

**IMPACT OF IMPROVED MAIZE VARIETIES ADOPTION ON SMALLHOLDER
FARMERS' MARKETED MAIZE SURPLUS IN OROMIA REGIONAL STATE,
ETHIOPIA**

ABADI TEFERI ALEMAW

**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE
IN AGRICULTURAL AND APPLIED ECONOMICS OF
SOKOINE UNIVERSITY OF AGRICULTURE.
MOROGORO, TANZANIA.**

ABSTRACT

Adoption of improved agricultural varieties in Africa is low. This situation is not different in Ethiopia. Though increasing yield is a priority, mere increase in production do not motivate farmers to adopt new varieties. When farmers are able to produce more and can sell in the output markets, they will have much more incentive to adopt the new varieties and be productive. This study, therefore, aims at evaluating the impact of adoption of improved maize varieties on farmers' market participation in three woredas of the Oromia regional state, Ethiopia. The study utilized cross-sectional household level data collected by CIMMYT in 2012/2013 from 300 randomly selected sample households. Both descriptive and econometric methods have been used to analyze the data. The descriptive analyses results show the existence of significant mean and proportion difference between adopters and non-adopters in terms of HHH age, education, family size, livestock ownership, land holding, distance to main market, accesses to output and input markets, access to extension services, and access to credit in favour of adopters. The results of the logit model show that adoption of the improved maize varieties among households was found to be positively influenced by adult-literacy, family size, livestock wealth, access to output market and credit access for the new varieties. On the other hand, farmer associations, distance to main markets and fertilizer credit influenced adoption negatively. Moreover, the results of the ATE model show a robust and positive increase in marketed maize grain per household which ranges from around 442kg in the case of kernel-based matching at bandwidth of 0.05 to 483kg in the case of radius matching at a radius of 0.03 at $p < 0.01$. The results from this study revealed that the significant impact of adoption on improving the farmers' participation to output markets. Therefore, it is recommended to promote adoption of the improved varieties as it is essential for inducing farmers' market participation that helps them in generating income and in improving their lives.

DECLARATION

I, Abadi Teferi Alemaw, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within a period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

.....

Abadi Teferi Alemaw
(M.Sc. Candidate)

.....

Date

The above declaration is confirmed by:

.....

Dr. Damas Philip
(Supervisor)

.....

Date

COPYRIGHT

No part of this dissertation may be reproduced, stored in any retrieval system, or transmitted in any form or by any means without prior written permission of the author or Sokoine University of Agriculture in that behalf.

ACKNOWLEDGEMENTS

God has always been with me. Thank you God, the Almighty.

My greatest thank you goes to my supervisors Damas Philip (PhD), Department of Agricultural Economics and Agribusiness, Sokoine University Agricultural, Tanzania and Moti Jaleta (PhD), CIMMYT-Addis Ababa, Ethiopia for their constructive and professional comments on my research.

I thank the African Economic Research Consortium (AERC) for the full scholarship grant, without which joining the M.Sc. program would have not been possible. I also like to thank CIMMYT, Ethiopia for providing me with the complete data set for my study.

It is difficult to mention here all people who assisted me in various ways toward the successful completion of this research. But, I would like to say thank you to: Degefu Kebede, Daniel Jaleta, Million Sileshi, Teshome Lenjisa, Alemu Tolemariam and RAS Gilbert Ntimba and Joyce V. Kadada.

DEDICATION

I dedicate this work to my beloved mother Amit Gebru (Amete).

