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THE DETERMINANTS OF ADOPTION OF IMPROVED MAIZE VARIETY
IN KOLA TENBEN DISTRICT, CENTRAL ZONE TIGRAY, ETHIOPIA

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Declaration

This is to certify that this thesis entitled “Determinants of adoption of improved maize variety in Kola Tenben Woreda, Central Zone, Tigray Regional State, Ethiopia” is submitted in partial fulfillment of the requirements for the Degree of Master of Arts in Development Economics at Mekelle University, department of Economics written by Ataklti Kidanemariam is done inline all requirements. The thesis has not been submitted earlier for an award of any degree and has also acknowledged all sources through proper citations.

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Acronyms and abbreviations

ADLI	Agricultural Development Led Industrialization
BOARD	Bureau of Agriculture and Rural Development
BOFED	Bureau of Finance and Economic Development
CSA	Central Statistical Agency
DAP	Di Ammonium Phosphate
DAs	Development Agents
FAO	Food and Agricultural organization
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
HYV	High Yielding Varieties
MOFED	Ministry Of FINANCE and Economic Development
GYGA	Global Yield Gap Atlas
ESE	Ethiopian Seed Enterprise
GMO	GENETICALLY MODIFIED
NGO	NON GOVERNMENTAL ORGANIZATION
UNDP	UNITED NATIONS DEVELOPMENT PROGRAM
OPV	OPEN POLLINATED VARITIES

Abstract

In most of the world's poorest countries and especially, those in Africa, agriculture contributes to offer the leading sources of employment and to contribute large fraction of national income. In many of these countries, however, agricultural productivity is extremely low. Maize plays a major role in the livelihood and food security of most small holder farmers in Africa.

Adoption of improved maize varieties in agricultural production is considered as one of the most promising ways to ensure food security and alleviate poverty in Ethiopia. However, the adoption and dissemination of these varieties were constrained by various factors. This study was aimed at identifying the factors that influence adoption and adoption of improved maize varieties in Kola Tenben District of Central Zone, Tigray. Cross-sectional household level data were collected during the 2024/25 production year from 137 randomly selected sample household and used for the study. Both descriptive statistics and econometric model were used to analyze the data. The result of descriptive statistics indicated, existence of significant mean and proportion differences between adopters and non-adopters in terms of age of the household head, family size, educational level of the household head, frequency of contact with extension agent, access to fertilizer, number of oxen owned and radio ownership. From seven explanatory variables included in the model, four variables (frequency of contact with extension agent, access to fertilizer, number of oxen owned and radio ownership) were the important variables which had positively and significantly influenced adoption and adoption of improved maize varieties. Based on the findings, the following recommendations were forwarded. Policy and development intervention should give emphasis to the improvement of institutional support system by strengthening the existing agricultural extension system, providing the required fertilizers and agricultural training on time, expanding the distribution of radio program and expanding access to credit for the purchase of oxen and other inputs to achieve the target of adoption of improved maize varieties for increasing the production and productivity of smallholder farmers in Kola Tenben district.

Key words: agriculture, adoption of maize varieties, determinants of adoption, probit model.

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Chapter One

1. Introduction

1.1 Back ground of the study

In most of the world's poorest countries and especially, those in Africa, agriculture contributes to offer the leading sources of employment and to contribute large fraction of national income (Musba Kedir,2018). In many of these countries, however, agricultural productivity is extremely low. Maize plays a major role in the livelihood and food security of most small holder farmers in Africa.

Maize was originated in Central America and introduced to West Africa in the early 16th Century and to Ethiopia between the 16th and the 17th. It is Africa's maize was originated in Central America and introduced to West Africa in the early 16th Century Per capita consumption of maize in Africa is highest in eastern and southern Africa. Maize is processed to offer various product ranges, which include whole maize meal flour, sifted maize meal, vegetable oil, flour for confectionery, dough, corn flakes, snacks and crackers, starch converted to process sugars like glucose syrup and dextrose (Noah, 2005)

In Ethiopia agricultural sector have been played significant role in securing food security and economic growth with its share in GDP(43%), In Ethiopia 90% of the poor earn their livelihood, its employment generation (80%), share of export (70%) and providing about 70% raw material for the industries in the (UNDP, 2013). Despite such outstanding potential roles, currently, the productivity of the agricultural sector in Ethiopia has been limited and challenged due to many determinants (Ketema and Kebede, 2017). lack of appropriate and affordable new agricultural technologies, poor infrastructure, inefficient marketing systems, land degradation, rapidly expanding population, and inaccessibility to agricultural inputs and low adoption rate toward new agricultural technologies are important unproductively of agricultural sector (Bihon, 2015). Currently, Ethiopia is the fourth largest maize producing country in Africa, and first in the East African region (FAO, 2015). It is also significant that Ethiopia produces non-genetically modified (GMO) white maize, the preferred type of maize in neighboring markets. This strategy envisions exports markets being a significant part of the demand sink for Ethiopian maize. Maize is largest cereal commodity in terms of total production, average, and the number of farm holdings. It ranks second after Teff in area coverage and first in total production. The results of

the year (CSA, 2016), Meher season postharvest crop production survey indicate that total land areas of about 12,558,444.55 hectares were covered by grain crops. Out of the total grain crop areas, 81.27% (10,144,252.30 hectares) was under cereals. Of this maize covered 16.98% (about 2,135,571.85 hectares) and average yield Q/t/ha (3.67) and gave 78,471,146.57 quintals (CSA, 2016). The productivity of is very low as compared the developed counties 6.2t/ha because of lower utilization of improved agricultural technologies such as improved maize variety and chemical fertilizer among maize producing farmers. Maize is mainly grown in the four big regions of the country: Oromo, Amhara, SNNP, and Tigray. Oromia and Amhara contribute to almost eighty percent of the maize produced in 2012 (CSA, 2015/2016).

Maize is a staple food crop in Ethiopia, playing a crucial role in food security and the livelihoods of millions of people. In Kola Temben, a district in the Tigray region, maize production is vital for local economies. However, despite its importance, maize yields in this area remain below potential levels due to various factors. This research aims to identify and analyze the determinants of improved maize production in Kola Temben, focusing on agronomic practices, socio-economic factors, and environment. Maize is one of the cereal crop produced in most part of Ethiopia. In 2007/08, maize production was 42 million qt, 40 percent higher than teff and 75 percent higher than wheat production. With an average yield of 17.4 qt per hectare (equal to 32 million qt grown over 1.8 million hectares) from 1995 to 2008, maize has been the leading cereal crop in Ethiopia since the mid-1990s in terms of both crop yield and production (Rashid et al., 2010). In the year 2008/09, cereals contributed 84.6⁹% (about 144.96 million qt) of the grain production in Ethiopia. From which maize, wheat, teff and sorghum made up 22.97% (39.32million qt), 14.83% (25.37 million qt), 17.69% (30.28 million qt) and 16.38% (28.04 million qt) of the grain production, respectively. The average yield of cereals namely maize, wheat and teff were 22.24, 17.46 and 12.22 qt per hectare, respectively (CSA, 2009).

Ethiopia can be considered a success story for maize production as apart from South Africa; it is the only country in Sub-Saharan Africa that has shown substantial data from the Global Yield Gap Atlas (GYGA) shows that the average maize yield gap in Ethiopia is 82%. The yield gap is defined as the difference between potential yield and actual yield. Potential yield is the maximum yield that can be produced on a parcel of land given agro-climatic conditions,

assuming either rain fed or irrigated conditions (Abate, et al., 2015). Despite its significance, maize productivity in the country remains low compared to other countries in the region. One strategy to improve maize productivity is the adoption of improved maize varieties that are better suited to local conditions and have higher yields

1.2 Statement of the problem

The adoption of agricultural innovation in developing countries including Ethiopia has attracted considerable attention because it can provide the basis for increasing production and productivity. Adoption is the process of a decision to make full use of a technology as the best course of action available and consists of three stages namely pre-adoption, adoption, and post-adoption. It is apparent that agricultural productivity improvements will be improved among farmers through improved agricultural technologies which had developed at the research centers and disseminated to farmers' mainly through extension services (Stephen et al., 2014). On the other hand, the farmers' integration of these improved agricultural technologies into their farms is greatly influenced by socio-economic, institutional, attitude and perceived technology attributes (Bihon, 2015). The limiting maize productivity include production and market risks, low level of crop management practices, weeds, pest and diseases, erratic rainfall, erosion, low soil fertility, poor infrastructure, and post-harvest crop losses (Sisay.,2016). In study area During 2016-2017 meher cropping season maize covered a total of 4500 tsimad of land from these 2500 tsimad was covered by local maize varieties and 35100 quintal of maize was obtained while 2000 tsimad of land was covered by improved maize varieties and 43200 quintal of maize was obtained. The productivity of maize crop is very low because of lower utilization of improved agricultural technologies such as improved maize variety, poor management practices, seed quality, disease and pest infestation and chemical fertilizer among maize producing farmers. Moreover, information with regard to maize production in the study area has been focused mainly on the adaptability study of newly released different maize Varieties (Gebre and Mohammed, 2015). Improved maize variety is not yet widely adopted in the study area. Thus, research in this area is vital for understanding the problems related to the improved maize varieties production, adoption level of improved maize technologies and its determinants. The limiting maize productivity include production and market risks, low level of crop management practices, weeds, pest and diseases, erratic rainfall, erosion, low soil fertility, poor infrastructure, and post-harvest crop losses (Sisay.,2016). Therefore, with the above mentioned gaps, the

researcher intended to conduct examining the determinants of improved maize varieties, adoption level and recommended determinants with a view to filling the existing knowledge gap into the study area.

The agricultural sector productivity is one of the lowest which is even showing a decreasing trend with causing a decline in per capita cereal consumption. According to previous researches, there exists a wide cereal yield gap among the farmers that might be attributed to factors such as lack of knowledge and information on how to use new crop technologies, poor management, biotic, climate factors and others (Sisay et al., 2015). Despite the importance of maize as a food and industrial crops and the efforts made so far to generate and disseminate improved production technologies, its productivity remains far below its potential.

In wereda Kola Tenben were related to maize varieties and technological adoption (Wondimu, 2014), (Bealu et al., 2013). Why the productivity in improved maize production remained low in the study area? Previous studies have not addressed such question of the low adoption of improved maize in the study area. In addition to this, no studies have conducted on the determinants that affect adoption of improved maize in the study area. Thus, there is considerable scope to adopt improved maize and also productivity by increasing efficiency and sustaining the efficiency of those operating at or closer to the frontier. Improvements in efficiency and productivity lead to achieve more improved maize output and food supply which reduce malnutrition and poverty. To address this gap, the researcher motivated to study the Determinant of adoption of improved maize variety and adoption in Kola Tenben District.

1.3 Objective of the study

1.3.1 General objective

The main objective of this study is to examine the determinants of adoption of improved maize Variety in Kola Tenben District, Central Zone Tigray ,Ethiopia.

1.3.2 Specific Objectives

Specifically, this research intends:

1. To review the adoption of improved maize variety in the study area.
2. To assess the intensity of improved maize varieties in kola tenbien district.

3. To identify the determinants of adoption of improved maize variety in the study area.

1.4 Research questions

This study will be intended to answer the following research questions:

1. What are the determinants of adoption of improved maize variety in kola tenben?
2. What are the intensity of improved maize variety among the adopters in the study area?
3. What are the varieties of improved maize adopted in kola Tenben district?

