conducted by different people and institutions on farmers' adoption behavior both outside and inside Ethiopia using econometric models. The results of various empirical studies confirmed that adoption of a new technology offers opportunities for increasing productivity and output quality. The empirical studies have not observed in using improved agricultural varieties of lentil in the production and productivity but to contain some related crops (pulse crop).

A study conduct by (Sanzidur*et al.,* 2018) indicated that jointly identifies the determinants of improved variety adoption, productivity and efficiency of 2700 pulse producers from 10 pulse-growing districts of Bangladesh using a Sample-selection Stochastic Production Frontier model you get the result shown that the decision to adopt improved pulse technology is significantly influenced by yield, farming experience, education and extension contact though subsistence pressure discourages adoption. Land, fertilizer, mechanical power, pesticides and labour are the significant determinants of improved pulse productivity. Productivity is significantly lower for improved varieties of lentil, black gram and chickpea as compared to mung bean and for farmers who use own-sourced seed.

A study conducted by (Masresha*et al*., 2017) Determinate of the Adoption improved white haricot beans in East Shewa Zone, South-Eastern Ethiopia, the data analysis using in a double hurdle model. The report showed that the decision to adopt white haricot beans variety is influenced positively by frequency of extension visits, land size allocated to haricot beans, agricultural income, price perception, training obtained and perception on fertility enhancement benefit of the crop, and negatively significant by distant to market, ownership of haricot beans farm land and nutritional perception of the crop. The intensity of adoption of white beans is affected negatively by the number of dependents in the household, ownership of haricot beans land and positively by non-farm income and contact with NGOs**.**

A study conducted by (Solomon *et al*., 2014) Adoption of improved wheat varieties in Robe and DigeluTijo Districts of Arsi Zone in Oromia Region, Ethiopia the data analysis using in a double-hurdle. The report showed that the empirical evidence of positive impact of household sex, field day participation, district and access to all weather road in enhancing the adoption of improved wheat varieties.

A study conduct by Alemitu (2011), Tobit econometrics model was employed using STATA11. The results indicated that the relative influence of different variables on probability and intensity of adoption of improved haricot bean production Thus, sex of house hold head, attending training on improved haricot bean production, attending field day programs, conducting demonstration, access to improved seed credit and membership of seed multiplication group were positively and significantly influenced whereas market distance negatively influenced adoption and intensity of adoption of improved haricot bean varieties and associated agronomic practices.

Negash (2007) conducted a study to understand the major factors ofadoption of improved haricot bean production package in Alaba special woreda, southern Ethiopia by using Tobit model was used to identify factors affecting farmers' adoption and intensity of adoption of improved Haricot bean technology package in the study area indicated that household head's attitude towards haricot bean production technology package, participation in extension event (participation in training and field visit) and access to credit were important variables which had positively and significantly influenced adoption and intensity of adoption of improved haricot bean production package.

Shiyani*et al.* (2002) conducted study on Adoption of improved chickpea varieties by using the Tobit model they showed the report that all explanatory variables, except market distance and level of education, were significant and have expected signs. Among variety traits, time duration to mature the variety, farm size, yield risk, and farmers' experience of growing chickpea crop was found the most important determinant influencing adoption of new chickpea varieties and among these, the coefficient associated with the variable access to extension, access to seed, farm size and proportion of area allocated to chickpea are significantly different from zero and therefore influence the adoption of improved chickpea variety in respective.

(Negash 2007) citing Wolday (1999) conducted a study to understand the major factors which dictate the use of improved seeds in Ethiopia and reported that, price of inputs, access to credits, fertilizer use, economic status of the household, size of land owned, visits of extension agents and infrastructure development are the principal determinants of the adoption of improved seed.

2.7.Conceptual Frame Work

A conceptual framework is a diagrammatic presentation of the relationship between dependent and independent variables which is one element of scientific research process in which a specific concept is defined as a measurable occurrence or in measurable terms that basically give clear meaning of the concept. Based on the empirical reviews, adoption of a given technology is hypothesized to be influenced by Demographic characteristics, socio cultural characteristics, Institutional characteristics and economic characteristics of sample respondents. Both economic and non-economic reasons are essential motives for shaping the farmers attitude towards the new technology and its final adoption.

Based on the literature review, adoption of a given technology is hypothesized to be influenced by personal attributes (age, family size, Labor availability, experience etc), institutional (credit, market, extension, Distance from the nearest market etc) and socio-economic (income, etc.) factors. As noted by Degnet and Belay (2001) the reasons for adoption or non-adoption at farm level vary over space and time. Factors influencing adoption are neither totally economic nor purely non-economic.

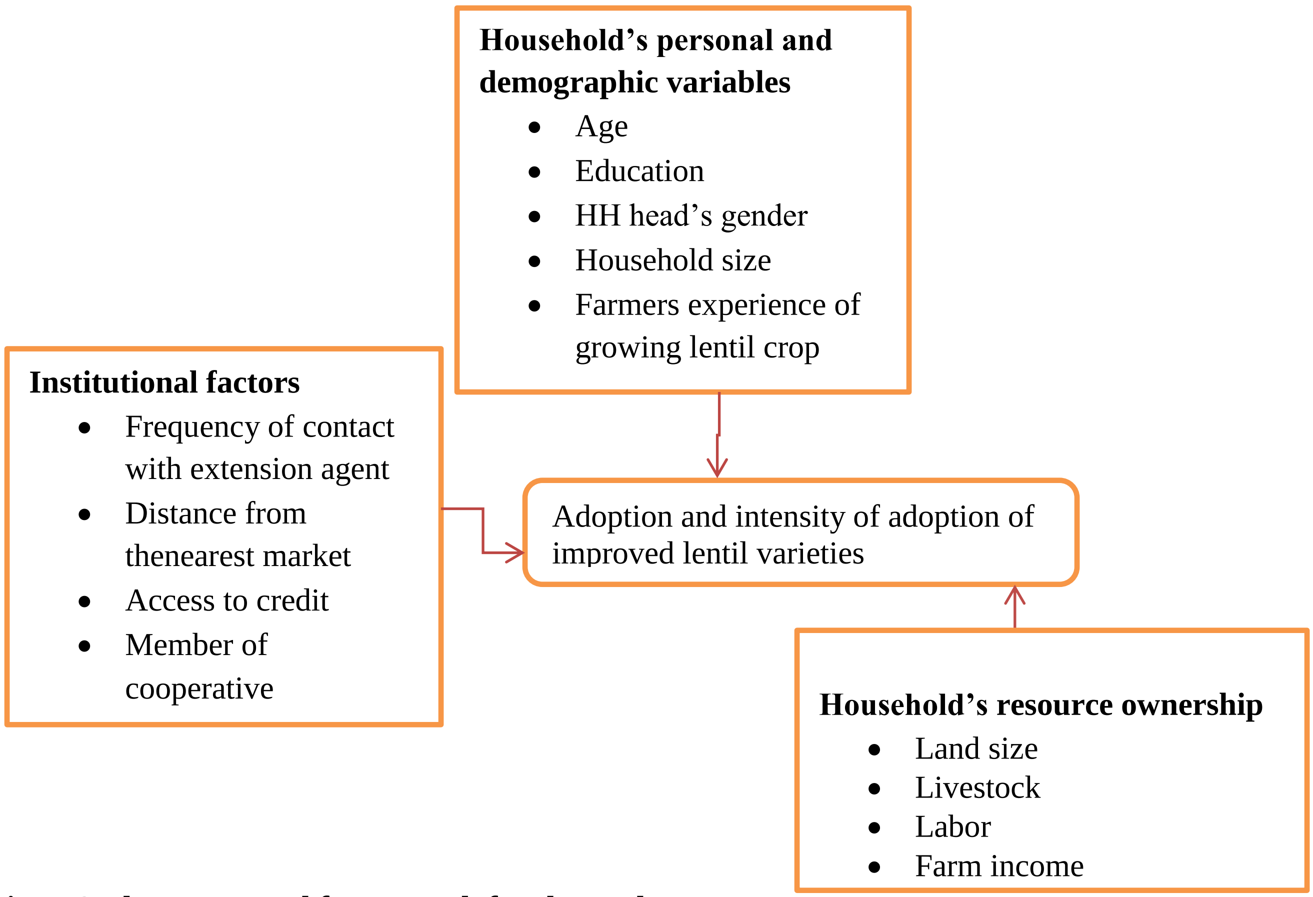

Figure2.The conceptual frame work for the study

Source: Authors conceptual frame work

3. RESERCH METHODOLOGY

This section describes the research design and methodological steps, includes description of the study area, research design and sampling techniques, data collection instruments, method of data analysis.

3.1.Description of the Study Area

The study was conducted in Gimbichu district located in East Shewa zone, Oromia Regional State in the central highlands of the country. It is located north east of Debre Zeit which is 50 kms south east of Addis Ababa. Gimbichu is bordered on the south with Lome, on the southwest with Ada'aChukala. The administrative center of the district is named Chefe Donsa. Most parts of the district are situated in high altitude of more than 2300 meters above sea level. Lentils, chickpeas and fenugreek are important cash crops in the district.