TABLE OF CONTENTS

ABSTRACT.....	2
DECLARATION.....	2
COPYRIGHT.....	3
ACKNOWLEDGEMENTS.....	4
DEDICATION.....	5
TABLE OF CONTENTS.....	5
LIST OF TABLES.....	7
LIST OF FIGURES.....	7
LIST OF ABBREVIATIONS.....	8
CHAPTER ONE.....	10
1.0 INTRODUCTION.....	10
1.1 BACKGROUND OF THE STUDY	10
1.2 PROBLEM STATEMENT OF THE STUDY	11
1.3 OBJECTIVES OF THE STUDY.....	12
1.3.1 OVERALL OBJECTIVE.....	12
1.3.2 SPECIFIC OBJECTIVES.....	12
1.4 RESEARCH HYPOTHESES.....	12
1.5 RESEARCH QUESTIONS.....	13
1.6 ORGANIZATION OF THE DISSERTATION	13
CHAPTER TWO.....	14
2.0 LITERATURE REVIEW.....	14
2.1 THE DEFINITION AND CONCEPT OF AGRICULTURAL TECHNOLOGY ADOPTION	14
2.2 ADOPTION OF IMPROVED CROP VARIETIES -FARMERS' DECISION-MAKING BEHAVIOUR	14
2.3 THEORETICAL FRAMEWORK FOR ADOPTION.....	14
2.4 METHODS FOR IMPACT ASSESSMENT	14
2.5 MATCHING ALGORITHMS	15
2.6 REVIEW OF EMPIRICAL STUDIES	16
2.6.1 EMPIRICAL STUDIES ON AGRICULTURAL TECHNOLOGIES ADOPTION	16
2.6.1.1 <i>Personal and demographic variables</i>	16
2.6.1.2 <i>Socio-economic factors</i>	16
2.6.1.3 <i>Institutional factors</i>	16
2.6.1.4 <i>Psychological factors</i>	16
2.6.2 EMPIRICAL STUDIES ON THE IMPACTS OF AGRICULTURAL TECHNOLOGIES ADOPTION.....	17
2.7 ETHIOPIAN AGRICULTURAL DEVELOPMENT POLICY	17
2.8 CONCEPTUAL FRAMEWORK OF THE STUDY.....	18
CHAPTER THREE.....	20
3.0 RESEARCH METHODOLOGY.....	20
3.1 DESCRIPTION OF THE STUDY AREA	20
3.2 SURVEY DESIGN AND DATA.....	21
3.2.1 NATURE OF DATA AND SAMPLE SIZE.....	21
3.2.2 IMPROVED MAIZE VARIETIES.....	21

3.3 DATA ANALYSIS PROCEDURE.....	21
3.3.1 DESCRIPTIVE ANALYSIS	21
3.3.2 EMPIRICAL MODELS	21
3.3.2.1 <i>Empirical framework of the logit model for adoption</i>	21
3.3.2.2 <i>Econometric model specification for adoption</i>	22
3.3.3 EMPIRICAL FRAMEWORK FOR IMPACT EVALUATION ANALYSIS.....	23
3.3.3.1 <i>Treatment effect model</i>	23
3.3.3.2 <i>Propensity score matching (PSM) method</i>	25
3.3.3.3 <i>Matching procedure</i>	28
CHAPTER FOUR.....	28
4.0 RESULTS AND DISCUSSION.....	28
4.1 STATISTICAL DESCRIPTION OF THE SOCIO-ECONOMIC CHARACTERISTICS OF SAMPLE HOUSEHOLDS.....	28
4.1.1 HOUSEHOLD PERSONAL AND DEMOGRAPHIC VARIABLES	28
4.1.2 FARM CHARACTERISTICS.....	29
4.1.3 INSTITUTIONAL FACTORS.....	30
4.1.4 GEOGRAPHICAL FACTORS.....	32
4.2 DETERMINANTS OF ADOPTION FROM THE LOGIT ESTIMATION	32
4.2.1 HOUSEHOLD PERSONAL AND DEMOGRAPHIC CHARACTERISTICS.....	32
4.2.2 FARM CHARACTERISTICS	33
4.2.3 INSTITUTIONAL FACTORS.....	33
4.3 IMPACTS OF VARIETIES ADOPTION ON FARMERS' OUTPUT MARKET PARTICIPATION	41
4.3.1 PROPENSITY SCORE MATCHING RESULTS	41
4.3.2 DETERMINANTS OF MARKET PARTICIPATION.....	41
4.3.3 ESTIMATION OF TREATMENT EFFECT ANALYSIS BASED ON MATCHING ALGORITHMS.....	45
4.3.4 CHECKING ROBUSTNESS OF AVERAGE TREATMENT EFFECT.....	46
CHAPTER FIVE.....	47
5.0 CONCLUSIONS AND RECOMMENDATIONS.....	47
5.1 CONCLUSIONS.....	47
5.2 RECOMMENDATIONS.....	47
5.3 AREAS FOR FURTHER RESEARCH.....	47
REFERENCES.....	49