1.5 Scope of the study

This study was conducted in Kola Temben District located in Tigray region. The study was restricted to cross-sectional household level data and identification of factors determining of adoption of improved maize seed varieties in the study area. Accordingly, improved seed varieties coverage is limited to only improved maize production and also limited to the district in terms of area coverage. Due to shortage of time, budget and other resources primary data collection for the study will limit to three purposively selected rural kebeles in the distant 137 sample households were interviewed. The data used for this study is based on a farm-household survey. Besides, the study paying attention on the application of **probit** model to assess the adoption and determinants of improved maize varieties.

1.6 Significance of the Study

This study would be contribute to the existing body of knowledge on improved maize adoption in kola tenben and provide valuable insights for policymakers, agricultural extension workers, and farmers. By identifying the determinants of improved maize adoption, the research will support efforts to enhance food security and livelihoods in Kola Temben. This could facilitate allocation of major resources for research, extension and development programs. Hence, understanding these factors are important for the researchers in providing information to develop agricultural technologies, which is favorable to the current situation of smallholder farmers in the study area. There are several reasons to invest in studying the adoption of agricultural technologies. These include improving the efficiency of technology generation, assessing the effectiveness of technology transfer, understanding the role of policy in the adoption of new technology, and demonstrating the impact of investing in technology generation. The findings

will provide valuable insights for policymakers and stakeholders working in the agricultural sector, helping them develop targeted interventions to promote the adoption of improved maize varieties in the region. Ultimately, the research aims to contribute to enhance food security in Kola Temben.

1.7. Limitation of the Study

A range of studies are aimed at establishing factors underlying adoption and determinants of improved maize varieties. As such, there is an extensive body of literature on the economic theory of technology adoption. Several factors have been found to affect technological adoption. These include government policies, technological change, market forces, environmental concerns, demographic factors, institutional factors and delivery mechanism. However, the study is concerned only with limited sample size, socioeconomic factors, demographic factors and institutional factors to assess factors that affect farmer's decisions to adopt improved maize varieties and to assess factors that affect improved maize varieties and also the perception of farmers towards improved maize varieties on local maize variety. This is mainly because of the limited resource available to the study on a wider scale, especially money constraints to collect data is the huge limitation of this study.

1.8. Organization of the thesis

This study is organized into five chapters. The first chapter outlined introduction, statement of the problem, research questions, objectives, significance and, scope and limitations of the study. Concepts and definition used in the present study along with a review of the past works are discussed in chapter two. Chapter three describes the study area and research methodology applied. Chapter four deals with descriptive results and discussions, econometric analysis results and discussions, Chapter five, deal with conclusion and recommendations

CHAPTER TWO

2. Literature Review

2.1 Improved Maize Varieties

Seeds are basic agricultural inputs. More importantly, quality seeds of any preferred variety are a basis of improved agricultural productivity since they respond to farmers needs for both their increasing productivity and crop uses (Pelmer, 2005). Improved seed varieties can be defined seeds that aim at increasing quality and production of crops by having characteristics such as drought tolerance, high yielding and early maturity (FAO, 2009). Nkonya (2001) defines an improved seed variety as any variety that has been bred using formal plant breeding methods. Cho (2013) define improved seeds by dividing it into pieces as: Open pollinated seeds which are those produced from natural, random pollination. Traditionally, farmers saved the best of these seeds for use from year to year. Hybrid seeds result from cross-breeding two parent plants that have desirable traits. The resulting plants realize their potential in the first season, but lose effectiveness in subsequent generations so farmers must buy new seeds each year and genetically, modified seeds are created when one or two genes with the desired traits from any living organism are transferred directly into the plants genome

2.2. Adoption of Agricultural Technology

The adoption of new agricultural technology such as improved seed varieties plays a fundamental role in the development process. In order to increase adoption of new agricultural technology different strategies needs to be undertaken. One of these strategies is promotion of the new agricultural technology. Promotion can be done through field trials and demonstration plots. Promotion can enable farmers to see the benefit from the introduced technology. After promotion evaluation must be done in order to see whether the technology has been adopted by the target group. Adoption of improved seed varieties is important because it helps farmers to have enough food and reduce poverty. For instance, a study in Mexico showed that adoption of improved maize varieties improves household welfare (Becerril and Abdulai, 2010). Similarly, in sub-Saharan Africa, adoption of improved maize varieties was indicated to have positive outcomes in poverty reduction (Alene et al., 2009). Several scholars' defined adoption of agricultural technologies in different times. According to Doss (2003), adoption can be defined

as the continued use of recommended idea or practice by individuals over a reasonably long period of time and the adoption is not a permanent behavior. Adoption is a mental process through which an individual passes run equilibrium when the farmer has full information about the new technology and its potential whereas the later refers to the spread of new technology within a region and is measured by the aggregate level of specific new technology with a given geographical area or within the given population. The intensity of adoption is defined as the level of adoption of a given technology. The number of hectares planted with improved seed varieties referred to as the intensity of adoption (Nkonya et al., 1997).

2.3. Improved maize varieties and Productivity

Productivity increases in agriculture can reduce poverty by increasing farmers' income, reducing food prices and thereby enhancing increments in consumption (Diagne et al., 2009). It is also of considerable significance that when agricultural production increases through the use of improved varieties of crops in a given area, farmers and their communities derive added socioeconomic benefit. Such activities can increase the value of locally produced crops, generate local employment, stimulate local cash flow, and through processing, marketing, and related activities can bring about improvement in socio-economic status and the quality of life (Mwabu et al., 2006). However, several research findings have pointed to the fact that the use of new agricultural technology, such as high yielding varieties of improved seed could lead to significant increase in agricultural productivity in Africa and stimulate the transition from low productivity subsistence agriculture to a high productivity agro-industrial economy (World Bank, 2008). Solomon et al. (2011) stated that governments of developing countries have sought to promote the diversification of production and exports away from the traditional commodities in order to accelerate economic growth, expand employment opportunities, and reduce rural poverty. However, mere increase in production cannot guarantee for the overall improved welfare of the smallholder farmers. Domestic and international markets opportunities should be created so that farmers can supply their surplus production and support their lives with additional incomes. Increasing maize productivity will benefit smallholder farmers only if the marketing activity (aggregation and trading) is well-developed (IFPRI, 2008).

Low crop productivity in SSA including Ethiopia is mainly due to a limited use of improved seeds varieties by smallholder farmers. The supply of certified seeds of grain crops in Ethiopia is

estimated to be about 10% of the annual seed planted (Spielman et al., 2010). Farmers' access to seeds of adapted varieties of modern or landrace to their agro-ecologies is critical in increasing production (Feder et al., 1985). However, deficiencies have been observed in improved seed supply due to inadequacies in seed varieties demanded and quantity required, prices, and untimely seed delivery (Sahlu et al., 2008).

2.4. Seed System and Smallholder Agriculture in Ethiopia

One of the most important inputs in agriculture is seed. Seeds form the foundation of all agriculture. Without seeds there is no next season's crop. The genetic traits embodied within seeds reflect and determine the nature of farming systems dependent on them. The genetic and physical characteristics of seed determine the productivity in line with the use of other agricultural inputs and improved cultural practices within the farming system. Improving the genetic and physical properties of seed can trigger yield increase and lead to improvement in the agricultural production and food security. In order for seed to act as a catalyst in agricultural transformation, however improved seed has to be made available to a broad base of farmers on continuing basis.

The use of good quality seed of improved varieties is widely recognized as fundamental to ensure increased crop production and productivity. This is even more important in SSA in the view of increasingly available land, declining soil fertility and ever growing population; those facts increase the importance of promotion and use of good quality seed as a means to intensify crop production. The potential benefits from the distribution of good quality seed of improved varieties are enormous, and the availability of quality seed of wide range of varieties and crops to the farmers are the key to achieve food security in SSA. Enhanced productivity, higher harvest index, reduced risks from pest and disease pressure, and higher incomes are some of the direct benefits potentially accrued to the farmers (FAO, 2004).

The supply of any seed material depends on the availability of seed from the formal and the informal sectors and their ability to develop and provide seeds of the cultivars needed by the local producers. The Ethiopian formal seed sector is composed of the Ethiopian Institute of Agricultural Research (EIAR) and Universities (as crop breeding bodies) and the Ethiopian Seed

Enterprise (ESE) (as seed multiplier and supplier). Unlike the formal sector where there is clear distinction between cultivar development and seed production and supply, in the informal seed sector both, the production and the supply ends are linked, as farmers are the ones who manage both. It is largely recognized in Ethiopia that farmers can obtain seed from the formal (seed companies/enterprises, agricultural research centers and universities) as well as the informal (local or traditional including farmers' saved seed, local markets exchanges). (Yealembirhan,2006).Production and distribution of improved seed and the creation of institutions that facilitate it are some of the critical components (Lipton, 2005). In Ethiopia, there have been only two seed producing enterprises, one is the Ethiopian Seed Enterprise (ESE), established in 1979 and the other was the multinational private company (Pioneer Hi-bred Ethiopia established in 1990).Before 1979, the Ethiopian Seed Industry was very much ad hoc, and seed multiplication and distribution were carried out by a number of small uncoordinated agencies such as Agricultural Research centers, Colleges and Universities of Agriculture, different project related agencies such as Rural Development Unit. Until 1990, ESE was solely responsible for the sale of seed, distribution of inputs such as seed, fertilizers and insecticides (Gemeda et al., 2001).Historically, the ESE largely used to supply seed to state owned farms in the late 1970s and 1980s, under the Dengue regime. After the regime changed in 1991, the enterprise extended its service to smallholder farmers whose demand was triggered by the mid-1990s extension package intervention of SG2000 later widely adopted by the government (Belay, 2003). SG2000 conducted identification of potential varieties and undertook demonstrations on large plots of land to show the impact. Seed and other inputs were delivered to farmers on credit through government offices.

The supply of basic seed such as improved maize varieties are the mandate of public research institutes while the Ethiopian Seed Enterprise (ESE) mainly handled certified seed provision until 2008. Seed and other inputs were delivered to farmers on credit through government offices. The private seed companies have a considerable market share (30-40%) (Tesfaye et al., 2012) in the hybrid maize seed provision whereas the OPVs are entirely provided by the public sector. Most of the private companies use publicly-bred seed and antractors to the ESE except for the Pioneer Hybrid. Both the public and the private seed enterprises deliver their seed through the public extension services to farmers' cooperative unions for distribution and marketing. The

average seed production cost of private companies is lower than that of public seed enterprises (e.g. ESE), but the marketing and the promotion costs are prohibitively high for them (Alemu et al., 2008). Moreover, OPVs are not attractive to the private seed companies because the farmers can recycle the seed for multiple years once they have obtained the seed. The public seed enterprises are expected to make profits as well as to meet the needs of the farming community. Nevertheless, they are unable to satisfy the needs of the smallholder farm households residing in the countries highly diversified and risk prone agro-ecologies.

Like in many other Sub-Saharan African countries, maize plays a major role in the livelihood and food security of most smallholder farmers in Ethiopia. Maize is grown in most parts of the country with different productivity potentials. For many years, maize in Ethiopia has been the first in production and second (next to teff) in area of cropped land (Legese et al., 2011). Agriculture continues to be the dominant sector in Ethiopia's economy, with cereals playing a central role. Grain production and marketing are particularly important, previous studies show that cereals account for 65 percent of the agricultural value added, equivalent to about 30 percent of the national GDP. In 2015 production year, smallholder farmers (14.16 million farmers) cultivated 12.57 million hectares of land for grain crops. Out of the total grain crop area, 80.78% (10.14 million hectares) was under cereals. Teff, maize, sorghum and wheat took up 24.02% about (3.02 million hectares), 16.80% (2.11 million hectares), 14.58% (1.83 million hectares) and 13.25% (1.66 million hectares) of the grain crop area, respectively. Cereals contributed 87.31% (about 236.08 million quintals) of the grain production. Maize, teff, wheat and sorghum made up 26.76% (72.35 million quintals), 17.57% (47.51 million quintals), 15.65% (42.32 million quintals) and 16.05% (43.39 million quintals) of the grain production.