The district is geographically located 8.9542^0 N latitude and 39.1014^0 E longitudes. The district is characterized with 75% *Vertisols*. Its average annual rainfall is 843mm.The 2007 national census reported a total population for this district is of 86,902, of whom 45,126 were men and 41,776 were women; 6,330 or 7.28% of its population were urban dwellers. The majority of the inhabitants said they practiced Ethiopian Orthodox Christianity, with 95.78% of the population reporting they observed this belief, while 1.6% of the population were Protestant, 1.41% of the population practiced traditional beliefs, and 1.17% of the population were Muslim. With an estimated area of 707.49 square kilometers, Gimbichu has an estimated population density of 123.4 people per square kilometer, which is less than the Zone average of 181.7.

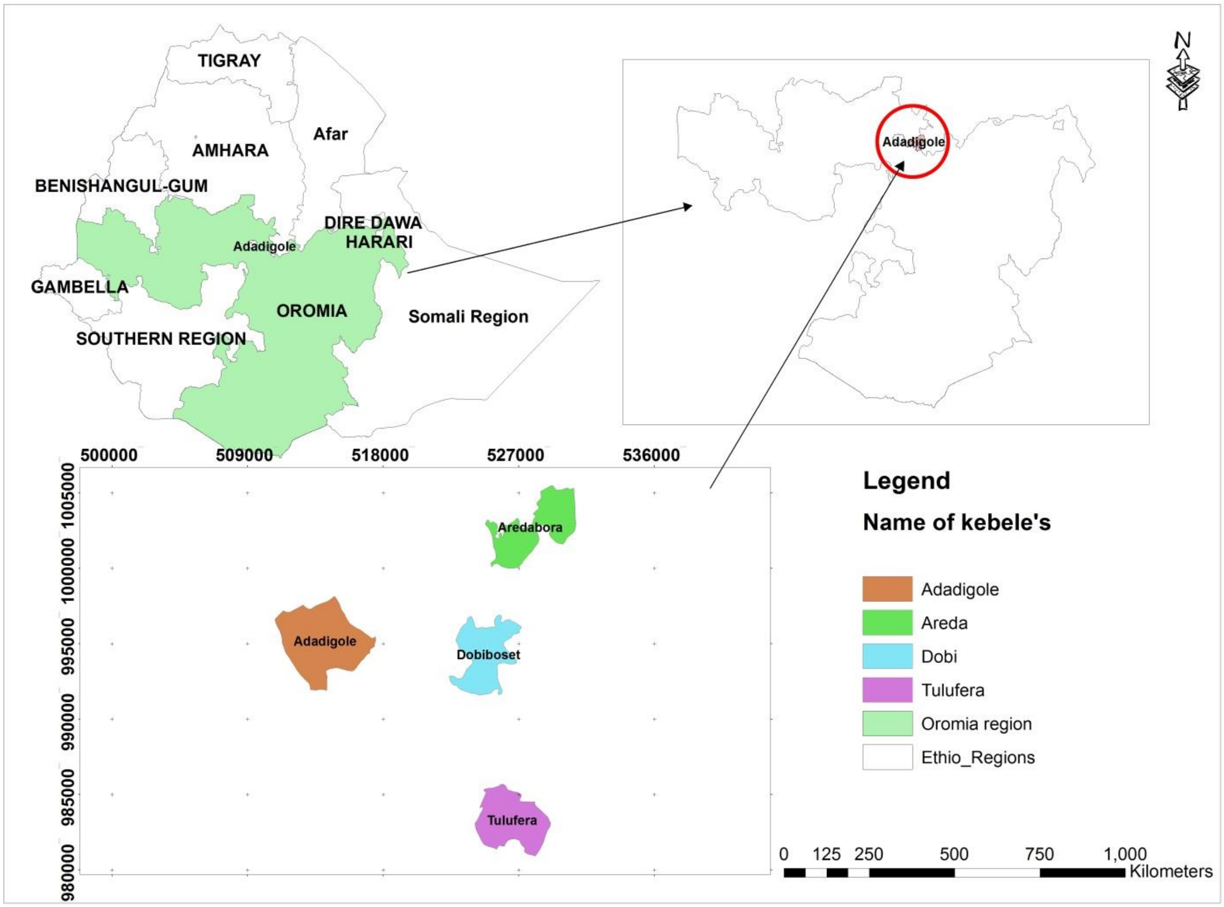

Figure 3. Map of the study area

Source: Drown by GIS

3.2. Data Types and Sources

This study employed cross sectional research design. To this end, quantitative methods of data collection and analysis were utilized. In order to meet the research objectives, both quantitative and qualitative data were collected from primary and secondary sources. Primary on data related to socio-economic, institutional and demographic characteristics of the respondents, and other related information that were used which are essential for the research purpose. The secondary data was collected from published and unpublished materials, which include books, journals, scientific research works and office records. A two-stage random sampling procedure was followed to select studying areas and sample farmers.

3.3.Sampling Technique and Sample Size

3.3.1.Sampling procedure

For this study, two stage sampling techniques were employed to select the sample respondents. Study area was purposively selected based on production status and past lentil technology promotion. First stage was randomly selection of lentil growing Kebeles of the districts, followed by selection of sample households. Four lentil growing kebeles were randomly selected as a sample from 26 kebeles of the district. Second stage: 166 sample respondents were selected using systematic random sampling technique from each kebeles based on probability proportional to size for the interview purpose.

3.3.2. Sampling size

The sample size for the study was determined by the formula of Yamane (1967) to minimize availability of error and bias during sample determination selection for the study. The formula for sample determination at 8% confidence interval is described as follows

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

$$n = \frac{N}{1+N(e)^2} = \frac{2,660}{1+2,660(0.08)(0.08)} = 166$$

Where n is the sample size for the study, N is the total households of the study area which is 2660,*e* is the maximum variability or margin of error or which is 0.08 in this study. The sample size from each *kebeles* was determined based on their proportion to total share of households residing in each *kebeles*.

Table 3.Number of respondents in each of the selected rural kebeles

No	Kebeles	Number of lentil grower household heads	Selected number of respondents (HHH)
1	AdadiGole	737	46
2	Areda	689	43
3	Dobi	641	40
4	Tulu Fera	593	37
	Total	2,660	166

Source: Computed from own survey data, 2019

3.4. Method of Data Collection

The interest of the respondents in survey work is an issue to be given top priority. Farmers was show little cooperation unless their concerns are taken care of very seriously. Therefore, in order to gain their trust, the respondents were carefully informed about the objectives of the survey and the direct and indirect benefits to them. In this regard, Farmers were also informed that information related to household and farm characteristics would be kept confidential.

Firstly, the interview schedule was tested at the farm level on randomly selected farm households. In the light of pre-testing, essential amendments were made on such things as ordering and wording of questions and coverage of the interview schedule. Furthermore, the pre-test enabled to know whether farmers had clearly understood the interview schedule.

After pre-testing and prior to the final administration of the interview schedule, enumerators were given training and briefings on the objective, contents of the interview schedule and were also acquainted with the basic techniques of data gathering and interviewing techniques and on how to approach farmers. Then using the amended structured interview schedule, primary data were collected by using personal interview technique from sampled farmers. The interview schedule was administered by using trained enumerators. In order to increase the reliability of the survey data and to reduce technical and linguistic problems at the farm level; the researcher (the author) spent much time with enumerators during all survey days. At last, to fill gaps observed during personal interviews, focused group discussions were conducted with group of farmers in each selected rural kebeles.

3.4.1. Focus Group Discussions (FGD)

For this study one focus group discussion, containing eight to twelve members was conducted in each selected villages. The purpose of the focus group discussion is to generate in-depth information on some of the survey findings and to know what kind of improved varieties perceptions of the farmers that may not have been adequately captured by the semi- structured questionnaire interview about adoption and intensity of use of improved lentil varieties by using checklists. This technique enabled the researcher to explore what they know or think about the research problem that the questions would cover, and then to verify, confirm and add depth to the results of the household survey.

3.5.Method of Data Analysis

Both descriptive statistics and econometric model were used for analysis of the data. The data was analyzed using software SPSS version 21.0 and STATA 14 software Descriptive statistics like mean, standard deviation, percentage and frequency were used in analyses.

3.5.1 Econometric model for determinants of adoption of improved lentil varieties and intensity of adoption

Factors' affecting the adoption of a farm technology has been widely analyzed using the Heckman (1979) and Tobin (1958) models. Heckman (1979) model is used with the assumption of selection bias in the process of adoption. Tobin (1958) model is the most widely used. The prime assumption for a Tobin (1958) specification is that farmers demanding modern technologies have unconstrained access to the technology. Studies show that underdeveloped input supply and marketing systems play on input choices and technology adoption in the case of smallholder agriculture (Asfawu *et al*., 2011; Shiferawu *et al*., 2008).