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

°C	Degree Celsius
ATE	Average Treatment Effect
ATT	Average Treatment on the Treated
CIA	Conditional Independence Assumption
CIMMYT	International Maize and Wheat Improvement Center
CSA	Central Statistical Authority
CSA	Common Support Condition
DD	Double-Difference
EARO	Ethiopia Agriculture Research Organization
EIAR	Ethiopia Institute of Agricultural Research
FDRE	Federal Democratic Republic Ethiopian
GDP	Gross Domestic Product
HHHs	Household Heads
IFPRI	International Food Policy Research Institute
IV	Instrumental Variable
Kg	Kilograms
Km	Kilometers
KM	Kernel-based Matching
LPM	Linear Probability Model
MLE	Maximum Likelihood Estimation
NERICA	New Rice for Africa
NGOs	Non-Governmental Organizations
NNM	Nearest Neighbour Matching method
PSM	Propensity Score Matching
RATES	Regional Agricultural Trade Expansion Support program
RD	Regression Discontinuity
RM	Radius Matching method
SD	Standard Deviation
SM	Stratification Matching method
VIF	Variance Inflation Factor
WB	World Bank
WDR	World Development Report

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

Ethiopia is the second most populous African nation (population estimated to be 84 million) occupying 1.12 million square km (Central Statistical Agency (CSA), 2011). The country's economy relies heavily on agriculture. The sector contributes about 41% of the GDP and employs 83% of the economically active population (National Bank of Ethiopia, 2011). It also serves as the main source of food and generates 90% of the foreign exchange earnings. It provides raw materials for more than 70% of the country's industries. Within agriculture, 60% of the output of the agricultural GDP comes from crop production, whereas, 30% and 7% is from livestock and forestry, respectively (World Bank, 2007). In agriculture, cereals play a central role accounting for roughly 60% of rural employment, 80% of total cultivated land.

The major cereal crops cultivated in the country are teff (2 761 190 ha), maize (1 963 179 ha), sorghum (1 897 733 ha), wheat (1 553 240 ha), and barley (1 046 555 ha). Although agriculture is the foundation of the country's economy, crop productivity has remained low. For instance, the average national yield of important food crops such as teff, maize, sorghum and wheat were 1.26, 2.54, 2.08 and 1.84 tons per hectare respectively (CSA, 2011) while the potential of those crops is two to three times higher (MoARD, 2008). Food insecurity has been a persistent issue in the country where the recurrent drought considerably affects crop production of its numerous villages (Dercon *et al.*, 2005). Growing drought tolerance varieties is a promising means of increasing food production particularly in drought-prone areas.

Among cereals, maize is the most important crop in terms of production and contributes significantly to the economic and social development of Ethiopia (CSA, 2011). Maize cultivation is largely a smallholder phenomenon. The smallholder farmers that comprise about 80% of Ethiopia's population are both the primary producers and consumers of maize in Ethiopia (Alemu *et al.*, 2008). About eight million smallholders were involved in maize production in 2010/11, compared to 6.2 million for teff and 5.1 million for sorghum, making it critical to smallholder livelihoods in Ethiopia. In addition, its production accounts for 27% of the total cereal production in the country with the greatest production at 3.8 million tons compared to teff and sorghum at 2.7 million and 3.0 million tons respectively in 2007/08 (CSA, 2008; Yu *et al.*, 2011).

In addition to the aforementioned facts, Table 1 clearly shows the growth rate (%) of maize between the 2003/04 and 2007/08 in Ethiopia. It shows the area covered by maize increases by 35.9% from the year 2003/04 to 2007/08 which was the highest growth rate. Nevertheless, the growth rate in production was 52.7% which makes it remain behind teff and sorghum showed a growth rate of 79% and 57% respectively. Though the area share has grown by 6.8%, which is the highest, the growth rate in yield was far below (12%) the other cereals like teff and sorghum which showed 38% and 27% growth rate in yield respectively in spite the area share growth of these cereals was far less than maize (Table 1).