Maize is Ethiopia's leading cereal in terms of production, with 7.2 million tons produced by 8.68 million farmers across 2.11 million hectares of land (CSA, 2015). Over two-thirds of all Ethiopian farmers grow maize, mostly for subsistence, with 75% of all maize produced being consumed by the farming household. Maize is the cheapest source of calorie intake in Ethiopia, providing 20.6% of per capita calorie intake nationally (IFPRI, 2011). Maize is thus an important crop for overall food security. As compared to other cereals, maize can attain the highest potential yield per unit area. World average yield for maize is about 5.0 t/ha and that of developed countries is 6.2 t/ha (MoA, 2014). The average yield in developing countries is 2.5

t/ha. In Ethiopia the national average yield is about 3.43 t/ha (CSA, 2015).

Maize is instrumental for the food security of Ethiopian households, and is the lowest cost caloric source among all major cereals, which is significant given that cereals dominate household diets in Ethiopia; the unit cost of calories per US dollar for maize is one-and-a-half and two times lower than wheat and teff respectively. Maize is also a low-cost source of protein in comparison to other cereals: maize provides 0.2 kg of protein per USD, compared to 0.1 kg of protein per USD from teff and 0.2 kg of protein from wheat and sorghum. An average Ethiopian consumes a total of 1,858 kilocalories daily of which four major cereals (maize, teff, wheat, and sorghum) account for more than 60 percent, with maize and wheat representing 20 percent each (Rashid et al., 2010). During the past years, the government and NGOs have undertaken various attempts to enhance agricultural productivity particularly that of cereal crops so as to achieve food security and to reduce poverty in the country. The available studies on the productivity of cereal crops in general and maize production in particular in Ethiopia found low productivity in comparison with the international standards (Alemayehu, 2009), although, the current average national maize productivity of Ethiopia African countries. However, it is still low compared to that of the world average

Maize productivity (50t/ ha) (MoA, 2014). The importance of maize in the country's agricultural economy and household level food security calls for increasing its production and productivity through use of improved maize varieties. However, smallholder farmers' knowledge and use of agricultural technologies in general and improved maize varieties in particular, are limited due to various factors that are either internal or external to the farmers' circumstances. Most commonly internal factors that affect adoption and use of agricultural technologies are farmers' attitude towards risk (Feder et al.,(3.43 t/ha)(CSA, 2015) is better than the national productivity of manyal., 1985), household characteristics that affects the level of production and consumption, resource endowments, and the like. External factors could be access to technologies, in particular through a well-developed seed system (Byerlee and Heisey, 1996; Croppenstedt 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;Tripp and Rohrbach, 2001).

2.5. Adoption of Improved Maize varieties

2.5.1. Farmers' decision-making behavior

The theories of decision-making have been largely rooted in disciplines economics and psychology. In psychology, observations are made to describe human judgment process and how people make alternative judgments based on their perception. According to Dunn (1984) decision-making is a ubiquitous activity inherent in the behavior of individuals or society. Decision can be categorized as intuitive, programmed, and analyzed. Those choices that individuals make without conscious thought as to the alternatives and the relative evaluation are known as intuitive decisions. Whereas programmed decision making are those in principle capable of being automated. There are certain decisions that one has to analyze possible outcomes and their consequences (Gebre-Mariam, 2012). A decision problem consists of (i) alternatives available to the decision maker, (ii) state of nature (rainfall, price etc), (iii) probability attached to the state of nature influencing the decision problem (iv) consequence of action, (v) process of conducting experiments to obtain additional benefit, (vi) process of conducting additional information about the likelihood of outcome given the state of nature, and (vii) the strategy for action which are conditional on the experimental outcome observed (Dunn, 1984). The distinction between farmers producing improved varieties or old or both is key for studying farmers behavior which is much complex when the environment is highly unpredictable. Decision-making takes different aspects.

According to the Rational Decision-making Model; a model in which decisions are made systematically and based consistently on the principle of economic rationality people strive to maximize their individual economic outcomes (Taher, 1996; Mendola, 2007). Information about all possible alternatives, their outcomes and the preference of decision makers is assumed available. Various statements identified the factors influencing the decision-making process in farm management. Taher (1996) emphasized the community influence on the farmer. He argues that decisions in farming will be determined not only by the goal of maximizing the benefit or of reducing the risk, but also by willingness to accept criticism from the community (depending very much on a farmer's social position indifferent groups). According to Reijntjes et al. (1992), the decision-making process is influenced not only by the culture of the community to which the household belongs but also by other factors such as personality of the decision maker,

biophysical characteristics of the farm, the availability and quality of external inputs and services, and socio-economic and cultural processes within the community. More details about the characteristics of households that influence the farm household decision-making are the number of men, women and children, their ages, state of health, abilities, desires, needs, farming experience, knowledge and skill, and the relations between household members. Those factors that influence the farmers' decision-making to achieve their outcomes can be systematized in physical environment, socio-economic environment (included political aspect), and farmers' household size and production factors. Adoption is acceptance and use of new agricultural technologies by the farmers. It is a dynamic process that is determined by various factors such as farmers perception of benefits of the technology, efforts made by the extension services to disseminate these technologies to the farmers, risks involved, costs involved, profitability and complexity like that the likelihood that farmers will be able to apply it correctly. Adoption of agricultural technologies by the farmers is an essential pre-requisite for economic prosperity in less developed countries (Nkonya et al., 1997). If certain groups of farmers are not adopting improved agricultural technologies or are adopting them at a lower rate than other groups, then, there is need to determine why.

Consequently concerted efforts are needed to unearth the exact reasons behind low levels of adoption of agricultural technologies; otherwise the appropriate technologies could remain on the shelves while yields in agricultural production especially maize, the staple diet continue to decline. This is because it only by understanding the reasons, that the researchers will be able to develop improved technologies that are appropriate for all such as technologies that will influence farmers' perception towards adopting them entirely. Most empirical studies on adoption of agricultural technologies such as Ransom et al. (2003) concentrate on farmers' characteristics as the main factors that influence adoption or rejection of agricultural technology package. They compare farmers who have adopted or rejected a certain technology at a point in time against their own socio-economic characteristics. They overlook the influence that technology characteristics can have on adoption. Technology specific attributes can influence the farmers adoption decision in the same way as his/ her own socio-economic circumstances can influence his/her decision to adopt or reject a technology. These technology characteristics include initial cost, risk involved, relative profitability and complexity of technology. The

present study has used some selected socioeconomic, demographic and institutional characteristics to examine how they have influenced adoption of improved maize varieties in Kola tenben district.

2.5.2. Farmers Seed Variety Adoption

Improving maize production is considered to be one of the most important strategies for food security in the developing countries. The diffusion of the improved maize varieties (IMV), like hybrids and open pollinated varieties (OPV) can greatly increase maize yield per unit of land. However, farmers' choice on improved varieties is one of the most crucial factors affecting the productivity of a crop. This is influenced by many factors that affect the farmers' variety adoption decisions (Rogers, 2003).

Decision of farmers to adopt a new agricultural technology in preference to other alternative technologies is based on intricate factors such as farmers' resource endowment, socio-economic status, demographic characteristics and access to institutional services (Negatu and Parikh, 1999). Farmers' decision-making may not be based on as rational decision-making model suggests, is based on the assumption that individual have perfect information and there are less constraint in choices thus individuals are expected to maximize their economic outcomes (Taher, 1996). The adoption of agricultural innovation such as improved maize seed varieties has obtained substantial attention among researchers and policy makers because the majority of the populations of less developed countries derive their livelihood from agriculture mainly crop farming. Improved agricultural technologies (improved seed varieties) are believed to offer an opportunity to increase production substantially. The introduction of improved agricultural technologies, however, has met with only limited success, as measured by observed rates of adoption. Spielman et al. (2010) documented aggregate adoption of crop in Ethiopia between 4.7% to 19%. Langyintuo et al. (2010) reported that improved maize adoption in many Africa countries is low with few exceptions. Agricultural technology adoption is described as a decision made to use an innovation in usual farming practice (Feder et al., 1985). An innovation can be described as technological entity that can improve the production frontier, yet it has perceived uncertainties since it is new for the adopter. The uncertainty is expected to weaken over time as the adopter develops experience and confidence (Feder et al., 1981). In this research, adopters are farmers who have experience using improved varieties of maize seed.

2.6. Farmers Access to Maize Seed and the Seed Quality in Ethiopia

Access to quality seed is crucial for food crop production. In order to realize sustained crop production and productivity, modern breeding has considerably increased the yield potential and improved varieties of crops seed over the last century. Both modern breeding and farmer seed selection have significantly contributed in generating suitable seed for sustainable food production. The provision of improved variety seeds has remained a point of discussion in developing countries such as Ethiopia (MoFED, 2010).

Different approaches of seed provision such as local seed projects and emergency seed projects have been tried in developing countries in order to increase farmers' access to suitable seed (Tripp, 2006). In Ethiopia, for example, farmer based seed multiplication and marketing schemes were executed across the country to boost certified seed provision (Sahlu et al., 2008). However, the practice did not last beyond the project periods as it was based on creating contractual seed producers for the formal seed enterprise rather than establishing a self-sustaining seed provision entity at the community level with sufficient linkage to basic seed provision. There are two sources of seed in the Southern Nation Nationality People Regional State to renew the seed stock. The formal one, which is dominantly supplied by Ethiopian Seed Enterprise for cereals and different types crop seeds, Seedlings of different fruit and other perennial crops multiplied in government and NGOs' owned modern nursery sites. The informal seed sources that include a seed retained by the farmers from current harvest and obtained through farmers-to farmers exchange. However, both have their own drawbacks. That is, the capacity of the formal sector is limited to supply the nations demand and the traditional one (informal system) is incapable of producing improved quality seed in the existing situation.

2.7. Empirical Studies on Improved Seed Varieties Adoption

Many studies have focused on the relationships of key variables to the adoption behavior of farmers. A review of previous studies is important as it provides some conceptual and theoretical basis for identifying the relevant variables to be included in the analysis. Hassan et al, (1998), for Kenya, Adesina and Baidu- Forson (1995) for Burkina Faso, Baidu-Forson (1999), for Niger, and Itana (1985), for Ethiopia, reported that farmer's age is negatively related to adoption and hence implying that the older the farmer the lower is the probability of adoption. According

to their analyses, this may be because conservativeness (risk aversion) increases with age, which may be one cause of low adoption of agricultural technologies. Freud et al. (1996) in the case of Ghana and Cote d'Ivoire, have found that farmer's age and adoption of modern varieties of cocoa are not at all related, whereas, Hossain et al (1992), revealed that the probability of adoption of new farm practices increases with farmer's age in Bangladesh.