The double hurdle model originally proposed by Cragg (1971) in addition to its assumption that the two decision tiers are not necessarily affected by the same set of factors, is a remedy to the problem of corner solution arising in the Tobit model, and has been extensively in use in several studies (Mignouna *et al*., 2011; Yu and Ninpratt, 2014; Martínez-Espiñeira, 2006; Moffat, 2003; Newman *et al*., 2001)

The first hurdle is to decide to be a potential adopter, while the second hurdle is how much (intensity) to adopt. The advantage with this approach is that it allows us to understand the characteristics of a class of households that adopted the technology, households wanting to adopt but reporting no positive use (due to access constraint) and households that have never adopted the technology (Yu and Nin-Pratt, 2014; Mignouna *et al*., 2011). However, it has not widely been used in the area of adoption of agricultural technologies with some exceptions (Yu and Nin-Pratt, 2014; Sosina *et al*., 2014;Asfawu *et al*., 2011;Berhanu and Siwnton, 2003).

This study used a double hurdle model assuming that factors that affect farmer's choice of adoption are not necessarily the same to the factors that affect the intensity of adoption. A double hurdle model consists of two separate stochastic processes that determine the decision to adopt, and the intensity (degree) of use of a technology. The first hurdle is an adoption decision equation with a probit model. The model has an adoption (Y) decision with an equation

$$\left.\begin{array}{l} Y_i = 1 \text{ if } Y_i^* > 0 \text{ and } 0 \text{ if } Y_i^* \leq 0 \\ Y_i^* = \alpha' Zi + Ui \end{array}\right\} \quad \text{Adoption equation}$$

Where Y* = latent variable that takes the value 1 if the farmer adopts improved lentil varieties and 0 if otherwise

Z= vector of household characteristics

α = vector of parameters.

The level of adoption (T) has an equation of the following:

$$\left\{\begin{array}{l} T_i = T_i^* \text{ if } T^* > 0 \text{ and } Y^* > 0 \\ T_i = 0 \text{ otherwise} \\ Ti^* = \beta' X_i + Vi \end{array}\right\} \quad \text{Intensity equation}$$

Where Ti is the observed answer to the proportion of improved lentil varieties

X is a vector of the household characteristics

β is a vector of parameters.

The error terms, Ui and Vi are distributed as follows:

$$U \sim N(0, 1)$$

$$V \sim N(0, \delta^2)$$

The log-likelihood function for the double-hurdle model is:

$$\text{Log L} = \sum_0 ln[1 - \emptyset(\alpha Z'i)(\frac{\beta X'i}{\sigma})] + \sum_+ In[\emptyset(\alpha Z'i)\frac{1}{\sigma}(\frac{Yi-\beta Xi}{\sigma})]..$$

Under the assumption of independency between the error terms Vi and Ui, the model, as originally proposed by Cragg (1971), is equivalent to a combination of a truncated regression model and Probit model. The Tobit model, as presented above, arises if $\lambda = \beta/\delta$ and X=Z

The estimation of the model Tobit log-likelihood is the sum of the log-likelihoods of the truncated and the probit models. Therefore, one simply has to estimate the truncated regression model, the Tobit model, and the Probit model separately and use a likelihood ratio (LR) test. The LR-statistic can be computed using Green (2000):

$$\Pi = -2[\ell n\ LT - (\ell n\ LP + \ell n\ LTR\ ) \sim \chi^2 k. \ldots.$$

$Xt\beta = \beta 0 + \beta 1X1 + \ldots + \beta 12X12 + \varepsilon_i$

Where β0 = constant;

X1 = AGE (age of the household head);

X2 = SEX (sex of household head);

X3 = EDUCATION (level of education household head);

X4 = FAMILY SIZE (house hold size);

X5 = LAND (land size of the household);

X6 = CREDIT (Access to credit in farmer);

X7 = DISTANCE (distance to nearest market);

X8= EXTENSTION (farmer received extension visit)

X9 = LIVESTOCK (Total livestock holding);

X10 = INCOME (annual income of the farmer);

X11 = COOPERATIVE (cooperative membership of the farmer)

$X12$ = FARMERS EXPERIENCE (farmer experience of growing lentil crop) and

X13 = LABOR (Active labor force)

ε_i= The error term of the model

The model parameters are estimated by maximizing the Tobit likelihood function of the following

$$L = \Pi_{Y^* > 0} \frac{1}{\delta} f\left(\frac{Y - \beta t X t}{\delta}\right) \Pi_{Y^* \leq 0} F\left(\frac{-\beta t X t}{\delta}\right)$$

Where f and F are respectively, the density function and cumulative distribution function of $Y^* \leq 0 \Pi_{Y^*}$ means the product over those i for which $Y^* \leq 0$, and$>0\Pi Y^*$means the product over those i for which $\Pi Y^* > 0$.

3.6.Definition of Variables and Hypotheses

The following explanatory variables were hypothesized to influence the adoption and factors to influence the intensity adoption of improved lentil varieties in the study area.

3.6.1. Dependent variables

The dependent variables in the Double hurdle model are improved lentil varieties adoption status of farmers dummy variable (for adopter of lentil =1; otherwise=0) and intensity of adoption which proportion (%) of land(that is, from total land under lentil) allocated Alemhaya, Derash, Teshale varieties (improve varieties).

3.6.2.Independent variables

Farmer's age: It a continuous variable is measured in number of years. It is argued that older farmers have more experience and acquire indigenous knowledge than younger farmers, hence, have a higher probability of adopting the practice. It is expected that farmers age increase the probability of adopting improved lentil is increase (Hailu, 2008).

Sex of household head's (HH_Sex): is a dummy variable equals to 0 if the household head is female and 1if the household head is male. Household head's sex is an independent variable that is commonly used in technology adoption studies in developing countries because in some communities, socio-cultural factors limit females to access a resource adoption is negatively affected (Tesfaye*et al*., 2001; Mesfin, 2005).

Education level (EDU_lev): Level of education is assumed to increase a farmer's ability to obtain, process, and use information relevant to the adoption of improved lentil varieties and accruement of knowledge via formal education is supposed to be important factor in a way that education would have the capacity to adopt the technology in a proper way and can assure the end target expected from the technology. The findings of Afework and Lemma (2015) and Nkonya *et al*. (1997), indicated that farmer's education had positive and significant influence on adoption. Hence, those farmers with higher formal education are in a better position to know the benefits of new technology. So this variable is expected to influence the improved lentil varieties adoption positively.

Household size (HH_size): it is the number of people living in a house including as a parents, children, and other relatives who live in the same and share food together under one household leader. It was expected that as the size of the house hold increases, the adoption of new technology to increases, indicates that large family size is more involved in adopting the new varieties during their farm production effort Wilfred *et al*., (2002) and Kudi *et al.*, (2011)

Land size of the household (LAND_SIZE):large land holding sizes positively influence adoption and factors level of adoption because more opportunities to test new varieties and an improved ability to tolerate risks associated with early technology adoption. Adoption of technology needs resource like land, farmers with larger land are available to adopt than those with small land. Hailu (2008) reported that farm size exerts a positive influence on adoption of improved technologies Wilfred *et al*., (2002) and Kudi*et al.*, (2011).

Access to credit (ACC_ CREDIT): It is measured in terms of whether respondents have access to credit in terms of availability of credit sources and possibility of getting credit. Improving credit access often regarded as the key element for increasing agricultural productivity and has been an effective strategy to increase smallholder productivity and alleviate poverty (Adugna and Heidhues, 2000). Earlier study also reveals that credit is one of factors that affect the probability of adoption of improved varieties and the quantity of fertilizer farmers apply (Legesse, 1992; Tesfaye and Shiferaw, 2001).Farmers who have access to credit may overcome their financial constraints and therefore to buy inputs. It is expected that positive the probability of adopting improved lentil varieties in the access to credit was increase.

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Distance to nearest market (DIST.MARK): Short distance to the nearest market has a positive influence because it enable farmer to sell the product and purchase the input supply for production. It is continuous variable. Availability of the market for the improved varieties products determines the decision of adopting the technology. The closer they are to the nearest market, the more likely it is that the farmers were received valuable market and product information (Abadi, 1999; Roy, 1999). Therefore Distance to market center was hypothesized to be negatively related to the probability of adoption of improved lentil varieties (Hassen, 2014).

Household contact with extension agent (CON.EXTEN): Literature suggests that households may learn about improved varieties and share experience through agricultural associations' programs. Similarly, households may learn about a new agricultural technology from extension agents and other farmers. It is frequently argued that households who are active in an agricultural association and have contact with extension agents are more likely to adopt new agricultural technologies. It is dummy variable. In some studies the findings of Dana *et al* (2006), Afework and Lemma (2015) indicated that agricultural extension services had positive and significant influence on adoption. Agricultural extension services provided in the study area by the DZARC of represent the major source of information for farmers. Contact with extension agents (development agents) was hypothesis to increase a farmer's likelihood of adopting improved lentil varieties.

Livestock holding (LIVESTOCK): It is a continuous variable and measured by Tropical Livestock Unit (TLU). Livestock is the farmers' important source of income, food and draft power for crop cultivation in Ethiopian agriculture. Doss *et al*. (2002), and Shiferaw and Tesfaye (2006) reported that owning large number of livestock had a significant influence on the adoption of improved technologies. The number of livestock owned by a farmer was hypothesis to be positively related to the adoption of an improved lentil variety.