Table : Area, production and yields of maize and related cereals in Ethiopia, 2003/04 to 2007/08

		Cereal crop				
		Barley	Maize	Sorghum	Teff	Wheat
2003/04	Area 000 hectare	911	1 300	1 242	1 985	1 075
	Production 000 tons	1 071	2 455	1 695	1 695	1 589
	Yield tons/ha	1.2	1.9	1.4	0.8	1.5
	Area share %	13.4	19.1	18.2	29.1	15.8
2007/08	Area 000 hectare	985	1 767	1 534	2 565	1 425
	Production 000 tons	1 355	3 750	2 659	2 993	2 314
	Yield tons/ha	1.4	2.1	1.7	1.2	1.6
	Area share %	11.4	20.4	17.7	29.6	16.4
Growth rate (%)	Area	8.1	35.9	23.5	29.2	32.6
	Production	26.5	52.7	56.9	79.0	45.6
	Yield	17.0	12.3	27.0	38.6	10.0
	Area share	-14.9	6.8	-2.7	1.7	3.8

Source : Yu *et al.* (2011)

While maize already plays a critical role in smallholder livelihood and food security of the country, this role can be expanded. Because of lack of modern way of farming, agricultural technologies, the production was 2.2 tons per hectare in 2008/09 with a potential for 4.7 tons per hectare according to on- farm field trials, when cultivated with fertilizer, hybrid seed, and improved farm management practices (Rashid *et al.*, 2010).

This shows that if smallholder farmers are able to adopt the improved maize technologies, they can produce more. As a result, they can meet their domestic consumption demands and supply for markets and this support them to earn additional income to improve their livelihood. Until recently, the choice of technologies available to farmers was largely determined by the need to increase production and productivity. Now agriculture has to fulfil diverse objectives such as the need to be internationally competitive, produce agricultural products of high quality while meeting sustainability goals such as food security. In order to be competitive, agricultural producers need rapid access to emerging technologies. This is a crucial issue in countries like Ethiopia where the population is increasing in an alarming rate while the land for cultivation is limited.

Recently, the Ethiopian government has promoted technology-led initiatives to enhance productivity, particularly in smallholder agriculture (Gebreselassie, 2006; FDRE, 2010). Reforming the research and extension systems, and pursuing other relevant strategies such as irrigation, credit and allied services, were undertaken to benefit smallholder farmers. By serving as a channel to transfer products to intermediate and final consumers, a well-developed marketing system creates the economic incentive for producers to invest in production and productivity enhancing activities. Although most maize produced in Ethiopia is used for household consumption, the maize that is marketed faces a market characterized by poor coordination, low scale and volume of operation, high cost and high risk (IFPRI, 2011).

In support of the growing popularity of maize, an extensive maize seed industry has emerged in Ethiopia over the last several decades. Agricultural research and technological improvements are crucial to increase agricultural productivity which is required to meet domestic consumption needs and to get marketed surplus. Maize is among a few crops which received special attention from the Ethiopian government and NGOs operating in the country. In this regard, research on maize in Ethiopia has been intensively underway since the establishment of the Ethiopia Institute of Agricultural Research (EIAR) in 1966. Studies to develop improved maize technologies have been conducted since then with the assistance of international research centres and foreign donors resulting in several improved maize varieties and management practices. The International Maize and Wheat Improvement Centre (CIMMYT) have also played a great role in the process of developing improved maize varieties (Srinivasan and Pandey, 2001).

Achieving national food security and diversifying export earning agricultural commodity is one of the major challenges currently facing developing countries like Ethiopia. Cereal crops in general and maize productions in particular play a great role in improving

household's food security. However, because of poor quality of production, the marketed maize is low (13.6%) compared to teff and wheat which account for about 53.2% and 17.8% respectively; maize export is also in poor status in spite of the country's geographical location to Middle East and Eastern and Southern Africa where there is immense potential demand for maize (RATES, 2003). However, still the opportunities for market development and commercialization are particularly favourable for crops like maize which tend to have higher domestic, regional and international demand.

Despite the various efforts made to transform smallholder agriculture in general and crops in particular, the adoption of improved varieties of major crops such as maize has remained low in Ethiopia (Spielman *et al.*, 2010). For instance, according to Yu *et al.* (2011), the area under improved seed and the area under both improved seed and fertilizer were only 0.6% and 21.6% respectively out of the total 891 300 hectare of land covered by maize in 2007. Moreover, only 26% of farmers used improved maize seed, and 23.6% used both improved maize seed and fertilizer in the country in 2007/08 (IFPRI-EDRI, 2008). Due to this, the yield of this crop is low as compared to its potential yield despite the country has high potential to increase production. In addition to the low adoption of improved technologies mainly seed, some of the contributing factors to the low productivity level are low yield potential of seed cultivars, low quality of seeds, erratic rainfall and recommended management practices (Alemu *et al.*, 2008). Farmers in the study area are among those who are suffering from the problem of low yield.