The study conducted on adoption of improved maize varieties in developing countries, particularly Africa and South Asia, pointed out a number of socio-economic characteristics, agro-ecological variables, and farmers' perception as an important determinant of maize varieties adoption (Bindod, 2010). Among these variables, extension contact, education, farm size, credit availability, use of fertilizer, low land area, yield and profitability are found to be major determinants which have strong positive influences. The adoption studies are found more focused to socio-economic variables in comparison to agro-ecological variables and farmers' perception. Researchers suggested considering these variables as important as the socioeconomic variables in any adoption studies of agricultural innovations (Bindod, 2010). The study conducted on Determinants of adoption and intensity of use of improved maize varieties in the southern low lands of Ethiopia by using Tobit model revealed that the adoption of improved maize varieties significantly influenced by education level of the household head, labor, farm size, farm income, availability of improved variety of maize and access to agricultural extension service (Alene et al, 2000). The study conducted on Determinants of Adoption of Improved Wheat Varieties By Smallholder Farmers: The Case of Kola tenben woreda central Zone, Tigray Region, Ethiopia by using Tobit model showed that the adoption of improved Wheat varieties significantly influenced by cultivated land size of the household, frequency of contact with extension agent(s), age of the household head, farm experience and Market distance to input and output centre (Abera, 2013). A study conducted by Shiyani et al., (2000) on the adoption of improved chickpea in Tribal Region of Gujarat, used Tobit model to identify factors, which determine adoption of new varieties. The result have shown that proximity to market center, level of education and experience of growing chickpea influence adoption positively, but the size of land holding was found negatively related with adoption. The study conducted on factors influencing adoption of improved maize varieties in Nepal Chitwan District which using logit model showed that the adoption of improved maize varieties significantly influenced by winter

maize cultivation, education of the household head, lowland area, upland area as well as access to credit and extension services (Pashupati and Atsushi, 2008).

Similarly, a study by Kidane,(2001) used a Tobit model and the result showed that frequency of contact with development agents, annual on-farm cash income and radio ownership were found to have a positive influence on adoption decisions of improved maize varieties, whereas distance of the farmers residence to the nearest market place was found to have a negative influence on probability of adoption and intensity of using the improved maize varieties. Mubarak (2009) also identified that farmers' educational level, farm size, number of oxen, total active labor force, total livestock holding, crop income, off-farm income, contact with extension agents and perception of the technology were found to have a positive influence on the probability of adoption and area allocated to the improved maize varieties, whereas age and market distance were found to have a significant and positive influence on the adoption decisions of the improved maize technology. Several studies in Ethiopia with regard to factors influencing the adoption of improved seed showed that extension service, access to credit and market are the main factors influencing the adoption of improved maize seed and also emphasized that access to credit is a powerful policy option in raising the probability of adoption of improved maize seeds like Negasa et al. (1997);Degu et al. (2000); Feleke et al.(2006). The study conducted by Aleneet al. (2000) to examine factors that influence the adoption and Intensity of utilization of improved maize varieties in the West Shoa Zone in the central Highlands of Ethiopia indicate that age, level of education, household labor, farm size, extension services, farm income, off farm income, and timely availability of improved maize seeds significantly influence the adoption and intensity of use of improved maize.

2.8. Models for analyzing maize variety Adoption

A number of previous studies used various econometrics techniques to identify the determinants of the status and extent of agricultural technology adoption. The application of each model depends on the objective of the research. Shiferaw and Tesfaye (2006), Hailu (2008), Assefa and Gezahegn (2010) and Moti et al. (2013) employed Logit or Probit models for estimating status of technology adoption. Some other authors such as Hassen et al. (2012) and Yu and Nin-Pratt(2014) used double hurdle model to analyze the status and intensity of technology adoption sequentially, Moti et al. (2013) and Menale et al. (2011) used multinomial probit model for

estimating the status of more than two interdependent technologies choice options. Hailemariam et al. (2013) estimated both multinomial and multivariate probit models for estimating adoption decisions of multiple sustainable agriculture practices in rural Ethiopia. Logit or probit is best suited if the objective of the research is to analyze only status of technology adoption, multinomial model for analyzing the status of more than two independent technologies adoption options and multivariate probit model for analyzing the status of more than two interdependent technologies adoption options. Tobit and Double-hurdle models estimate both status and intensity of adoption sequentially, but it overlooks the aspect of selectivity bias (Green, 2012). As a result, studies such as that of Nega and Senders (2006), Jon(2007), Solomon et al. (2011) and Moti et al. (2013) used Tobit model and assume the two decisions (status and extent of technology adoption) are affected by the same set of factors.

2.9. Conceptual Framework of the Study

Agricultural technology adoption and diffusion patterns often vary from location to location. The variations in adoption patterns are created due to the presence of disparity in agro ecology, Institutional and social factors. Moreover farmers' adoption behavior, especially Low-income countries, is influenced by a complex set of socioeconomic, demographic, technical, institutional and bio-physical factors.

A review of existing literature will be conducted to under. Similarly, Dessalegn et al. (2018) emphasized the role of extension services in disseminating knowledge and best practices to smallholder farmers. However, there is a gap in the literature regarding the specific determinants of improved maize production in the Kola-Temben District. This chapter gives a theoretical framework and a conceptual framework to govern the study. Previous studies have highlighted the importance of improved seed varieties, modern agricultural techniques, and access to extension services in enhancing maize production in Ethiopia. Berhane et al. (2015) found that the adoption of improved maize seed varieties significantly increased maize yields in the country. Similarly, Dessalegn et al. (2018) emphasized the role of extension services in disseminating knowledge and best practices to smallholder farmers. However, there is a gap in

the literature regarding the specific determinants of improved maize production in the Kola-Tembenregion.

Demographic factors

- House head age
- House head education
- House head farm experience
- Family size

Adoption of improved maize varieties

Institutional Factors

- Extension services
- Distance to market

Social Factors

Economic factors

- Farm income
- Off farm income
- Off farm income
- Owned livestock
- Owned oxen

Membership of farmers'

cooperatives union

CHAPTER: THREE

3. Research Methodology

The study was utilized a mixed-methods approach, involving both quantitative and qualitative data collection methods. A sample of farmers in Kola Temben would be selected using a stratified random sampling technique.

The method section of this research includes description of the study area; research design, research approaches, types and sources of data, data gathering technique, sampling design, method of data processing and analysis and definition of variables would be incorporated and presented as follows:

3.1 Description of the Study Area

The study was conducted in Kola Temben Tigray region, Ethiopia. This area was chosen due to its significance in maize production and the challenges faced by local farmers.. It is located in the central zone of Tigray Regional State. The district is located 827km north of Addis Ababa and 127km North West of Mekelle city which is the regional city of Tigray regional state. It is bordered on the north by Naeder woreda, south by Tanqaumlash, and East by Abi-Adi Town and on the west by Tselemti). The mean annual temperature of the district is 27^oC_33^oC and means annual rainfall ranges between 600-1400 mm. The altitude of the district range between 600 and 1200 meters above sea level, constituting 71.7% Kola agro ecologies,. The district is characterized by highly rugged topography dominated by mountains.

The total area of the district is estimated to be 71384 hectares having 47159.89, 6981.21,3010.97,974 and 4.23 hectares of cultivated land, grazing land, forest, irrigation and grassland, respectively (Kola Tenbien Woreda Agriculture administrative Bureau , 2025). The total population of the district was 108,452; the male=53922 and female-=54540 accounted for 49.7% and 50.29%, respectively (woreda kola-tenbien statistics, 2025).

The main economic activity in the district is farming. The livelihood of the population in the district depends on agriculture. Agriculture is the major source of food and cash needs of farmers. In the study district, mixed farming is practiced and both crop and livestock activities are equally important. Maize is the major economic enterprise and is grown by nearly all

farmers. The climatic pattern in the district has dictated farmers to plant the drought resistant local maize varieties over years though their yield potential is low. However, with introduction of improved maize seed varieties suitable for marginal lands by the researchers, farmers have started to plant them in the study area. These varieties have high yielding potentials especially when all the agronomic practices recommended for them are fully adopted. Farmers usually intercrop these improved maize varieties with beans, cow peas or pigeon peas as a way of increasing returns to land and also as crop diversification strategy against risks of crop failure.

3.2 Research Design

This study involved a cross sectional survey with 137 randomly selected households growing maize in Kola tenben District, Central zone of Tigray, Ethiopia. Kola tenben was selected purposely because of the importance of maize in the farming systems and the availability of maize technology dissemination programs in the 3 kebeles of the woreda

3.3. Data Type, Sources and Methods of Data Collection

In this study both primary and secondary data were used. The primary data was collected from randomly selected farmers. Primary data was supplemented with secondary data collected from the district office of agriculture, development centers, and Zonal Agricultural Office and other published and unpublished sources. Primary data was collected through personal and face-to-face interview using semi- structured questionnaire. Secondary data was obtained from various sources such as reports of Bureau of Agriculture at District Administrative office, previous research findings and other published and unpublished materials, which are relevant to the study.

3.4 Target Population

The target population for this study includes both adopters and non-adopters of improved maize varieties in Kola Temben. By interviewing both groups, we can gain a comprehensive understanding of the factors influencing adoption and develop targeted interventions to promote the uptake of improved maize varieties.

3.5 Sampling Design (sample size and Sampling technique)

3.5.1 Sample size determination

There are different formulas given by different educationalists for the determination of appropriate sample sizes. The researcher was chose the formula according to their needs and convenience. In choosing the right one, the researcher was have to take into from 16 kebelles, the researcher was select 3 kebelles which are 1500 Household heads(HHS).

From maize grower farmers' adopter and non-adopter of Melkasa1, Gibe3, Melkasa2, DK777,Shone maize variety were identified by using stratified sampling techniques. Then 137 farm household heads were selected using systematic random sampling technique taking into account proportional to size to the population procedure. The sample size was determined using (Kothari, 2004).

$$n = \frac{z^2 PqN}{e^2(N-1) + z^2 pq}$$

$$n = (1.96)^2 * 0.11 * .89 * 1500 / (.05)^2 * (1500 - 1) + (1.96)^2 0.11 * 0.89$$

$$n = 137$$

Where: n = sample size N = total number of household heads (1500heads). P = 0.11(proportion of population to be included in sample size i.e., 11%) q = estimate of the proportion of the population to be sampled (1-p). e = is the degree of accuracy desired (0.05), 5% error term. Z= standard normal deviation (e.g. 1.96 for 95% confidence level).

3.6. Sampling Procedure

In this study three-stage sampling procedure was used to select representative sample farmers that were included in the study. In the first stage, out of the 22 woredas of Central zone, Kola tenben woreda was selected purposively based on accessibility and agro-ecological suitability for maize production(among 16 kebeles)where improved maize has been introduced in the kebeles. In the second stage from 16 maize producing kebeles of the district, 3 kebeles were selected randomly. In the third stage, from the selected kebeles, 82 from adopters households and 55 from non-adopters households which made a total of 137 respondents were randomly selected based on probability proportional to sample size technique of households of each kebeles(Table 1).

Table1. Distribution of sample households in sampled kebeles(Melkasa1, Melkasa2,Melkasa3, Melkasa4,Gibe1,Gibe2,Gibe3,BH545,BH546,Damot,Shone and DK777) improved maize growers.

N ^o	Sampled kebeles	Adopter	Non-adopter	Total HouseHolds	Sampled adopter	Sampled non-adopter	Total sample
1	Debregenet	240	160	400	25	17	42
2	Debretsahay	230	170	400	25	17	42
3	Begashaka	420	280	700	32	21	53
Total		890	610	1500	82	55	137

3.7. Method of Data Analysis

Data were analyzed using the statistical software STATA14. Determinants of adoption of improved maize variety and adoption of improved maize were analyzed

Descriptive statistics and econometric models were used to analyze the data. Descriptive analysis was employed to assess the similarities and differences between the adopters and non-adopters. Factors influencing the adoption and intensity of adoption of improved maize varieties were analyzed by econometric analysis using Probit and Tobit models.

3.7.1. Descriptive Statistics

Descriptive statistics involving mean, percentage and standard deviations were used to assess the socioeconomic characteristics of the sample households and farmer's response for adoption of

improved maize varieties. And also, t-test and chi2 –test were employed to assess the relationship among the variables of interest.

3.7.2. Econometric Analysis

The probit and Logit are the two most commonly used models for identifying and analyzing the determinants of various factors on the probability of adoption of improved maize technology.