Annual income of the farmer (INCOME): The farm income refers to the total annual earnings of the family from sale from agricultural and non-agricultural produce such as sale of crop, livestock and livestock products, mining and trade activities for meeting family requirements. This is believed to be the main source of capital for purchasing agricultural inputs. It is treated as a continuous variable. According to Chiputwa *et al*., (2011) households with relatively higher income are expected to better adopt technology.

Farmer experience of growing lentil crop (FARMERS EXPERIENCE)

With increased farming experience, farmers are generally better able to assess the relevance of new technologies. This often comes from their interactions with their neighbors and the outside world. It is measured in number of years of experience in lentil production. 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).It is hypothesized that it was affected positively with the more experience of growing lentil crop of farmers (Dawit, 2017).

Cooperatives membership (COOPS): It is dummy variable which takes the value 1 if the household head is a member and 0 otherwise. It is conceivable that, cooperatives have a number of contributions for smallholder rural farmers in developing countries. For example, cooperative institutions provide necessary inputs, market information and buy their produce at better prices. Hence, membership to cooperative is hypothesized to affect adoption improved lentil positively as compared to non-adopting (Aberham, 2013and Geremew, 2012).

Labor Availability (LABAVA) labor was measured in terms of man equivalent. Availability of labor is likely to influence the gross marginal of innovation. A farmer with larger number of workers per hectare (unit) is more likely to be in a position to try and continue using a potentially profitable innovation and it is expected to influence adoption positive. It is hypothesized that it was affect positively with more productive labor force for agricultural production (Hassen, 2014).

Table 2. Definition of the variables and units of measurement

Variables	Measurement	Expected	Descriptions of the Variables
Age of HHHs	Years	-	Age of HHs negatively influence improved lentil varieties adoption
Household head's sex	Dummy	+	Adoption was expected to more positively in male
Education level	Dummy	+	Adoption was expected to positively correlate as education increases.
Annual Income	Birr	+	The effect of annual income on household's adoption decision was +ve
Credit accessibility	Dummy	+	Credit was positively influence improved lentil varieties adoption
Extension Contact	Dummy	+	The access to extension services was expected to positively influence farmers' adoption
Cooperative membership	Dummy	+	Social participation in household positive influence improved lentil varieties adoption
Household size	Number	+ /-	Total HH size was expected +ve or –ve of improved lentil varieties adoption
Market distance	Minute	-	It was expected that HH who have the access to output markets to adopt.
Livestock	TLU	+	A larger livestock holding was expected to positively influence adoption.
Labor availability	Number	+	productive labor force was affect positively with more for agricultural production
HH size	Hectare	+	A larger land holding was expected to positively influence adoption.
HH experience	Years	+	If the HH experience of cultivated lentil crop the hypothesis to influence positive to adopt improved lentil.

4. RESULT AND DISCUSSION

This part presents the finding of the study and discussion in comparison with the result similarity. It is organized under different sections: the first section deals with the description of demographic characteristics, socioeconomic characteristics, institutional support services and psychological factor. The second section covers the results on the status, level of adoption of improved lentil varieties by smallholder farmers in the district.

4.1.Descriptive Statistics

4.1.1. Demographic and Socio-economic characteristics of the respondents (Dummy variables)

For this study, the data was collected from both adopters and non-adopters of improved lentil varieties. Tables, below depicts the statistical t- test and χ_2-test comparison of variables expected to determine adoption of improved lentil varieties produce by sample households.

The descriptive results show that adopters of improved lentil varieties were significantly different from non-adopters in many cases such as sex of household head, active labour force, livestock ownership, farm land holding size, family size, cooperative membership, access to credit services, frequency of extension contact, educational level, off/non-farm income, and farming experience toward improved lentil varieties on certain attributes. On the other hand, adopters did not make significant difference in terms of Age of household head, market distance with compared to non-adopters.

From total of 166 sample households, only 8 were female-headed and the majority of sample respondents, about 158 samples were male- headed households. As shown in Table 5, from the entire household heads interviewed, about 95% were male headed while about 5% were female headed, who are divorced or widowed at the time of survey. The survey data show that statistically significant difference is observable in the sex of household head since almost all of the respondents were male headed households. Accordingly toχ_2-test result (χ_2= 6.7775, P= 0.009) show that is statically significant difference between adopters and non-adopters at 1%.

Literate households are expected to have better skills, better access to information and ability to process information. Adopter categories were seem to significantly vary in terms of formal education level that is years of schooling (Table 5). The distribution of total sample respondents in terms of literacy level has shown that 23.49% were illiterate and 76.51 % were literate. The literacy level was argued to have positive impact on the adoption of new technologies. The result of this study shows that the proportion of literate farmers in the non-adopters category was 60%. The result Chi-square statistics showed that there was statistically significant between the adopters and non-adopters(χ_2= 7.9879, P= 0.005)of household heads indicates statistically significant in the educational status among adoption categories. This shows that the education level of adopters of improved lentil is higher than non-adopters of the technology, implying the influence of the variable in making adoption decisions similar result with (Tesefay *et al.,* 2016).

An agricultural extension services provided to farmers is believed to be the main source of information about improved agricultural technologies and it is widely accepted that substantial productivity increases could be achieved when farmers get appropriate extension services. The survey result showed that frequency of extension contacts by extension workers varies among the sample households. From the total sample households, 22.29% were reported not frequently having contact with extension agent, while 77.71% of sample households were reported having frequently contact with the extension agent at different level of frequency. From the non-adopter groups 55% of respondent did not have any contact with extension agents frequently. This clearly shows that the major proportion of adopters get extension service on improved lentil production than non-adopters. The chi-square analysis result ($\chi2$ = 32.55, p = 0.000) shows significant relationship of contact of extension agent with the adoption and intensity of use of improved lentil varieties.. The earlier researchers, Girmachew (2005), Abrhaley (2007) and Dawit (2017)) also reported similar result.

From sampled respondents 68.67 % reported having access to credit while the remaining 31.33% reported lack of access to credit in the study area. With respect to credit accessibility response of farmers in the adoption categories 22.50% of non-adopters and 83.33% of adopters used credit for purchasing agricultural technologies (improved seed, fertilizers, chemicals, etc). The hypothesized proposition was supported by the significant relationship ($\chi 2$=52.22, p=0.000) found at < 1 % significant level.

The respondent member of the cooperative farmer in the study area were 84.34% reported having member of cooperative, while the remaining 15.66% reported has no member. (Table 5), indicates that, 87% of the adopter and 75% of the non-adopter sample respondents member in cooperatives to share their own common values and experience. The respondents' member of the cooperative had significant relationship with the adoption and intensity of use of improved lentil variety with ($\chi 2$=3.47; P=0.062) the result revealed that there is significant relationship between member of the cooperative organization and the adoption and intensity of use of improved lentil varieties production at 10% significant level

Table 3. Results of Dummy explanatory variable

Variables	Adopters (N= 126)		Non adopters (N= 40)		χ2- value	Total sample (N=166)	
	Freq.	Percent	Freq.	percent		Freq.	percent
Sex of HHH							
1 for Male	123	97.62	35	87.50	6.777***	158	98.18
0 for Female	3	2.23	5	12.50		8	4.82
HHH affiliation to an cooperative							
Yes	110	87.30	30	75	3.478*	140	84.34
No	16	12.70	10	25		26	15.66
Whether HHH Access to Credit							
Yes	105	83.33	9	22.50	52.229***	114	68.67
No	21	16.67	31	77.50		52	31.33
Whether HHH Access to							
Extension		88.10	18	45.00	32.554***	129	77.71
Yes	111	11.90	22	55.00			
No	15					37	22.27
HHH education							
Literate	103	87.75	24	60	7.9879***	127	76.51
Illiterate	23	18.25	16	40		39	23.49

***** ,*** shows significant at <1% and 10% level of significance.
Source: survey data, 2019

4.1.2. Demographic and Socio-economic characteristics of the respondents (Continuous variable)

The survey results showed that the average size of cultivable land owned by the sample respondents was about 1.04 ha for non-adopter households and 1.85 ha for the adopters. The mean differences of total land holdings for the two groups have strong significance. The average farming experience of sample respondents was 14.34 years with standard deviation of 6.5. The average farming experience of the adopters and non-adopters were 15and 12, respectively. The mean difference in farming experience among adopters and non-adopters is statically significant at 1%. Accordingly tot-test result the adopters and non-adopters households statistically similar result with Tesefay *et al*., 2016).

In this study the household farm cash income was estimated based on the sales of crops, livestock and livestock products. (Table 6), indicates that, the average annual farm income of the sample households was 37,774.36 ET birr. The maximum annual farm income was 112,576 ET birr while the minimum was 4,140 ET birr. The average annual farm income for adopters and non-adopters sample households was birr 40,807.73 Birr and 28,219.22 Birr respectively. The minimum and maximum farm income of adopter and non-adopter sample households ranges from 6375 Birr to 112576 Birr and 4140 Birr to 94110 birr respectively. The major cash income for sample households in the study area is from sale of crop. The mean comparison (t= -3.3380, P=0.0005) test result showed that significant mean difference among adoption categories.