1.2 Problem Statement of the study

In today's more integrated world economy, success in productivity-based agricultural growth crucially depends on market opportunities. Improving the competitiveness of developing countries' agricultural products in international, regional, and domestic markets is the key to expanding market opportunities (WDR (2008) as cited by Solomon

et al., 2011). Very low adoption makes the traditional varieties dominate the local and export markets as most (95%) maize is sold by the smallholder farmers who mainly produce for subsistence (RATES, 2003); and the low productivity of these improved maize varieties limits the farmers' competitiveness in these markets. because of poor quality production, the marketed maize is low (13.6%) compared to teff and wheat which account for about 53.2% and 17.8% respectively; maize export is also in poor status in spite of the country's geographical location to Middle East and Eastern and Southern Africa where there is immense potential demand for maize (RATES, 2003). However, still the opportunities for market development and commercialization are particularly favourable for crops like maize which tend to have higher domestic, regional and international demand.

Several studies have been conducted so far related to maize technologies adoption in other parts of Ethiopia *e.g.* Yu *et al.* (2011); Shiferaw and Tesfaye, (2005); Yishak and Punjabi, (2011); and Alene *et al.* (2000). The focuses of these studies were to identify factors affecting the adoption of improved maize technologies or to assess the intensity of adoption. Some studies were also conducted to assess the welfare impacts of adopting the new maize technology. But as to the knowledge of the researcher, no study has been conducted on maize technologies adoption in the study area and no research was conducted to assess the impacts of these maize technologies on marketed surplus maize grain in the country, which is the main focus of the present study. Hence, this dissertation tried to fill this research gap.

Understanding the maize technologies adoption current status in the study area and its impact on market integration of the smallholder farmers to output markets is vital in promoting use of the maize technologies in order to enhance its production in the study area in particular and in Ethiopia in general. Besides there are only few empirical studies

which show the linkage between technology adoption, productivity gain and market integration in developing countries' settings (Edmeades, 2006; Balagtas *et al.* 2007; Bellemare and Barrett, 2006). Therefore, it is imperative to examine the adoption level of the improved maize technologies in the study area and its impact in enabling smallholder farmers to produce marketed maize surplus in the output markets.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of the present study is to analyse the impact of improved maize varieties adoption on smallholder farmers' marketed maize surplus in the study area.

1.3.2 Specific objectives

The specific objectives of the study are to:

- i. examine the current adoption status of improved maize varieties;
- ii. identify the demographic, socio-economic and institutional factors which determine the adoption of improved maize varieties by smallholder farmers; and
- iii. assess the impact of improved maize varieties adoption on marketed surplus of maize grain.

1.4 Research Hypotheses

H₀: Improved maize varieties adoption is not influenced by different demographic and socio-economic and institutional characteristics of farmers.

H₀: Improved maize varieties adoption does not have any significant impact on small holders' grain market participation.

1.5 Research Questions

- i. How is the current status of improved maize varieties adoption in the study area?
- ii. What are the demographic, socio-economic and institutional factors which determine the adoption of improved maize varieties by smallholder farmers?
and
- iii. What is the impact of improved maize varieties adoption on marketed maize surplus?

1.6 Organization of the Dissertation

The dissertation is organized in five chapters. The first chapter consists of background of the research, statement of the problem, the study objectives and the study hypotheses. The second chapter deals with the review of literature on topics relevant to the study. The third chapter presents the study methodology. The fourth chapter brings forth the results and discussion, and the final chapter depicts conclusions and recommendations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Definition and Concept of Agricultural Technology Adoption

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. Feder *et al.* (1985) have also defined adoption as the integration of an innovation into farmers' normal farming activities over an extended period of time. Adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages (Bahadur and Siegfried, 2004). It can be considered as a variable representing behavioural changes that farmers undergo in accepting new ideas and innovations in agriculture anticipating some positive impacts of those ideas and innovations. Adoption is the decision-making process in which an individual assesses from first hearing about an innovation to final adoption (Rogers, 1962).