These models also provide the predicted probability of adoption .The Logit model follows a logistic distribution function, where as the Probit model follows a normal distribution function. Yet both models usually yield more or less similar results. The choice between the two models is the thus a matter of convenience to the analyst. However, often probit model is preferred as it simplifies the estimation and interpretation of parameters (Fernando, 2011). Hence the current analysis is opted for the Probit model and employed in modeling demographic, socio-economic, institutional, and psychological (perceptions) factors determining the probability of adoption improved maize variety farm households in the research area. In analyzing the adoption of improved maize varieties, the dichotomous adopter or non-adopter classification may not give a complete picture. Even within adopters there is a wider range of variation in the intensity of maize area allocated to improved maize varieties. Some households allocate only limited share of their maize plots to the improved varieties while others were completely replacing the existing practices. To assess the intensity of adoption, this study only used the area share of improved maize varieties. The adoption of maize can be influenced by various set of socio-economic, demographic and institutional factors. Modeling households response towards these influencing factors of adoption practices of improved maize varieties will, therefore, become important both theoretically and empirically. Adoption decisions can be analyzed with different binary choice models. When a dependent variable is binary, the ordinary least squares (OLS) method can no longer produce the best linear unbiased estimator (BLUE); that is, OLS is biased and inefficient. Limited dependent variable models are often used to evaluate farmers' decision-making process concerning adoption of agricultural technologies. Those models are based on the assumption that farmers are faced with a choice between two alternatives (adoption or no adoption) and the choice depends upon identifiable characteristics (Pindyck and Rubinfeld, 1997). In adopting new agricultural technologies, the decision maker (farmer) is also assumed to maximize expected utility (expected profit) from using a new technology subject to some constraints (Feder et al.,

1985). In many cases (e.g. Kaliba et al., 2000) a Probit or Logit model is specified to explain farmers adoption of a given technology without considering the intensity of use of the technology. However, the Probit or Logit models cannot handle the case of adoption choices that have a continuous value range. Intensity of use is a very important aspect of technology adoption because it is not only the choice to use but also how much to utilize that is often more important. The Tobit model of Tobin (1958) can be used to handle such a situation. Tobit model is used when the decision to adopt and intensity of adoption are assumed to be made jointly and factors affecting the probability to adopt and intensity of adoption are assumed to be the same (Asfaw et al., 2011). Heckman's selection model assumes that the probability to adopt and the intensity of use are not explained with exactly the same set of explanatory variables, where some (at least one) variables are only explaining the probability to adopt. Tobit and Double-hurdle models estimate both status and intensity of adoption sequentially, but it overlooks the aspect of selectivity bias (Green, 2012). As a result, studies such as that of Nega and Senders (2006), Jon (2007), Solomon et al. (2011) and Moti et al. (2013) used Tobit model and assume the two decisions (status and extent of technology adoption) are affected by the same set of factors. The present study also employed a Tobit model to analyze factors affecting probability of adoption and intensity of adoption of improved maize varieties. Because it handles both the probability and intensity of adoption at the same time and assume the two decisions (status and extent of technology adoption) are affected by the same set of factors. Tobit and Probit models are differing in mapping of the latent variable in to unobserved variables that is, extension of probit model and it is one of the approaches dealing with the problem of censored data (Johnston and Dandiro, 1997). Some authors call such model Limited dependent variable model, because of the restrictions put on the values taken by the regress and (Gujarati, 1995). Tobit model is superior over other dichotomous regression models in that not only attempts to explain factors influencing the probability of adoption of the technologies by the farm households but also the intensity of adoption of technology. Strictly dichotomous variable often is not sufficient for examining intensity of adoption (Feder et a.l, 1985).In this study, Tobit and Probit models were used to examine determinants of adoption of improved maize variety and adoption of improved maize varieties. Moreover, because of the significant number of observations on dependent variable having a value zero, Tobit model was found to be appropriate to deal with such censored data and used to analyze the use of improved maize varieties and determinants of adoption.

Empirical model specification

Based on the above backgrounds, the linear probit model can be specified as the follows:

$P(Y_i = 1) = \beta_0 + \beta_i X_i + e$ Where P is the probability of an individual farm household to adopt improved maize varieties in the specified survey production year (2024/25), β_i is the vector of parameters to be estimated, X_i is the vector of exogenous explanatory variables expected to influence the adoption decision probability and e is the error term.

In the second stage of double-hurdle model we examine factors affecting the intensity of use improved maize varieties, conditional on adoption decision, which is implemented using the truncated regression analysis. Thus, it involves the truncated regression that can be specified as:

$$Y = Y^* \text{ if}$$

$$Y^* > 0$$

=1 (3) $Y = 0$ other wise From this, we can specify the reduced form of the truncation model as:

$$Y = \beta_0 + \beta_{oi} Z_i + U_i$$

(4) Where Y is the observed amount land allocated for maize production , Y^* is the latent variable which indicates the level of maize adoption is greater than zero, β_i is the vector of parameters to be estimated, Z_i is the vector of exogenous explanatory variables and U_i is the error term. The empirical model used in this study assumes that the total amount of land allocated for improved maize in the survey year of (2024/25) is a linear function of continuous and dummy explanatory variables.

3.8. Definition of Variables and Working Hypotheses

The **dependent variable** of the model: It is a continuous variable and measured the intensity of adoption for improved maize varieties.

Different variables were expected to determine household adoption status of improved maize varieties in the study area.

The **independent variables**: The independent variables that were hypothesized to determine the farmers' adoption decision of improved maize varieties were combined effects of various factors such as: household characteristics, socioeconomic characteristics and institutional characteristics in which farmers operate. The number of improved maize varieties a farmer could know depends on several factors which include farmer's own interest in gathering variety information, social networks he/she has within and outside the village, maize production potential of area where he/she lives, closeness of maize breeding research centers and variety testing sites. Based on the review of adoption literature and past research findings, the important key variables that are expected to influence the adoption of improved maize seed varieties in the study area are considered as explanatory variables. Among the large number of factors which could be expected to relate to farmers' adoption behavior, 18 potential explanatory variables were considered in this study and examined for their effect in farmers' adoption decision of improved maize varieties. These are presented as follows.

Age of the household head: It is a continuous variable and measured in number of years from birth. The role of a farmer's age in explaining technology adoption is somewhat controversial in the literature. Whatever the condition, it is important to include age as a factor that would help explain adoption decisions. It is assumed that as farmer age increases the probability of adoption is expected to decrease, because as the farmer's age increases, it is expected that the farmer becomes conservative (Techane et al., 2006). Contrary to this Hailu (2008) reported positive relationship between age and adoption which enables easy adoption of new technologies. In this study it was hypothesized to affect improved maize variety adoption positively or negatively.

Sex of the household head: It is a dummy variable used as (1 if male, 2 female). Gender difference is found to be one of the factors that determine adoption of new technologies. Due to many socio-cultural values and norms, male has freedom of mobility and participation in different extension programs and consequently have greater access to information (Mesfin, 2005; Teha, 2007). Therefore, it was hypothesized that male farmers are more likely to adopt a new technology.

Educational level of the household head: This is a categorical variable measured in years of schooling. Education level increases farmer's ability to get process and use information and

increase farmers' willingness to adopt a new technology. According to Binod (2010), education level is assumed to increase farmer's ability to obtain process and use the information relevant to adoption. Therefore, this variable was hypothesized to positively influence improved maize variety adoption.

Farming experience of the household head: It is a continuous variable measured in years since a respondent started farming on his own. Farmers with higher experience appear to have often full information and better knowledge and are able to evaluate the advantage of the technology. Farmers having more experience are expected to adopt improved maize varieties (Tura et al, 2010). Therefore, this variable was hypothesized to positively influence improved maize variety adoption.

Family size of the household: It is a continuous variable measured in number; that refers to the number of family members of a given household. The family members are important in the operation of farm activities, such as weeding and harvesting. Family size had a positive and significant relation with adoption of improved maize varieties (Motuma et al., 2010). Previous research result reported by Tesfay and Alemu (2001) shows that family size influence adoption of new technology positively. Therefore, family size was hypothesized to influence the adoption of improved maize varieties positively.

Farm size of the household head: It is a continuous variable measured in hectares or tsimads. Land is one of the most important and scarce resources in agricultural production. Research result by Nega and Sanders (2006) and Hassen et al. (2012) found a positive and significant relationship between farm size and improved maize varieties adoption. Therefore, farm size was hypothesized to influence the adoption of improved maize varieties positively.

Land fertility: This is a dummy variable that take a value of 1 when the land is fertile and 2, otherwise. A difference in fertility of land could also have a bearing in the decision of the farmer to adopt a new crop technology or not. Farmers with a relatively fertile land tend to be more receptive to improved crop technologies, as they supplement a relatively minimum quantity of commercial fertilizers, than those with poor fertility of lands. Therefore, in this study, it was hypothesized that land fertility would have positive correlation to adopt improved maize varieties.

Access to fertilizer: This is a dummy variable, which took a value of 1 if the farm household has access to fertilizer and 0 otherwise. As availability of fertilizer supply at the sowing time increases, farmers' use of improved maize varieties will be enhanced. On the contrary, if maize seed and fertilizer supply are not adequate at the time of sowing, farmers allot their land to other crops. Fertilizer availability determines adoption decision of new maize varieties (Asfaw et al. 1997; Teferi, 2003). Availability of fertilizer on time to the farmers' increased, adoption/intensity of adoption is expected to increase. Therefore, in this study access to fertilizer was hypothesized to positively influence adoption of improved maize varieties.

Total livestock owned by the farm household: This refers to the total number of livestock measured in tropical livestock unit (TLU). Livestock is important source of income, food and draught power for crop cultivation in Ethiopian agriculture. Therefore, in this study it was hypothesized that higher TLU would have positive and significant influence on the adoption of improved maize varieties. Previous research result reported by Tesfaye et.al. (2001) confirmed that livestock holding have positive influence on agricultural technology adoption.

Access to credit for improved maize varieties: It is a dummy variable, which took a value of 1 if the farm household had access to credit and 0 otherwise. Adoption of new agricultural technology with complementary inputs required considerable amount of capital for purchase of inputs (seed, fertilizer). Salasya et al. (2007); Mugisha and Diiro (2010) in their studies on factors influencing adoption of improved maize varieties and its effects on yields among smallholder maize farmers found that access to credit relaxes income constraints of famers hence enabling them to have access to key inputs as well as in hiring of labor. In this study it was hypothesized that access to credit would influence adoption of maize technology positively.

Frequency of extension contact: It is continues variable and measured by number of contact with extension agents. Empirical results revealed that extension services play important role in the implementation and diffusion of innovation and has positive and significant influence on adoption of new agricultural technology (Solomon et al., 2011). Extension agent acts as agent for change and as a communication media who builds the gap between farmers and the innovation (Tura et al., 2010; Mignouna et al., 2011; Akpan et al., 2012).Following this argument; in this

study extension contact was hypothesized to influence farmers' decision to adopt improved maize varieties positively and significantly.

Radio ownership: It is a dummy variable, which takes 1 if the farm household has radio and 0 otherwise. Radio is one of the sources of information to the farmers. Farmers who owned radio at their home are more have high probability of adoption of improved maize varieties than those households who have no radio at their home(Yishak and Punjabi,2011).Therefore, it was hypothesized that farmers' ownership of radio would influence adoption of improved maize varieties positively. **Access to agricultural training:** It is a dummy variable, which took 1 if the farm household has attended farmers training program and 0 otherwise. Participation on farmer training will help farmers to identify the productivity differences between improved maize varieties and local maize seed. Training is one of the means by which farmers acquire new knowledge and skills. Hence, participation in training is expected to positively and significantly influence farmers' adoption behavior (Alemitu, 2011; Belay, 2003). Therefore, access to farmers' training was hypothesized to influence adoption of improved maize varieties positively.