The maximum and minimum tropical livestock unit of the sample households was 13 TLU and 2.56TLU for adopters. For non-adopters the maximum and minimum tropical livestock unit of the sample households was 4.93 TLU and 1TLU. On average the total sample households have about 5.37 tropical livestock unit. The tropical livestock unit was strongly and statistically significant difference between adopters and non-adopters of the sample households.

The average labor available for sample households in man-equivalent was 3.34 with standard deviation of 1.58. In adopter and non-adopter the maximum and minimum labour available for sample household is 8 and 1 person above 15 ages (Table 6). This is evident from the result (t=-3.9091 and P= 0.0001) which shows as significant mean difference between adoption categories.

In this study, it is hypothesized that the farming experience (measured in years) is positively correlated with the decision to adopt newly introduced crop varieties. The average farming experience of sampled households was 14.34 years with standard deviation of 6.5. More experienced farmers may have better skills and access to new information about improved technologies. It could also imply that knowledge gained over time from working in uncertain production environment may help in evaluating information thereby influencing their adoption decision (Idrisa *et al*., 2012). The respondents' farming experience had significant relationship with the adoption and intensity of use of improved lentil variety with (t=-2.6160; *P*=0.0049) the result revealed that there is significant relationship between farming experience in lentil grown and the adoption and intensity of use of improved lentil varieties production at 1% significant level.

Large family size may be an indicator for availability of labor provided that there are more people within the age range of active labor force. Based on this assumption, the variable was hypothesized to have positive and significant relationship with adoption and intensity of adoption of improved lentil varieties. In this study, the average family size of the sample households was 5.53 persons with standard deviation of 1.98. The average family size of households were 5.8 and 4.65 persons for adopters and non- adopters, respectively. The maximum family size was 11 while the minimum was 1 person. Accordingly tot-test result (t=-3.3358, P= 0.0005) the adopters and non-adopters households statistically significant 1%.

Table 6. Results of Continuous explanatory variable

Variables	Adopters (N= 126)		Non adopters (N= 40)		t- value	Total sample (N=166)	
	Min	Max	Min	Max		Mean	SD
Age of HH	25	67	25	60	0.44	40.30	8.71
HH size	1	11	1	9	3.33***	5.5	1.9
Farming experience	3	33	4	30	2.61***	14.34	6.5
Farm size (ha)	1.125	3	0.25	1.75	11.87***	1.65	0.51
Farm income’000	6.375	112.576	4.14	94.11	3.33***	37.77	21.40
Livestock unit TLU	2.56	13	1	4.93	7.68***	5.36	2.45
Active labour force	1	8	1	8	1.7032**	3.34	1.58
Distance to nearest market	2	180	2	60	0.6229	24.04	22.8

*****, **** shows significant at <1% and 5% level of significance.
Source: Own survey, 2019

Under normal conditions, improved lentil varieties are preferred by smallholder farmers in the study area which have better yield potential, resisting crop diseases, ecological characteristics and market price. According to the survey, the improved varieties Alemaya and Derash, were known by 89.68% and 53.97% have been widely demonstrated to farmers and adopted with associated cultural practices in the study areas.

Table 7. Types of improved lentil varieties adopted and Not-adopted by smallholder farmers

Name of improved lentil Varieties	Frequency		Percent	
	Adopter	Non-adopter	Adopter	Non-adopter
Alemaya	113	13	89.68	10.32
Derash	68	58	53.97	46.03
Teshale	27	99	21.43	78.57
Adaa	6	120	4.76	95.24

Source: Own survey (2019)

Focused group discussions

The group discussions were made at Dobi and Adadi Gola peasant association with nine and ten lentil producer farmer for respective kebeles. The discussions focused on improved lentil under the area. The farmers said that newly released varieties were used to increase production and productivity. But, starting 2010E.C production is low due to a biotic and biotic stresses like lack of the varieties on time, lack of credit, market problem and lack of enough extension support from development agents were the major problems in the area. Especially, the most serious problem for production in the area is lentil disease (rust, Ascochyta blight, and wilt). There is no applied recommended agricultural input (fertilizer and seed rate) to lentil farm, though it is common with others cereals. In previous years improved varieties have shown up to 14 quintalsin ha on farmers' field. Farmers' land plowing frequency coincides with the research recommendation. The research recommendation plowing frequency for lentil is three to four times depending on the environment. Most of the farmers discontinuing planting all lentil varieties (improved and local)to give their reasons were insect and disease. FGD discussion explained the role played by women in lentil cultivation as very crucial. According to farmers of the study area, women role is not restricted to biological, labor and social reproduction; they are also involved in productive role of farming activities. In relation to lentil production they play role in the whole production process except plowing. Although they were found to participate in different activities of production process such as sowing, weeding, cultivation, harvest, transport, storage and preparation of threshing field, the nature of participation is not full time because of biological reproduction of child birth and lactation and laborer production which involves the daily regeneration of the labor force through cooking, cleaning, washing, nursing and so on.

4.2.Econometric Model Results

The probit model was employed to identify factors influencing adoption of improved lentil varieties by smallholder farmers in the study area. The chi-square ($\chi2$) distribution was used as the measure of overall significance of a model in probit model estimation. The model had a log pseudo likelihood of (-11.60) after seven iteration. The Wald chi2 test statistics with 13 degree of freedom is equal to 40.37, and prob> chi2 = 0.0001is used to test the dependence of the adoption of improved lentil on the selected independent variables in the model (the hypothesis that all coefficients are equal to zero is rejected at 1% significance level). The pseudo R^2 (0.8735) which indicates 87.35 % of the variation between adopters and non-adopters of improved lentil varieties which explained by the variables.

4.2.1.Determinants of adoption of improved lentil varieties by smallholder

Hence, the adoption decision of improved lentil varieties by households is best explained by the probit mode. The results of the model show that out of the thirteen variables included in the model, five are correlated with improved lentil varieties adoption and found to have statistically significant effects on the adoption of improved lentil varieties on the sample respondents. The binary probit model outputs showed that sex of household head, livestock holding, land holding size, education level and cooperative membership are significant factors affecting the probability of adoption of improved lentil varieties.

The model outputs showed that sex of household, member of cooperatives, tropical livestock unit and land holding size have significantly correlated influence on the households' adoption decision of lentil varieties at 1% significance level. Whereas having difference in education level and extension service are significant factors affected adoption of improved lentil varieties at 5% of significance level. Having household size significantly correlated with decision of household lentil varieties adoption at 10% significance level (Table 8).

The probit model results show that household head sex is positively and significantly associated with adoption of improved lentil varieties. The result confirms that as compared to male-headed households, female-headed households are less likely to adopt improved lentil varieties than male-headed farmers. Implication female-headed households on likelihood of adoption of improved lentil varieties might be that female-headed households have a lower labor endowment, lower farm land holding and livestock unit ownership, and less access to information on improved lentil varieties compared to their counterpart.

From marginal effects, being male-headed households, *citrus paribus*, increase by 18.48% the adoption of improved lentil varieties as compared to female-headed households. In the study area, letting females to be a household head is not yet well developed and recognized in such instances, due to the cultural and socio-economic factors, their likelihood of adopting improved lentil varieties becomes negligible. The overall finding is consistent with the results reported by (Solomon *et. al*, 2014 and Menale *et.al*, 2012) pointed out a positive association between a female-headed household and improved wheat variety adoption.

Livestock holding unit also is the other important factor found to have significant influence on the household decision to adopt the available improved lentil varieties of smallholder farmers. Livestock are considered as an asset that could be used either in the production process or be exchanged for cash (particularly small ruminants) for the purchase of inputs (seed, fertilizer, herbicide, etc.) whenever the need arises. Tropical livestock unit, which is a proxy for measuring wealth status of household head (in terms of tropical livestock unit), is found to have a positive and significant influence on adoption of improved lentil varieties, indicating that farmers with large number of livestock are more likely to adopt improved lentil varieties than others.

Results of analysis of marginal effect show that a unit increase in tropical livestock unit increases the decision of improved lentil varieties adoption by 6.37% of adopters of sample households. This is because farmers with relatively more livestock unit make use of their income obtained from sale of livestock for the purchase improved seed for grown improved lentil varieties. Also livestock, particularly oxen, are used for draft for different farm operations. This implies that being owner of more livestock unit increase the probability of adoption of improved lentil varieties (Tesfaye *et al.*, 2016; Hailu, 2008; Leake and Adam, 2015).