A distinction exists between adoption at the individual farm level and aggregate adoption within a targeted region. Adoption at the farm level reflects the farmer's decision to incorporate a new technology into the production process while aggregate adoption is the process of spread or diffusion of a new technology within a region (Feder *et al.*, 1985). At the farm level for investigating the adoption process there should be a complete analytical frame work that include farmer's decision making model determining the extent and intensity of use of a new technology at each point throughout the adoption process. Aggregate adoption is measured by the aggregate level of use of a specific new technology within a given geographical area or a given population (Rogers, 1962).

2.2 Adoption of Improved Crop Varieties -Farmers' Decision-Making Behaviour

The theories decision-making have been largely rooted in disciplines economics and psychology. In economics, mathematical probability analysis are conducted to explain what value people assign to the utilities for alternatives outcomes of and seek to maximize their expected utility. 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 behaviour of individuals or society. Decision can be categorized as intuitive, programmed, and analysed. 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 which in principle capable of being automated. There are certain decisions that one has to analyse possible outcomes and their consequences (Gebre-Mariam, 2012).

When an individual has alternatives each with significant consequences, and that he or she is unsure about which choice is the best a decision problem exists. 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 income, (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 key for study farmers behaviour 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.

To describe the characteristics of the farmers' decision-making some author refers to the characteristics of farm management. 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 in different groups).

2.3 Theoretical Framework for Adoption

The study of improved agricultural technology adoption received attention of researchers and policy makers expecting that the adoption of agricultural innovation improves production. A household level adoption study considers the decision made by the household head to include new or improved variety in usual farming practice. The decision made to adopt or otherwise depend on different factors. Farmers' decision to adopt improved varieties is assumed to be the product of a complex preference comparison made by a farm household. To adopt or not to adopt a technology is often a discrete choice. Discrete choice models have widely been used in estimating models that involve discrete economic decision-making processes (Guerrem and Moon, 2004).

The two commonly used discrete choice models in the adoption studies are the probit and logit models. The results from the two models are very similar since the normal and logistic distributions from which the models are derived are very similar except for the fact that the logistic distribution has slightly fatter tails (Gujarati and Porter, 2009). The dependent variable which is normally used with these models is dichotomous in nature, taking the values 1 or 0, a qualitative variable which is incorporated into the regression model as dummy variable. In this case the value 1 indicates a farmer who adopts the improved maize varieties while the value 0 indicates the farmer who does not adopt. Adopters of improved maize varieties are defined as farmers who planted improved maize seed at least for the 2012/13 cropping season and non-adopters are defined as farmers who did not plant the improved seed.

The other models used to study adoption are the Tobit model and Heckman procedure known as Double-Hurdle models. The Double-Hurdle model and the Tobit model are alternatively used to identify factors which affect adoption and the intensity of adoption (Berhanu and Swinton, 2003; Mignouna *et al.*, 2011; Alene *et al.*, 2000). These two models differ from the above two due to the assumption that factors that affect the farmers' choice of an option should not necessarily be the same as those that affect the intensity of use. This is because the decision to choose a particular maize option is obviously associated with some threshold effects. Hence, only the logit model was employed in this study as to the taste and convenience of the researcher.

2.4 Methods for Impact Assessment

Estimation of impact of maize technology adoption on smallholders' maize grain market participation based on non-experimental observations is significant because of the need of finding counterfactual of intervention.

While estimating the ex- post impacts of adopting the improved varieties which means impact on market participation in this context, due concern must be taken that the market surplus may not be observed for both groups of the households (adopters and non-adopters). This is because the technology is not randomly distributed to the two groups of the households, but rather by the decision of the households themselves based on the information they have. Therefore, Solomon *et al.* (2011) state that adopters and non-adopters may be systematically different; this difference may manifest itself in differences in access to market, infrastructure, access to institutions and household asset holdings and characteristics. Thus, performing ex-post assessment of gains from adoption using observational data may lead to wrong conclusion, because of possible selection bias due to observed and unobserved household characteristics. This problem could again lead to inconsistent estimates of the impact of adoption. In other words, the unobservable characteristics that affect the probability of adoption may also affect the outcome variable, *i.e.* marketed surplus.

Different methods have been developed and used in the literature to address the fundamental question of the missing counterfactual. These include Randomized evaluations, Matching methods, specifically Propensity Score Matching (PSM), Double-Difference (DD) methods, Instrumental Variable (IV) methods, Regression Discontinuity (RD) design and pipeline methods, Distributional impacts, and Structural and other modelling approaches (Shahidur *et al.*, 2010). Each of these methods carries its own assumptions about the nature of potential selection bias in program targeting and participation, and the assumptions are crucial to developing the appropriate model to assess the ex-post impacts.