Perception on current input price: is dummy variable represented by 1 if the farmers perceive the prevailing input price is expensive and 0 otherwise. This variable refers to the cost of improved maize varieties which are average, financial layouts of input measured in Birr. Higher perception of input price decreases the probability of adoption of new technology (Leaku and Adam, 2015). Therefore, in this study, this variable was hypothesized to affect adoption of improved maize variety negatively.

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Distance to the main road: It is a continuous variable measured in kilometers. It refers to the distance from farmer's home to all weather roads. This variable affects adoption decision of farmers negatively and significantly (Isaiah et al., 2007). Therefore, in this study, this variable was hypothesized to affect adoption of improved maize varieties negatively.

Distance to the nearest market: It is a continuous variable measured in kilometer. It refers to the distance between the farmers' residence and the nearest market center. It shows access to the market to buy input and/or to sell output. As market distance increases adoption and intensity of adoption is expected to decrease (Hailu, 2008). Previous result reported by (Alemitu, 2011; Kidane, 2001) revealed that market distance negatively and significantly influence adoption of agricultural technology. Therefore, in this study it was hypothesized to affect adoption of improved maize varieties negatively.

CHAPTER: FOUR

4. RESULTS AND DISCUSSIONS

This section consists of two sub-sections. The first one is description of sample households' characteristics and the second subsection is econometric methods.

4.1. Descriptive Results

In this chapter the overall findings of the study is presented under different sections. Next to description of determinants of adoption and adoption of improved maize varieties, the influence of different personal, demographic, social, economic, institutional and psychological factors on adoption and adoption of improved maize discussed consecutively. In this section of analyses descriptive statistics such as mean, percentage, standard deviation and chi-square test were employed using STATA 14 software programs. In this study, adopters of a technology refer to farmers who are used improved maize varieties and those who are more productive by allocating proportion of their land for improved maize varieties and those farmers who experienced growing of local variety considered as non adopters.

4.2. Descriptive Statistics of Demographic, Socio economic and institutional characteristics

Table 4.1 demographic, institutional and Economic characteristics of the respondents

Variable	Obs	Mean	Std.dev.	Min	Max
Age	137	53.44	7.99	38	71
Sex	137	1.94	0.22	1	2
Educ	137	1.956	0.938	1	3
How long live here	137	51.08	11.42	2	71
Tabia	137	2.08	0.83	1	3
Family size	137	5.83	1.93	2	12
The type of off-farm	137	0.88	1.524	0	6
Farm size	137	4.116	1.036	2	7
Number of plots	137	1.32	0.513	1	3
Area allowed for crops	137	2.97	0.847	1.5	5
Nearest mkt	137	1.087	0.283	0.5	2
Number of oxen owned	137	1.23	0.678	0	4

Constraints	137	2.364	1.66	1	7
Contact with extension workers	137	1.226	0.419	1	2
Labor shortage	137	1.16	0.36	1	2
Sources of income	137	3.43	1.589	1	7
adopt improved maize	137	1.394	0.490	1	2
Type of improved maize variety	137	1.85	1.71	0	5
Other improved seed	137	1.6	0.49	1	2
Yield of improved maize	137	6.402	2.504	7	12
Yield of other seed	137	2.781	0.960	1	7
Did you get input	137	2.27	2.41	1	2
Distance to extension office	137	0.95	0.9	0.25	1.3

Source; own survey data, 2025

This table presents the descriptive statistics of respondents in the study area and examines the determinants of improved maize adoption and varieties of improved maize in Kola Tenben Central zone of Tigray Ethiopia. The result reflects the demographic, economic institutional and household characteristics of the surveyed population. The **average age of respondents** is 53.4 years, with a standard deviation of 7.99, indicating a relatively narrow age range. The minimum and maximum age observed are 38 and 71 respectively, suggesting that most participating are middle aged to older adults. Regarding education, the respondents have mean 1.96, standard deviation 0.94, completed an average of 1.96 years of schooling, with values ranging from 1 to 3 years. This suggests illiterate population, with some having completed primary education. This

table shows 2years of the household head live here and maximum living this area is 71 years. hence the deviation is positively shows 11.4 very far and small numbers. When coming to **adoption of improved maize variety**, the mean is 1.394, which represents average score across all observations (137). About 60% of observers adopted improved maize variety and 40% of the observers do not.

This aligns perfectly with the mean of 1.394 and the low standard deviation of 0.490. This shows with slight preference for adopter, but a substantial portion were non-adopter. Low standard deviation means the data points are closed to the mean, while standard deviation means they are more spread out.

Family size of the household: The average family size of the sample farmers in the study area was 6 persons. The average family size of the adopters and non-adopters were 5 and 6 respectively. This was found to have statistically significant mean difference between the two groups at 10% significant level (Table 4.1). The result shows that adopter's households have less family than non-adopters households.

Land holding: The land size of sample households varies from 2 to 7 tsimads with an average holding of 4.116 tsimads.

Number of Oxen Owned: The number of oxen owned by the respondents ranged from zero to four with mean holding of 1.23 oxen. The average number of oxen owned by adopters was 2.4, whereas for non-adopters was 2.2. The mean difference in oxen holding was found to be statistically significant at 10% significance level. The result shows adopters have more oxen than non-adopters.

Frequency of contact with extension agents: It was observed that sample households in the study area do have a better access to extension services that was illustrated by frequent visit of extension agents. With regard to the frequency of extension contact among the total respondents the average number of extension contact was 1.26 time per month. The mean frequency of extension contact for adopter was 0.419 and for non-adopters households were 0.02 per month. There was statistically significant difference between adopter households and non-adopter households in terms of frequency of extension contact at 1% significance level in favor of the adopters (Table 4.1).

Distance to all-weather roads: The survey result indicated that the average distance of the respondents' home from all weather roads was 1 hour. The average distance of the adopters and non-adopters from all-weather road was found to be 1.1 hrs and 1.25 hrs respectively, and the mean difference was statistically insignificant.

Distance to nearest markets: The survey result indicated that the average distance of respondents' home from the nearest market place is 2 hours. On average adopters were located

about 1.09hrs Distances whereas non-adopters were about 2:15 hours far away from the nearest market. The result also revealed that mean difference of distance to market was statistically insignificant.

4.1.1. Land allocation and production of improved maize varieties. The mean area planted by improved maize varieties was about 0.476 tsimads for adopters. The Study indicated that the average size of cultivated land holding of adopter households was 0.5 tsimad with standard deviation of 0.427 and they allocated about 29.70 % of their farm lands for improved maize production. The maximum area allocated for improved maize varieties was 1.25 tsimad and minimum land allocated to improved maize varieties was 0.25 tsimad.

4.1.2. Adoption of improved maize varieties

In this study, adoption decisions refer to use of improved maize varieties. A farmer is defined as an adopter if he/she uses at least one of the improved maize varieties, otherwise is a non-adopter. Based on their use of improved maize varieties farmers were classified as adopters and non-adopters. As results, a farm household is adopter of improved maize varieties if he/she used at least one variety of improved maize varieties during the cropping season. Under normal conditions, improved maize varieties are preferred by smallholder farmers in the study area which have better yield potential, shattering resistance, disease resistance, early maturing, drought resistance and marketability. There is some maize varieties in use and tend to stay with farmers due to resisting crop diseases and other ecological characteristics of varieties and few of them were discarded from production due to poor disease resistance and environmental problems. The resistant high yielding maize varieties such as Melkasa2 (24.09 %) have been widely demonstrated to farmers and adopted with associated cultural practices in the study areas.

Table 7: Types of improved maize varieties adopted by smallholder farmers

Improved maize varieties	Freq	Percent
Melkasa2	33	39.75%
Gibe3	13	15.6%
Other improved maize (Melkasa1,Gibe1-3,Shone,DK777	6	7.23%
Both Melkasa2 and Gibe3	31	37.34%

4.2.1. Determinants of adoption of improved maize varieties

Education: Level of Education of the head of the household has a positive and significant at 10% significance level, indicate that adoption and use of improved maize varieties with each additional year of schooling increasing the probability of adoption improved maize by 2.76 percent. Similar results were reported by Alene et al., (2000) and Ahmed (2015) as their result the more educated farmers were adopted improved maize varieties than those who had no education on improved maize varieties.

Family size: found to be positive and significant at 10% significance Level, indicate that each additional of family size increases the probability of adoption of improved maize varieties by 5.85 percent. Similar results were reported by Milkias and Abdulahi (2018) but Contradicting with the research finding of Ahmed (2015) as their result the family size had contribution on adoption of improved maize.

Farm income: found to be positive and significant at 1% significance Level, indicate that each additional amount of farm income by one birr increases the probability of adoption of improved maize by 9.50 percent. This indicates that, those farmers who have more farm income were more risk takers to try new technology such as improved maize adoption. The result of this research is identical with (Asfaw et al., 2010), as cited in Afework and Lemma, (2015).

Number of oxen own: found to be positive and significant at 10% significance Level. Owning oxen is crucial for farming activity. Those farmers who have more oxen had higher probability to prepare their land for different improved varieties and can use their cultivable land more properly, thereby to adopt new technology more rapidly. The probability of adoption of the package significantly affected by number of oxen owned at 10% significance level and each unit increase of the number of oxen farmers owned increases the probability of adoption of improved maize by 3%. This indicates when the number of oxen owned increases farmers' adoption of improved technologies, particularly improved maize varieties will increase. This result is similar with the result of Solomon (2012) and Jaleta et al., (2013) that as the number of owned oxen were adopted improved maize varieties than those who had no oxen.

Livestock (TLU excluding of oxen): Livestock holding was positively and significantly affect the adoption of improved maize varieties at 10% level of significance, this means that as the number of livestock holder farmers increase by one unit the probability of adoption of improved maize varieties are increased by 1.2% implying that farmers with more livestock holding are more likely to devote significant amount of produced improved maize varieties than those households with less livestock holding. This result is lined with Yenealem et al., (2013) result that indicate those farmers with large number of tropical livestock units are more likely to adopt improved maize varieties than those who own small number of TLU

Number of oxen	.302473	.2205062	1.37	0.170	-.1297112	.7346572
Total livestock sold	-.5009363	.3382185	-1.48	0.139	-1.163832	.1619598
education						
Only read but not write	.4893582	.4094655	1.20	0.232	-.3131793	1.291896
Illiterate	.4056087	.272927	1.49	0.137	-.1293184	.9405357
Did you get enough amount of seed	.5849465	.326342	2.22	0.026	.0686469	1.101246
Contact with extension agents	-.7344203	.3409715	-2.15	0.031	-1.402712	-.0661284
Own radio or TV	.2712436	.29446	0.92	0.357	-.3058874	.8483745
Cons	.64764	1.550102	0.42	0.676	-2.390504	3.685784

The probit regression model was employed to identify and analyze the major factors influencing the adoption of improved maize varieties in the study area. A total of thirteen explanatory variables were incorporated into the model to capture both socioeconomic and institutional determinants of adoption behavior. Although the joint contribution of these variables to the model was not statistically significant, the examination of individual variables provides useful insights that align with economic reasoning and the realities of smallholder farmers.

Among the explanatory variables, **access to improved maize varieties** emerged as an important and statistically significant determinant. The positive coefficient associated with this variable indicates that farmers with reliable access to improved seed are more likely to adopt the

technology compared to those who face constraints in obtaining it. This finding is intuitive, as accessibility reduces transaction costs, improves confidence in seed quality, and increases the likelihood that households will shift from traditional practices to improved technologies. The result suggests that strengthening distribution networks, ensuring timely seed supply, and expanding coverage of agricultural cooperatives or input suppliers could substantially enhance adoption rates.