Farm land size is a limiting factor of production in the improved lentil varieties adoption decision that significantly affects improved lentil varieties adoption. It is worth to note that, having more farm land size is one best option whereby smallholders could be prompted in diversifying their crop production. Farm size has a positive and significant effect on adoption of improved lentil varieties. The positive effects of farm land size indicate that farmers with relatively large farm land size decide to adopt improved lentil varieties than owners of small farms land size. This is in agreement with the hypothesis formulated regarding the relationship between improved lentil varieties adoption and land holding size of the households. As a basic production factor, the more farmers have cultivable land, the more likely to adopt agricultural technologies particularly improved lentil varieties that could possibly increase crop yield. Probably, owning more arable land could be taken as a prerequisite to adopt and employ agricultural technologies since farmers incur a cost. Being rational decision makers, while incurring a cost for improved varieties, totally, farmers want to employ improved varieties within their own land where the final crop yield could not be shared and sub-divided.

The marginal effects indicated that as land holding of the households' increases by a unit (1 hectare), the farmers' probability to use improved lentil varieties increases by 43.34% as compared to non-adopters. During focus group discussion farmers told that shortage of farm land due to cultivated on small pies of land. The result is supported by findings of earlier studies on technology adoption of (Hailu, 2008; Masresha *et al.*, 2017 and Geremew,2012).

Memberships to cooperative have positively and significant influence on adoption of improved varieties at1% significance level. This implies that farmers who are members of cooperative are more likely to adopt improved lentil varieties. The primary cooperatives available also facilitate mostly to purchase improved seed, fertilizers production supporting agricultural inputs such as plant protection chemicals for farmers'. As a result, memberships in the cooperative have favorably influence the households' likelihood decision to adopt improved lentil varieties.

The marginal effects result shows that being member of cooperative, *citrus paribus*, increase by 11.5% the likelihood of adoption of improved lentil varieties. . Generally, it is known that being a member of cooperative is advantageous to farmers since they can get information easily and can access different services Contrary to this, Tewodaj *et al*. (2009), Degnet and Mekibib (2013) and Degefu *et al.* (2017) found a positive result of relationship of cooperative membership with technology adoption.

Having extension contact has positively and significantly related to adoption of improved lentil varieties, implying that's farmers with having extension service are more likely to adopt improved lentil varieties than those not having extension service. Extension service is powerful and crucial to achieve better adoption of improved agricultural innovations. Henceforth, extension service by development agents with farmers is assumed potential force which accelerates the effective dissemination of adequate agricultural information to the farmer, thereby enhancing farmer's decision to adopt improved lentil varieties.

For the analysis marginal effect, having extension service from development agents during the production season, increase the likelihood of adopting improved lentil varieties by 6.7% adopters of smallholder farmer. The farmer how have more frequency of extension contact with development agent update themselves on the availability and arrival of improved lentil and aware of application technology than those less visited by the development worker. The studies conducted by Isaiah *et al*. (2007), Hailu (2008), Solomon *et al*. (2011) and Leaked and Adam, (2015) found frequency of contact with extension agent affect positively and significantly adoption decision of smallholder farmers.

Education of the household head positively influences participation in improved technology. Education was significant at 1% level of significance. The positive marginal effect indicates increasing participation with every additional year of education. For instance, a marginal effect of 0.085 implies that if an individual adds one grade in school the probability of being an adopter increase by 8.5%. This implies that education of the household head increases the probability of using improved varieties. This finding corresponds with Afework, and Lemma, (2015) and Leaked and Adam, (2015) who found similar results.

Family size to be positive and significant at 10% significance Level, indicate that each family adding in one person the probability of adoption of improved lentil varieties increased by 1.05%. Similar results were reported by Alene *et al.* (2000): Milkias and Abdulahi (2018) but Contradicting with the research

Table 4. Estimation of the probit model for adoption of improved lentil varieties

			Robust Marginal effect			
Variables	**Coef.**	**Std.Err.**	**dy/dx**	**Std. Err.**	**Z**	**P**
Age	0.0410145	0.035416	.0016334	.001331	1.23	0.224
sex	4.64251***	1.200535	.1848875	.0553157	3.34	0.001
active labor force	0.2169037	0.2062334	.0086382	.0075806	1.14	0.246
TLU	1.600112***	0.3927941	.0637243	.0181292	3.52	0.001
Family size.	0.2652833*	0.1562797	.0105649	.0054351	1.94	0.078
Cooperative	2.907142***	0.9032011	.1157766	.0307274	3.77	0.001
membership	1.00938	0.7982818	.0401984	.0270398	1.49	0.153
Credit use	1.689698**	0.8074209	.067292	.0289228	2.33	0.041
Extension service	-0.0204368	0.018149	-.0008139	.0006998	-1.16	0.251
Nearest market	10.88288***	2.900026	.4334093	.0852986	5.08	0.000
distance	2.138104**	0.8721654	.0851498	.0447751	1.96	0.045
Total land size	-.0295814	0.0218661	-.0011781	.0008471	-1.39	0.129
Education	-.027243	0.0578571	-.0010849	.0024528	-0.44	0.817
Income	-28.37354	7.698518				
Experience						
_cons						

Number of obs = 166 Pseudo R2 = 0.8735

Wald chi2(13)=40.37

Prob> chi2 = 0.0001

Log pseudo ikelihood = -11.599741

*****, ** and * shows significant of coefficient at 1%, 5%and 10% respectively probability level.**
Source: survey data, 2019.

4.2.2. Determinants of intensity of use of improved lentil varieties

The determinants of the intensity of use of improved lentil varieties were estimated using the second double hurdle (Truncated regression) model. The empirical result from Table 9 of

Truncated regression model indicated that active labor force, household size, obtained credit and livestock unit had a significant effect on the intensity of use of lentil varieties at different significance levels.

According to the result of the Table 9 in the truncated model, active labour force had a positive influence on the intensity of use of improved lentil varieties at 1% significance level. This explains that new improved lentil varieties appear to be labor intensive. Suggesting that farmers who have more active family labor force allocate more area to improve lentil varieties since they can supply the required labor for different production activities of improved lentil varieties. This means active labor force increase by one person the adopter the allocated to cultivate improve lentil varieties increased by 0.38ha. This result is in conformity with other findings of Alene *et al*. (2000) and Hailu (2008).

The result of the truncated model revealed that the intensity of use of improved lentil varieties is positively and statistically significantly affected by access to credit at 1% significance level. This means that households to have access to credit the allocated to cultivate improve lentil varieties increased by 0.166ha than households without access. The expected access to credit provides an importance in intensification of improved lentil varieties by financing agricultural inputs, that is, improved seeds and fertilizers. The financial strength for households to engage in intensive farming leading to more marketable surplus. Another plausible reasoning could be that households with access to credit need to raise enough money to pay back their debts/loans. Hence, if farmers can get credit access, they can buy more improved lentil varieties. The finding is consistent with other study (Hassen *et al*., 2012)

The econometric result showed that household size affects households' level of adoption in improved lentil positively and significantly at 5% significance level. The household member's increases by one the allocated area to cultivate improve lentil varieties increase by 0.19 hectare. This confirms the finding of Benjamin *et al*. (2014), Siziba *et al*. (2011) and Makhura *et al*. (2001) that households with large family sizes need to use improved lentil.

Livestock ownership had positively and significantly influence of the intensity of improved lentil at 1% significance level. As the livestock ownership increases by one the household will the area to cultivated improved lentil increases in 0.047ha. As livestock provides the required draft power for different farm operation and cash for purchased of improved input like seed. This result is in contrary with other findings of (Hailu, 2008).

Table 5. Estimation of the truncated model for level of adoption of improved lentil varieties

Variables	**Coef.**	**Std. Err.**	**Z**	**P>|z|**
Age	.0015961	.0018313	0.87	0.383
sex	.0396127	.1186156	0.33	0.738
active labour force	.038362***	.010279	3.73	0.000
TLU	.0469766***	.0067465	6.96	0.000
Family size	.0197955**	.0082903	2.39	0.017
Cooperative membership	.0415918	.0458987	0.91	0.365
Access credit	.1660125***	.0529007	3.14	0.002
Extension service	.0419415	.0489463	0.86	0.392
Nearest market	-.0001491	.0006535	-0.23	0.820
Education	-.0120245	.0426221	-0.28	0.778
Experience	-.0010789	.0025334	-0.43	0.670
_Cons	-.297939	.1797211	-1.61	0.108
Number of obs = 126				
Wald chi2(11) = 83.31				
Prob > chi2= 0.0000				

***** and ** shows significant of coefficient at 1% and 5% probability level.**
Source: survey data, 2019

4.2.3. Constraints of lentil production

In order to utilize the lentil production sector, identifying the existing constraints and searching for solutions are best importance. The respondents identified 16 major constraints. All problems cannot be solved at once because of time and capital shortage. As a result, prioritization of the problems was made to identify and discussed the most important constraints that hinder the development of lentil production in the study area.

Based on the result of this study, farmers much suffered from a number of difficulties and challenges that are antagonistic to the success desired in lentil production. Outcomes from focus group discussions as well as key informant interviews suggested that farmers were willing to improve and expand their farm if access to technology could be improved. However, there were still some farmers who were not willing to improve their farming practices due to various reasons. According to the response of the farmers and available information on major challenges of the farmers, the first constraint of lentil production iscrop diseases (Table 10).