These methods vary by their underlying assumptions regarding how to resolve selection bias in estimating the program treatment effect (Shahidur *et al.*, 2010). Randomized

evaluations involve a randomly allocated initiative across a sample of subjects (communities or individuals, for example); the progress of treatment and control subjects exhibiting similar pre-program characteristics is then tracked over time. Randomized experiments have the advantage of avoiding selection bias at the level of randomization. DD methods assume that unobserved selection is present and that it is time invariant-the treatment effect is determined by taking the difference in outcomes across treatment and control units before and after the program intervention. DD methods can be used in both experimental and non-experimental settings. IV models can be used with cross-section or panel data and in the latter case allow for selection bias on unobserved characteristics to vary with time. In the IV approach, selection bias on unobserved characteristics is corrected by finding a variable (or instrument) that is correlated with participation but not correlated with unobserved characteristics affecting the outcome; this instrument is used to predict participation. RD and pipeline methods are extensions of IV and experimental methods; they exploit exogenous program rules (such as eligibility requirements) to compare participants and nonparticipants in a close neighbourhood around the eligibility cut off. Pipeline methods, in particular, construct a comparison group from subjects who are eligible for the program but have not yet received it (Becker and Ichino, 2002).

In the absence of an experiment, PSM methods compare treatment effects across participant and matched nonparticipant units, with the matching conducted on a range of observed characteristics. PSM methods therefore assume that selection bias is based only on observed characteristics; they cannot account for unobserved factors affecting participation (Rosenbaum and Rubin, 1983). The basic idea behind (PSM) is to match each adopter with an identical non-adopter and then measure the average difference in the outcome variable between the two. Studies by Solomon *et al.* (2011), and Kassie *et al.* (2010) used treatment effect and propensity score methods to assess the ex- post effects of adopting chickpea in Ethiopia and groundnut in Uganda respectively.

2.5 Matching Algorithms

As listed in Shahidur *et al.* (2010), the most commonly used matching algorithms are the Nearest Neighbour Matching (NNM), Radius Matching (RM), Kernel-based Matching (KM), and Stratification Matching method (SM). Four of these matching algorithms were employed to measure the impact of improved maize technologies on households' marketed maize surplus which in turn enhances market participation.

The NNM method matches each farmer from the adopter group with the farmer from the non-adopter group having the closest propensity score. The matching can be done with or without replacement of observations. NNM faces the risk of bad matches if the closest neighbour is far away. This risk can be reduced by using a RM method, which imposes a maximum tolerance on the difference in propensity scores. However, some treated units may not be matched if the dimension of the neighbourhood or the radius is too small to contain control units (Heinrich *et al.*, 2010).

The KM method uses a weighted average of all farmers in the non-adopter group to construct a counterfactual. The major advantage of the KM method is that it produces Average Treatment effect on the Treated (ATT) estimates with lower variance since it utilizes greater information; its limitation is that some of the observations used may be poor matches. The Stratification method divides the range of variation of the propensity score in intervals such that within each interval treated and control units have on average the same propensity score. Then, within each interval in which both treated and control units are present, the difference between the average outcomes of the treated and the controls is computed (Heinrich *et al.*, 2010; Shahidur *et al.*, 2010).

2.6 Review of Empirical Studies

2.6.1 Empirical studies on agricultural technologies adoption

Different literatures on adoption of high-yielding varieties and crop management technologies both outside and in Ethiopia pointed out that, the adoption decision of farmers is influenced by a number of variables such as personal and demographic, socio-economic, institutional, psychological and behavioural factors.

2.6.1.1 Personal and demographic variables

Household's personal and demographic variables are among the most common household characteristics, which are mostly associated with farmer's adoption behaviour. From this category of variables, age, sex, marital status and education are reviewed.

Sex is one of the important factors influencing adoption of improved agricultural technologies. Due to long lasted cultural and social grounds in many societies of developing countries, women have less access to household resources and also have less access to institutional services. Regarding the relationship of household's sex with adoption of agricultural technologies, many previous studies reported that household's sex has positive effect on adoption in favour of males. For example Techane (2002) in his study on determinants of fertilizer adoption in Ethiopia found that male headed households are more likely to adopt fertilizer use than female headed households. In addition, Kebede (2006) found that female farmers adopted compost than males while the reverse is true for the rough tillage adoption. Contrary to this, Abrehaley (2006) indicated that sex of the household head has no significant relation with adoption.