The non-significance of the overall model does not imply irrelevance of the included variables, but rather points to possible issues such as heterogeneity in adoption behavior, limited sample size, or the presence of unobserved factors that were not captured in the model. Nonetheless, the significant effect of access to improved varieties underscores the critical role of institutional support and market infrastructure in promoting agricultural innovation.

In conclusion, while the probit regression results show limited joint explanatory power, the significance of access to improved maize varieties highlights a clear policy implication. Interventions that increase the availability, affordability, and timely distribution of improved seeds can serve as an effective strategy for promoting technology adoption and, ultimately, improving productivity among smallholder farmers.

Table 4.3: Determinant of adoption of improved Maize variety (marginal effect, after probit)

	dy/dx	Std.	Delta method Err	Z	P> z	[95% Conf. Interval]
Sex	.2185254	-.2872292	-1.31	0.189	-.7155312	.1410728
age	-.0061575	.0052809	-1.17	0.244	-.0165078	.0041928
Family size	-.0246065	.022226	-1.11	0.268	-.0681686	.0189555
Farm size owned in tsimad	.0588724	.0465173	1.27	0.206	-.0322998	.1500446
Number of plots in tsimad	.0570385	.0922425	0.62	0.536	-.1237534	.2378304
Leased in in tsimad	.113535	.1605154	0.71	0.479	-.2010693	.4281393
Number of oxen	.1023743	.0731192	1.40	0.161	-.0409366	.2456853
Total livestock sold	-.1695457	.1120277	-1.51	0.130	-.3891159	.0500245

			Education			
only read but not write	.1645056	.1289182	1.28	0.202	-.0881693	.4171806
illiterate	.1380061	.0911241	1.51	0.130	-.0405938	.316606
Did you get enough amounts~d	.1979796	.0839929	2.36	0.018	.0333565	.3626027
Contact with extension ag~s	-.2485702	.1089126	-2.28	0.022	-.4620349	-.0351055
Own radio or TV	.0918045	.0988411	0.93	0.353	-.1019206	.2855295

The marginal effects obtained from the probit regression provide deeper insights into the determinants of adoption of improved maize varieties among smallholder farmers. While regression coefficients indicate the direction and statistical significance of each variable, they do not directly reveal the size of the impact in terms of probabilities. By contrast, marginal effects translate the regression results into more interpretable measures, showing how a one-unit change in an explanatory variable influences the likelihood of adoption, holding other factors constant. This distinction is crucial because it allows policymakers and practitioners to understand the practical magnitude of the determinants rather than only their statistical association.

The analysis shows that most of the explanatory variables included in the model have either weak or statistically insignificant marginal effects, implying that their contribution to explaining adoption behavior is limited in the study area. However, access to improved maize varieties emerges as both statistically significant and practically important. The marginal effect indicates that, *ceteris paribus*, access to improved seed increases the probability of adoption by approximately **19.8 percent**, significant at the 5% level. This means that farmers with reliable access to improved seed are nearly one-fifth more likely to adopt the technology compared to those without such access.

This finding emphasizes the central role of input availability in driving technology uptake. Whereas the regression coefficient alone suggested a positive and significant relationship, the marginal effect quantifies this influence in probability terms, making the result much more interpretable and policy-relevant. In practical terms, it underscores that improving seed distribution systems, enhancing cooperatives, and ensuring timely and affordable access to improved varieties can significantly boost adoption rates. Therefore, while many variables were considered, access to improved maize seed stands out as the most decisive determinant for adoption, with clear implications for agricultural development strategies.

54 left-censored observations at $areac_{dmaize} \leq 0$

83 uncensored observations

0 right-censored observations

The Tobit regression model was employed to identify the factors that influence the extent of adoption of improved maize varieties among smallholder farmers in the study area. Unlike binary adoption models, which only consider whether or not a farmer adopts, the Tobit model allows us to examine the intensity of adoption, measured as the degree or proportion of land allocated to improved varieties. The results, as summarized in the table, reveal that several explanatory variables exert both positive and negative effects on adoption intensity, with varying levels of statistical significance.

One of the key findings relates to the age of the household head. The results indicate that age negatively influences the extent of adoption. This suggests that older farmers are less likely to allocate larger portions of their farmland to improved maize varieties compared to younger farmers. This pattern can be explained by the fact that older farmers may be more risk-averse, less receptive to new technologies, or more reliant on traditional practices, while younger farmers are often more open to innovation and willing to experiment with improved technologies.

Another important factor is the number of farm plots owned by the household. The Tobit results show that as the number of plots increases, the extent of adoption decreases significantly. Fragmentation of farmland may reduce efficiency and make it more difficult to allocate sufficient land to improved varieties. Farmers managing multiple scattered plots may face challenges related to labor allocation, transportation of inputs, and supervision, all of which can reduce the effective intensity of adoption. Similarly, total farm size was also found to negatively influence adoption extent. This result is somewhat counterintuitive, as larger farms are often assumed to have more resources. However, the finding may indicate that households with larger landholdings diversify into different crops and therefore allocate a smaller share of land to improved maize varieties, reducing adoption intensity in relative terms.

Engagement in non-farm activities also emerged as a significant factor. Specifically, the number of days a household head spends working on non-farm activities negatively affects the extent of adoption. Time and labor diverted to non-farm employment reduce the resources available for farming activities, thereby lowering the likelihood that farmers will allocate larger areas of land to improved maize technologies. This reflects the trade-off between agricultural and non-agricultural income sources in rural economies.

On the other hand, institutional and extension-related variables showed a strong positive effect. Notably, the number of contact days with extension workers significantly and positively influences the extent of adoption. Farmers who have frequent interactions with extension agents are more likely to understand the benefits of improved maize varieties, receive technical advice, and develop the confidence to allocate more land to the technology. This result underscores the critical role of agricultural extension services in bridging knowledge gaps and enhancing farmers' decision-making.

In addition, public mobilization and awareness creation campaigns were highlighted as having the potential to increase adoption intensity. Community-level interventions that promote the benefits of improved technologies—such as higher yields, better resilience to climate variability, and improved food security—help to stimulate demand. Collective action through institutions and farmer groups can further encourage the spread of improved varieties by reducing information barriers and creating social incentives to adopt.

In conclusion, the Tobit regression analysis shows that both household characteristics and institutional factors significantly shape the extent of adoption of improved maize varieties. Variables such as age, number of plots, farm mechanisms that raise awareness and demand for improved technologies. At the same time, interventions should consider challenges related to land fragmentation, labor allocation, and the competing demands of non-farm activities, which can constrain adoption intensity. Size and engagement in non-farm activities reduce adoption intensity, while extension contact and public mobilization strongly enhance it. The findings suggest that policies aiming to increase adoption should prioritize strengthening extension services, facilitating farmer training, and supporting institutional

CHAPTER FIVE

Conclusion and Recommendations

The findings from the Tobit regression analysis provide important insights into the determinants of adoption intensity of improved maize varieties in the study area. The results demonstrate that both household-level factors and institutional factors play a significant role in shaping farmers' decisions to allocate land to improved maize technologies. On the one hand, variables such as age of the household head, number of farm plots, total farm size, and engagement in non-farm activities negatively affect adoption intensity. These results suggest that older farmers and those with fragmented or larger farms tend to diversify and allocate less land to improved maize, while non-farm activities divert time and resources away from agriculture. On the other hand, institutional support variables, particularly the number of contact days with extension workers and community-level awareness campaigns, exert strong positive influences on adoption. Farmers who are more exposed to extension services and mobilization efforts are significantly more likely to intensify their adoption of improved maize varieties.

RECOMONDATIONS

Based on these findings, several recommendations can be made. First, strengthening agricultural extension systems should be a top priority. Increasing the frequency and quality of extension contact can provide farmers with the knowledge, confidence, and technical support necessary to expand adoption. Second, policymakers and development organizations should invest in community mobilization and awareness creation campaigns. By promoting the economic and agronomic benefits of improved maize varieties, such programs can enhance demand and encourage collective adoption among farming communities. Third, interventions should address structural challenges such as land fragmentation and limited labor availability. Policies that support land consolidation, cooperative farming, or labor-saving technologies may help mitigate these constraints. Finally, tailored programs should be designed for older farmers, providing them with appropriate incentives, risk-reduction mechanisms, and demonstrations that highlight the benefits of adopting improved varieties.

In sum, adoption of improved maize technologies depends not only on farmers' characteristics but also on the strength of institutional support systems. A comprehensive approach that combines extension, awareness creation, and structural reforms is essential for increasing adoption intensity, boosting agricultural productivity, and ultimately improving rural livelihoods.

- Based on the findings of the study the following recommendations are suggested for the improvement of the livelihood of the smallholder maize producers in the study area.
- Education has a significant positive impact on adoption and intensity of use of improved maize varieties. Hence, strengthening adequate and effective basic educational opportunities to the rural farming households in general and to the study areas in particular is required. In this regard, the regional and local governments need to strengthen the existing provision of formal and informal education through facilitating all necessary materials. Such as:-Constant visiting site or demonstration site, preparing manual by their language and the other that is going with their farming practice and demonstration site.
- The family size has a significant positive impact on adoption of improved maize varieties this indicate that the study area were used the human capital (labour force) for farming activity and family size directly contributes to labour forces to farming activities but the recommendation to use the increased family size is contradicted with the use family planning, therefore, the government should substitute the technologies used in terms of family size such as tractors, harvester technology, thresher technologies and etc for different agricultural technology practice to minimize the human capital because it is not recommended to increase the family size.
- Government should make sure rural transportation and infrastructures are improved to make them passable in all seasons in order to make many producing areas accessible to input and output market and contribute to timely input delivery. Strengthening the knowledge of farmers' on the modern agricultural production by proper linking the extension services with farmers especially those smallholder maize producers by involving them in experimentation of innovations such as dissemination of those innovations to their fellow farmers which will motivate them to adopt the new agricultural technologies.
- From the finding of the study farm income has a positive effect on adoption and intensity of use improved maize varieties; therefore, scaling up and diffusion of improved maize varieties in the study area should be broadened and the income of small holder farmers were increased through their participation on farm activities. Increasing of small holder farmers' income had positive effect on the adoption and intensity of use improved maize varieties through supporting of the ability of farmers to buy improved seed and others input. Thus, it is recommended that encouraging households' participation on farming activities by creating favorable conditions and better opportunities for smallholders.

- Organizing of farmers to be a member of cooperative society would facilitate access to credit, access to extension information and access to market. This implies Strengthening and expansion of rural cooperatives is paramount importance to enhance adoption of improved maize production. Therefore, the government should encourage farmers to form an association of maize producers which will help them to find market for their products at profitable rate.
- The livestock play very important economic and socio-cultural roles for the wellbeing of rural households, such as food supply, source of income, asset saving, source of employment, soil fertility, livelihoods, transport, agricultural traction, agricultural diversification and sustainable agricultural production. Then Strengthening the existing livestock production system through providing improved health services, better livestock feed (forage), targeted credit and adopting agro-ecologically based high-yielding breeds and disseminating artificial insemination in the areas improve adoption and intensity of use of improved maize varieties..
- Farmers have their own preference criteria for adoption among the available high yielding maize varieties.
- The finding of this study suggested that farmers in the area seek specific varietal attributes, such as yield potential, tolerance to disease, shattering, and market characteristics. Information about the benefits of improved maize varieties should be important for smallholder farmers for priorities improved maize varieties. Therefore, the district agricultural office and extension system has to give more attention to farmers' priorities and needs related to agriculture.
- Furthermore, this research did not focus on the assessment of the impact of adoption of improved maize varieties on the income of smallholder farmers therefore; further research on this subject should be done to explore issues that were not captured by this study.