Based on the results of this survey, 100% of respondents had observed as a serious constraint affecting lentil production is crop diseases in their farm, that frequently put out of production and it was ranked 1st among the challenges identified. Diseases lower the yield of lentil. Diseases in the study area have harmful effects to lentil and hence lower the crop yield. The average productivity of lentil low at this data collecting time due to rust diseases. Usually rust causes about 25% yield loss in the normal year while crop loss seldom occurs (MOARD, 2003). In focus group discussion the farmers said that the effectiveness of agricultural chemicals like insecticides, herbicides and fungicides is too low. Due to inability of agrochemicals of not controlling pests and diseases, farmers end up with getting low yield. However, the cost of pesticides in terms of money and the cost of labour to spray the chemical are high. The crop damage caused by insects and diseases on lentil crop calls for the farmer to use that cost money in terms of cost of the chemical and cost of labour to spray the chemical. The study is supported by (Joshua, 2018)who noted that the principal constraints that face common bean production and commercialization include both diseases and pests.

Table 10rates insect pests as a second serious challenge in the study area accounted for 95%.This implies that pests lower the yield and quality of the crop. As reported by Rodríguez and Creamer (2014) and Joshua(2018) pest is a second serious constraint after diseases facing common beans production. Moreover, the study is consistent with Karanja (2016) who reported that most of the legumes are vulnerable to insect pests in the field and in storage. Also, the field and storage pests are responsible for losses in excess of 40% every year (Hillocks *etal*., 2006, KILIMO Trust,2013).

Most of the farmer suffering with timely not availability improved seed at the time of sowing. Improved lentil seed is timely not available the third constraint of lentil production and reported by 93.37% of the respondent farmer not get improved seed timely. Non-availability of quality seed of lentil is an important constraint in enhancing area and production pulse.

High cost of seeds was the other important constraint to lentil production and was reported by 88.55percent of the respondent farmers. This was not surprising given that, lentil seeds are very costly compared to other cereal crops. Smallholder farmers being resource poor, makes credit accessibility to be an important factor in lentil production. The use of improved seeds was further lowered by the fact that, alternative seed (local) was in many cases not purchased, but previous harvest was used for seed. Therefore, the farmer ends up choosing the cheaper option of using the local seeds.

High price of fertilizer was last to give prioritization constraint to lentil production and was reported by 81.33percent of the farmers. This situation was not surprising given that fertilizer is very expensive.

Table 6. Major constraint to lentil Production

Constraint to production	% of respondent farmers	Rank of the constraint
Timely availability of improved seed	93.37	3
High price of improved seed	88.55	4
Quality of seed	40.96	9
Availability of credit to buy seed	47.59	7
Timely availability of fertilizer	43.98	8
High price of fertilizer	81.33	5
Availability of credit to buy fertilizer	49.40	6
Access to market and information	33.73	11
Reasonable grain prices	21.08	12
Low price of output	37.35	10
Water logging	21.08	12
Insect pests	95.18	2
Floods	21.08	12
Crop diseases	100.00	1
Weed infestation	19.28	13
Soil fertility	17.47	14

Source: survey data, 2019:

5. SUMMARY, CONCLUSIONS AND RECOMMENDATION

5.1.Summary

Lentil is an important legume crop and plays an important role in human, animal feeding and soil improvement it's also contribution to households' nutrition, income and food security is very high. In Ethiopian, lentil productivity is very low due to several constraints like timely availability of improved seed, high price of improved seed, high price of fertilizer, insect pest and disease crop.

This paper aims to understand the extent and determinants of improved lentil adoption in Gimbichu districts of East Shewa zone.The study was based on data collected from 166 lentil producer analyzed the determinants of adoption of improved lentil using the double hurdle econometric model. These factors together with several household personal, demographic and socio-economic factors greatly affected the adoption of improved lentil production and productivity.

The probit model results showed that the contributing factors of adoption improved lentil varieties were Sex of household head, tropical livestock unit, family size, land holding size, extension contact, education level and member of cooperative of positively and statically significant to have contributed to the decision to adopt improved lentil varieties. The truncated model results showed that intensity of improved lentil produce by smallholder farmers influenced by active labour force, household size, obtained credit, and livestock unit had a significant effect on the intensity of use of lentil varieties produce at different significance levels in the study area. Major constraints of lentil production were reported that timely availability of improved seed, high price of improved seed, high price of fertilizer, insect pest and disease crop.

5.2. Conclusions

The level of adoption observed in the study area is an indication of the existence of substantial potential to improve smallholder productivity with minimum cost compared to development and introduction new technologies.

As repeatedly stated improved lentil varieties production is important in solving food security and poverty problem in agriculture based economies demand for substantial efforts in improving agricultural production and productivity. As result of this, institutional support provided to this sector, such as credit service, extension service was not to the expected level. These factors together with several household personal, demographic and socio-economic factors greatly affected the adoption and intensity of improved lentil varieties production and consequently production and productivity of the sector.

5.2. Recommendation

Based on the research finding and conclusions of this study, the following points are recommended to improve farmer's adoption of improved lentil varieties as to enhance its production and productivity.

Sex of the household was one of the significant variables determining the adoption of improve lentil varieties. It should focus on different strategies that should give attention on empowering women in using improved lentil technology, particularly, in improved varieties.

Livestock ownership was one of the significant variables determining the adoption and level of adoption improve lentil varieties. Therefore, making effort to improve the existing livestock ownership in the study area through improved livestock management approach has to be considered as a central and core component of any development intervention to improve the adoption improve lentil varieties.

Institutions like cooperatives play an enormous role in disseminating technologies such as improved seeds and fertilizers, and in providing information for farmers in order to disseminate technologies. Further attempts to address farmers through cooperatives, therefore, play great roles in enhancing adoptions of technologies.

Education of the household head positively influences participation in improved technology. This indicates that increasing adoption of improved lentil varieties would increase as the educational level of the households. This implies that interventions to speed up lentil technology adoption and dissemination must be targeted at improving farmers' knowledge and skills by capacitating and supporting FTCs focused especially on aspects of lentil production, marketing and consumption. Policies and strategies should therefore place more emphasis on expanding primary education and increasing school enrolment rates of children in rural areas to achieve increased agricultural productivity in the future.

Active labour force was powerful in explaining adoption and intensity of lentil technologies suggesting that these technologies required additional labour for different operations and hence may not achieve high adoption in areas where there are labour shortages. Therefore, policies and strategies should consider availability of labour before introducing such labour intensive technologies.

Land is a limiting factor of production in agriculture. Farmers with more land are more likely to adopt among households was found to be influenced a relatively higher share of their land for lentil varieties. Thus, adoption becomes more difficult in the farms with relatively small land size. However, increasing the size of landholding cannot be an option to increase lentil varieties adoption since land is a finite resource. Therefore, intervention aimed to improve land fertility status and increasing productivity of land through proper utilization of available land resource is required.

Furthermore, the finding of this study suggests that institutional service like credits are the key factors in influencing the level of adoption. Thus availability of credit service can help to facilitate farmers to adopt improved lentil varieties. Expanding sources of such institutional service is another possible recommendation from the present study, if actively to adopt of improved varieties the smallholder farmers is required in lentil production in the study area.

In order to improve farmers level of adoption of improved lentil varieties as well as land allocated for improved lentil, extension workers should provide farmers with more practical trainings under farmers' direct participation in the demonstration centers.

In addition to this as discussed in the descriptive part of the study larger numbers of farmers have reported the existence of disease problem in the study area, hence farmers should get training on how to avoid disease problem and avail materials required for crop protection based on their needs and other research should be done on it, especially on their prevention and control methods. Hence, Agricultural research center and agricultural offices should provide technical assistance of this crop about it; production, management pest and disease control.

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Appendix I: Questionnaire Schedule

Survey on Smallholder's Adoption of Improved Lentil Varieties in Gimbichu District, East Showa zone, Oromia National Regional State, Ethiopia.

HH ID: _______ Kebele ID: ______

Dear respondent! This survey questionnaire is designed with the objective of collecting information on the technology adoption of farmers. It therefore meant only for research purposes. For this purpose your genuine responses to each of the survey questions are highly useful. There is no "right" or "wrong" answers. Your responses will be confidentially used for this research purpose only.

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

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

Interviewer (Enumerator) Name: ____________________________
Tell: _____________________Sign. ________

General information

1. Date of interview_____________________(DD/MM/YYYY)

2. Name of kebele 1) Adadi Gole 2)Areda 3)Dobi 4)Tulu Fera

3. Agro-ecology 1) Mid high land (W. dega)2) high land (Dega)

4. Name of the enumerator___________________________

Household personal characteristics

1. Name of the household head: ____________________
2. Age of the household head_____________________________
3. Education level of HHH : 1) Illiterate 2) Read &Write 3) primary 4) secondary 5) above
4. Sex: 1) Male 0) Female

Household members list

No	Name of the HH members	Relation ship (Code 2a)	Sex 1. Male 0. female	Age (years)	Education (code 2b)	Marital status (code 2c)	Occupation (code 2d)
	Total						

Code 2a

1. Head
2. Wife/husband/partner
3. Son/daughter
4. Mother/father
5. Aunt/uncle
6. Grandfather/grandmother
7. Grandson/granddaughter
8. Mother/father in law
9. Brother/sister in law
10. Servant
11. other specify

Code 2b

1. Illiterate
2. Read &Write
3. primary
4. secondary
5. above

Code 2d

1. farmer/work in family farm
2. domestic work/housewife
3. manual worker
4. weaver/craft worker/blacksmith/potter
5. teacher
6. administrator
7. solider
8. trader
9. Student
10. others specify

Code 2c

1. Single
3. Divorced

2. Married4. Widowed 3. Not together for any reason

5. Total lentil farming experience of the household head in year's __________

6. Household head experience in improved lentil farming in years ____________

7. Did you grow improved lentil? 1. Yes 0. No

Socio-Economic Factors

Farm size

8. Land ownership in 2010/2011 E.C (total farm size owned (in hectare) _______________
9. Cropped land under (improved lentil) in hectare ______________
10. How did you get land? 1. Inherited from family 2. Gift from relatives/on kinship basis 3. Government redistribution 4. Rent in____

11. Crop production by the household in 2010/2011production season

No	Types crop grown	Area coverage (ha)	yield/ha(in quintal	Total yield	Type of production

Type of production: 1) Sole/mono/ cropping 2. intercropping

Livestock Holding

11. Livestock ownership by the end of 2010/2011 EC production season

No	Livestock type	Total	Remark
1	Oxen		
2	Cows		
3	Bulls		
4	Calves		
5	Heifer		
6	Sheep		
7	Goat		
8	Horses		
9	Mules		
10	Poultry		
11	Donkey		
12	Beehives		
13	Others		
14	Total		

Household Incomes

13. Household's **annual farm income** from sale of crops **2010/2011** E.C in quintals

No	Types crop grown	Annual harvest	Consumed	Gift	Sold		Total price
					Amount Unit	Unit price	

14. Income from **sale of livestock 2010/2011**E.C

No	Livestock type	Total number	Consumed	Seed reserve	Gift	Sold		Total price
						Amount	Unit price	
1	Oxen							
2	Cows							
3	Bulls							
4	Calves							
5	Heifer							
6	Sheep							
7	Goat							

8	Horses							
9	Mules							
10	Poultry							
11	Donkey							
12	Beehives							
13	Others							
14	Total							

Purpose includes 1. For purchasing farm inputs 2. For settling debts

3. For buying clothes for family 4.For buying food grains 5. Others (Specify) ____________________________

15.Income from sale of livestock products 2010/2011 E.C

No	Livestock type	Yield obtained/collected per year per in kg/lit/number	Amount Consumed	Amount sold	Unit price	Total revenue	Purpose of sale
1	Milk						
2	Egg						
3	Honey						
4	Butter						
5	Dung cake						
6	Others						

Purpose includes 1. for purchasing farm inputs2. For settling debts

3. for buying clothes for family 4. To buy food grains

5. Others Specify)_________________________

16. Total Annual income of the household (Income from agricultural production) ________birr.

Institutional Factors

Participation in Social Organization

17. In which of the following organization are you a member and leader

Organization/institution	Non-participant (0)	Member (1)	Committee member (2)	Leader (3)	Frequency of participation in activities		
					Never (0)	Some times(1)	Always (2)
village organization (Iddir, Mahber)							
School council							
PA council							
Saving and credit group (Equb, micro-finance)							
religious organizations							
Cooperatives membership							
Others							

Credit Accessibility

18. Do you or your households have a saving account? 1. YES 2. NO

19. If Yes, from which financial institution do you have saving account?

1. Bank 2. Microfinance

3. Saving and credit cooperative 4. Others

20. If NO, do you save money any ways? 1. YES 2. NO

21. If YES, Where do you save your money?

1. At home 2. Equb

3. With family/friend 4. Others

22. Have you obtained credit for IL production in the last five years? 1. Yes 2. No

23. If your answer for question number 22 is yes, Please fill the following table

No.	Credit Source	Amount	*Purpose of use

Purpose: 1. For purchasing fertilizer2. for purchasing improved seeds

3. For purchasing chemicals 4. Other (specify)………………………………

Extension Services

24. Do you get advisory services from extension agents on improved lentil varieties?

1. Yes 2. No

25. If yes, Frequency of the extension agent visits during 2010/11 production season?

1. Never 2. Once in a week

3. Monthly 4. Only during plantation

5. during input provision 6. Others (Specify)________________

25. When does extension agent visit you?

1. During land preparation 2. During sowing

3. When disease/ pest occur 4. During harvesting

5. Others (Specify)____

26. When have you first heard about improved lentil varieties?________________________

27. from who/ which source?

1. Mass media2. Contact farmer 3. Input dealers

4. Research Center 5 NGO 6. PA leader

7. Agricultural professionals8. Cooperative 9. Neighbors/ friends

10. Other specify______________________

28. Which improved variety of lentil have you first grown?

Name of improved lentil variety	Have you grown? 1= yes 0= No	Remark
Alemaya (FLIP 88-63L)		
Derash		
Chekol (NEL-2704)		

Teshale		
Adaa (FLIP 86-41L)		
AlemTena		
Chalew (NEL-358		
Gudo (FLIP 84-78L)		

Market distance

29. Market centers accessible to you

Name of the market	Distance	Mode of transport	Transport cost	Commodities sold at the market place

VI: Intensity of adoption of and improved lentilcrop management

31. Did you encounter disease problem in improved lentil cultivation in 2010/11 E.C production season?

1) Yes 0) No

32. If yes, what kind of measure did you take? 1) Local 2) improved 3) Nothing

33. If you did not apply improved method of disease control what is your reason? ________

38. Amount of improved lentil seed the farmers used and area Coverage by improved variety of in 2010/11 E.C

Subject	Name of improved lentil grown	Area in ha	Seed rate Kg/ha	Methods of planting		Fertilizer rate (kg)		Yield in kg
				Broad cast	Row	DAP	NPS/B	
Total area allocated for IL								

39. What are your constraints in using improved IL?

1) IL is not available 2) labor shortage

3) Lack of credit to buy seed 4) Weather not good

5) Low price of lentil 6) Lack of knowledge on usefulness of improved seed

7) Market problem 8) disease9) water logging

Key Production Constraints for lentil Production

43. What are the major problems related to lentil production in your area? (Rank them by giving one for the most severe)

No	Production constraints	**Lentil**	
		Constraints? **1 ye 0 No**	Rank its importance only those with Yes in column 2
	Socioeconomic		
1	Timely availability of improved seed		
2	High price of improved seed		
3	Quality of seed		
4	Availability of credit to buy seed		
5	Timely availability of fertilizer		
6	High price of fertilizer		
7	Availability of credit to buy fertilizer		
8	Access to markets and information		
9	Low price of output		
	Biological		
1	Drought		
2	Floods		
3	Pests		
4	Crop diseases (rusts…)		
5	Weed infestation		
6	Soil fertile		

Appendix II: Checklist for focused group discussion.

As you probably know, Agricultural research Center together with Woreda agriculture office is trying to popularize an improved variety of Lentil, which should significantly increase yields.

1. Is the improved variety profitable to farmers? ____

2. Do the farmers experienced difficulty in procuring the needed inputs? Do they need credit?

3. Can you get good quality production inputs of lentil? _________________________

4. How do you see the recommended seeding and fertilizer application rate?

____

5. Did farmers in this area faced disease problem in lentil production? _________________

______

6. Which one of the variety (local or improved) you prefer? And how do you rank those improved lentil varieties by using your own criteria? _________________________________

7. Constraints for production of improved lentil and constraints for marketing? Mention solution to these problems?

____

8. What is the role of women in lentil cultivation? ______________________________

Appendix III: Table of conversation factor

Appendix Table1. Conversion factors used to calculate Tropical livestock unit (TLU)

No	Animals	TLU-equivalent
1	Calf	0.2
2	Heifer and Bull	0.75
3	Cows and Ox	1
4	Camel	1.25
5	Horse	1.1
6	Donkey	0.7
7	Sheep and Goat	0.13
8	Chicken and Poultry	0.013

Source: Strock *et e*l (1999)

Appendix table 2.

Variance inflation factor

Variable	**VIF**	**1/VIF**
TLU	2.06	0.485053
Total land	1.63	0.612567
income	1.56	0.639036
Active labour force	1.09	0.917606
Experience	1.09	0.917729
Age	1.08	0.922592
Family size	1.07	0.930956
Nearest market	1.04	0.957422
Mean VIF	**1.33**	

```
. pwcorr adopterandnonadopter cooperativemembership credit  sex_hh education extenstionservice
```

	adopte~r	cooper~p	credit	sex_hh	educat~n	extens~e
adopterand~r	1.0000					
cooperativ~p	0.1448	1.0000				
credit	0.5609	-0.0409	1.0000			
sex_hh	0.2021	0.0578	0.2119	1.0000		
education	-0.0027	0.0294	0.0171	0.1121	1.0000	
extenstion~e	0.4428	0.0878	0.2624	0.0822	0.0242	1.0000