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Appendix

Questionnaire

MEKELLE UNIVERSITY

POST GRADUATE

Questionnaire developed for the determinants of adoption of improved Maize seed varieties in Kola temben, Tigray region.

General information

Questionnaire number ----- Interviewer's name -----

Date of interview ----- Name of tabia -----

Respondents (Household) Name ----- Sex ----- Age ---

Name of district -----

1. Personal information

1.1 Characteristics of the Household head

1.1.1. For how long the household has been living in this area --years.

1.1.2. Marital status,

1. Single 2. Married 3. Divorced 4. Widowed 5. Separated 6. Nun/Monk

1.1.3. Have you participated in leaderships in some formal social organizations (position) in the kebele?

1. Yes 2. No

If yes, for the above question , what is the status of household head in the kebele?

1. Kebele executive member 2. Kebele cadre 3. Religion leader 4. No status 5. Other specifies.

2. Family size

2.1. Total family size is -----

2.2. Family member's information

Name	Sex	Age	Education level

2.3. Have you or your family members worked in some off farm productive activities in this year outside your farm? 1. Yes 2. No

2.4 If yes, what is the number of family members worked in off farm activity -----

2.5 Number of days spent on off farm activities per year ----- and specify the type of off farm activities they are engaged in?

1, Ploughing 2, Harvesting 3, Weeding 4, Threshing 5, other specify

2.6. How many of your family members do permanently work on farm? -----

What about non - farm activities? Include it

3. Farm size

- 3.1. Total size of the land (farm size) owned -----
 Tsimad and number of plots -----
 .A. The grazing area (tsimad)-----B. Area allotted to annual crops(tsimad)-----

 C. Area allotted to tree crops(tsimad)-----D. Homestead area (tsimad)-----
 -----E. Leased-in(tsimad)-----F. Lease-out(tsimad) -----

 G. Others specify -----

Crops grown and area allocated to each crop during cropping season

Crop	Yes=1,no=2		Area(tsimad)		Yield(quintal)	
	improved	Local	improved	Local	Improved	local
Maize						
Wheat						
Teff						
Barley						
Other						

3.2.What is the type of the land ?

where is location of the land: 1.Dega 2.Woina dega3.Kolla 4.Others specify

3.3. How was the yield of your crops during the last year's crop season compared to the Previous years?(From 2016 to 2017)1. Very high 2. High 3. Low4. Very low 5. Medium

3.4. Which crop performed well in 2016 Choose the number.

Maize compared to barely -----1. Very high 2. High 3. Very low 4. Low 5. Medium

•Maize compared to wheat -----1.Very high 2. High 3. Very low4. Low 5. Medium

•Maize compared to teff----- 1. Very high 2. High 3. Very low 4. Low 5. Medium

3.5. Was the weather condition favorable for crop production in the 2016/17 .1. Yes 2. No.

If the answer is no for the above question, what was the existing problem?

1. Shortage of rain fall

2. Flood and snow

3, Agricultural input constraints others specify -----

3.6. Have you leased -out (rented out) your plot of land to other farmers?

1. Yes 2. No .If the answer is yes, what is the size of the land rented out? -----tsimads

If the answer is yes for the above question, what is the reason?

1, Shortage of seed 2, Shortage of ox (en) 3, Lack of labor 4.To smooth consumption

5.To run non-farm business 6.To subsidized families (health, education, mobility etc)7. To cover social events

8. Others specify

3.7 Have you leased in (rented -in) land from othefarmers?1.Yes2.No

If the answer is yes, what was the size of land? _____ tsimads

what is the reason for renting in the land?

1, Because of extra labor force I have on – farm

2, Because of land shortage

3, Because of extra seed I have

4, Because of extra oxen and livestock

- 5. To use irrigation scheme
- 6. Others specify -----
- 3.8. How many hours do you normally travel to reach the Nearest market_____ hr
- 2. Extension office -----hr
- 3. Paved or all weather road -----hr
- 4. District or the nearest town -----hr
- 5. School -----hr
- 6. Clinic -----hr .
- 7. Water supply -----hr
- 4. Livestock holding

4.1. What livestock types and number do you own?

No	Types of livestock	Number
1	Ox	
2	Cow	
3	Heifer	
4	Calf	
5	Sheep	
6	Horse	
7	Goat	
8	Donkey	
9	Camel	
10	Poultry	

4.2. Did you face shortage of oxen during this year? 1. Yes 2. No.

If yes, how did you overcome it?

- 1, Renting in 2, Borrowing 3, Exchange arrangement 4, others -----

5. Use of new technology

Did you adopt improved Maize variety?1. yes, 2. No

5.1. If yes to the above question, which type of Maize variety do you prefer?

- 1. BH 540 2. Melkasa 2 ,3. Gibe3 4. Both Melkasa2 and Gibe3 5. other

5.2. How many timad do you allocate for one/more of the prefer Maize variety adopted

5.3. What are your reasons for preferring it?(multiple answers are possible)

1=High yield 2= Resistance to disease 3= Resistance to lodging4= Drought resistance
5= Commercialized6=Seed color Earliness 7= Weed competition 8= Taste in dishes9= Other

5.4. For how long you adopt the improved Maize variety?

1. One cropping season2.twoCropping season3. Three cropping season4. above three cropping seasons

5.5 Have you ever interrupted growing improved varieties since your start? Yes=1 No =0. If yes, why?

1. Seed constraints 2. Seed too expensive 3. Labor constraints4. Vulnerable to drought

5. Susceptible to diseases to disease6. Vulnerable to frost7. Vulnerable to wild animals

8. Vulnerable to theft 9. Poor quality of seed10. Other =6(specify) _____

5.6 .On what basis did you obtain improved seed? 1. Purchase 2. Credit 3.(specify) -----

5.7. If purchased, where did you buy the seed?

1. From Merchant 2. Local market 3.Ethiopian seed enterprise

4.Other farmers 5. Farming cooperatives 6. Others (specify)_____

5.8. If the seeds were obtained on credit, were did you obtain it?

1. Extension 2. Other farmers 3. Cooperatives4. Others (specify)___

5.9. What was the price of improved Maize seed at the time of planting? -----Birr/Quintal

5.10. What was the price of local Maize seed at the time of planting? -----Birr/Quintal

5.11. What are the constraints in using improved Maize seed?

1. Limited supply 2. High technology price 3. Lack of credit to buy seed

4. Low yield potential5. Low output price 6. un aware 7. others _____

5.12. Did you get enough amounts of improved Maize seed in 2016

Yes =1 No =0

6. Extension service

6.1. Did you have any contact with extension agents during the 2016?

1. Yes 2. No

6.2. If yes, on average how many days did the development agents contacted (visited) you?

1. Once per month

2. Twice per month

3. Three times per month

4. Others

6.3. Have you been attending any agricultural training program? 1. Yes 2. No

Where/year? ----- For how long(days)? -----

.6.4. Have you ever attended any field demonstration day arranged by extension agents? 1. Yes

2. No. If yes, which types of improved maize were demonstrated? -----

6.5. Have you ever been observing when other farmers were using improved Maize seed? 1. Yes

2.No

If the answer is yes, what are your sources of information?

1. Other farmer2. NGOs 3.Extension agent's 4.Other specify-----

6.6. From whom do you get advice on the use of Maize (new technology) other than extension agents?

1. NGOs 2.Experts in woreda office3. Radio/ TV 4.Others specify -----

6.7 . Do you own radio or television? 1. Yes 2. No.

7. Labor availability

7.1. Did you face any labor shortage during the last crop season? 1. Yes 2. No.

If yes, for which farm operations did you face the shortage of labor?

1. Ploughing 2. Weeding 3. Thrashing 4. Harvesting etc.

7.2. And how did you solve the shortage?

1. Through hiring of daily laborers

2. Through ‘debo’ (by use of communal labor)

3. By using family labor

4. Others specify -----

7.3. Did you hire labor for improved Maize ploughing, and?

Operation/activities	No of workers	No of days	Wage rate per day	Total payment
Ploughing				
planting,				
Weeding				
Harvesting				

7.4. Can you get labor to hire when you are in need? 1. Yes 2. No

7.5. On which types of farm activity your female family members participated?

1. Weeding 2. Harvesting 3. Ploughing 4. Trashing 5. Others specify -----

7.6. On which activities do children < 18 years involves? -----

7.7. Are there family members who are engaged in off-farm activity?

Types of off-farm activities	Rate of payment	Duration of activity {month/year/day}	The amount of income obtained {Birr}	Numbers of family members working

8. Income and expenses

8.1. What are your main sources of income (in order of importance)? -

1, Crop sale 2, Livestock sale 3, Off-farm income

4, Small business 5. Remittance 6. Retirement/pension 7. others specify -----

8.2. What is the income earned from livestock and livestock products during 2016?

8.2.1 Income from sale of livestock 2016 E.C

Animal type	Number sold	Unit price	Total sale price
Ox			
Cow			
Goats			
Heifers			
Bull			
Calves			
Sheep			
Donkeys			
Horses			
Poultry			
Total			

For what purpose do you use the income from off-farm activities?

1) To purchase household items 2) to purchase farm inputs 3) to settle debts 4) to buy food

9. Market service and price

9.1. Have you sold Maize, recently? 1. Yes 2. No.

9.2. If yes, what is the total amount produced, consumed you have sold and price you have received during last production year?

9.3. Where do you sell your agricultural products?

1. At farm gate 2. Taking to Local market 3. Supply to dealers 4. Export to other markets 5. Others specify -

9.4. Do you think you have received a fair price for your crops sold? 1. Yes 2. No

9.5. At what season do you usually sell your farm product?

1. Right after harvest 2. Latter after harvest 3. In non-harvesting period 4. Summer 5. Others -----

9.6. What are the crops usually consumed by your family?

1. Wheat 2. Maize 3. Barely 4. Others -----

9.7. What amount of crops was consumed by your family during the 2016? 1. Maize ----- (Qt/kg) 2. Wheat ----- (Qt/kg) 3. Barely ----- 4, other (Qt/kg)

9.8. Would you tell me whether or not you meet the family food consumption?

9.9. If no, how do you feed your family in case of food shortfall?

1. Purchasing 2. Borrowing 3. Social protection (Aid) 4. Remittance 5. Livestock selling 6. Property selling 7. Others specify -----

9.10. If you purchase, what amount have you bought for family consumption during the 2016?

1. improved maize ----- Local maize ----- 2. Wheat ----- 3. Barely -

10. Input supply availability and price

10.1. Did you get input (Maize seed and fertilizer) on time during production season? 1. Yes 2. No.

If the answer is no, for how long it is late? ----

1, till the time of sowing passed 2, It is delayed little

3, We never get at all 4, other specify

10.2. Is there adequate number of input suppliers? 1. Yes 2. No.

If yes, which ones are the suppliers? 1.NGO or government?

If no, from where do you get the input especially Maize seed?

1. Buy from others (traders) 2. From woreda Agricultural office

3. From cooperatives 4. Other specify

10.3. What are the inputs and implements you have purchased for Maize, farm operation during the 2016? -----

s.no	Item	unit	amount	Unit price	Total price
1	Seed				
2	Fertilizer				
3	Chemical				
4	Other				

10.4. What are the major problem of the existing Maize seed and fertilizer supply system?---

1.High input price 2.Lack of credit 3.Shortage of supply

4.Poor quality 5.No problem 6. Other specify --