Age is also an important household characteristic influencing the adoption behaviour of subsistence farmers. However, results from different empirical studies revealed conflicting findings. For instance, Bekele *et al.* (2000) indicated that age of the household head

negatively affected the mean proportion of land allocated to improved wheat varieties. A similar result by Mahdi (2005) confirmed that when a farmer's age increases, the probability of using improved technology decreases. A reason given by the authors for the negative relationship between age and adoption of improved technologies is an assumed longer planning horizon for younger farmers relative to older ones.

On the other hand, Adesina and Chianu (2002) have found that age positively influences the adoption of alley farming agroforestry technology in Nigeria. The two reasons given for this effect are: First, older farmers may have accumulated more knowledge of the benefits of fallow, from their years of experience. Second, older farmers may find the management of the conventional alley farming system too labour-intensive.

Education is also associated with adoption because it is believed to increase farmers' ability to obtain, and analyze information that helps him/her to make appropriate decision. A study carried out by Mwanga *et al.* (1998) in Tanzania has indicated that education level significantly affected the adoption of improved wheat varieties. Similarly, Bekele *et al.* (2000) indicated positive relationship between education and adoption. Contrary to this, a study conducted by Asnake *et al.* (2005) in Ethiopia showed that education had no significant effect on the adoption of improved chickpea varieties.

2.6.1.2 Socio-economic factors

Socio-economic factors influence household's adoption decision of agricultural technologies. In this study, socio-economic variables such as total land holding, livestock ownership play a great role in determining the willingness and ability to invest in adoption of agricultural technologies.

Land related variables influence farmers' adoption behaviour as land holding is an important unit where agricultural activities take place. Concerning land holding, different studies reported its effect differently. For example, a study carried out by Tesfaye and Alemu (2001) reported that farm size contributed positively in farmers' adoption of improved wheat varieties. Asnake *et al.* (2005) conducted a study on adoption of improved chickpea varieties in Ethiopia and found that farm size was positively related to the adoption of improved varieties.

Livestock ownership is an important indicator of household's wealth position. Livestock is also an important income source, which enables farmers to invest on adoption of improved agricultural technologies. In most cases, livestock holding has positive contribution to household's adoption of agricultural technologies. Many adoption studies have reported positive effect of livestock holding on adoption. To mention some, Berhanu (2002) and Taha (2007) have found that livestock holding has positive influence on adoption of improved agricultural technologies.

2.6.1.3 Institutional factors

Institutional factors are one category of the variables which are mostly associated with farmers' adoption behaviour. From this category of variables, extension services, credit services and availability and distance to market places are the main ones. The relationship between farmers' access to extension services and adoption has been repeatedly reported as positive and significant by many authors. For instance, Teferi (2003) and Abrehale (2006) have shown that extension contact affect adoption of new technologies positively and significantly. Similarly, Kebede (2006) and Mekonnen (2007) found a positive and significant relation between extension contact and adoption of maize varieties and Integrated Striga Management (ISM) technologies of sorghum, respectively.

Many of the studies which have considered distance to the nearest main market, access to transport facilities and distance of farm from the house reported their significant relationship with adoption behaviour. To mention some, Legesse *et al.* (2001) showed that distance to market, which is determining the adoption and intensity of use of technologies and found to be negative with significant effects. In addition the results of many other researchers who reported that market distance as negatively and significantly associated with the adoption of crop technologies (Mahdi, 2005).

Credit service is also another institutional variable that farmers need to get to improve production and productivity. Capital and risk constraints are key factors that limit the adoption of high value crops by small scale farmers because these crops generally are much more costly to produce than the traditional crops and most growers require credit to finance their production. In line with this, studies conducted by Mekonnen (2007), Taha (2007) and Minyahel (2008) also found that the use of credit had positive and significant influence on adoption and intensity of adoption of the technology package. Similarly, Ebrahim (2006), Kebede (2006) and Tesfaye (2006) also found similar results.

2.6.1.4 Psychological factors

Most of the works done on adoption behaviour focused on only independent variable, however, few researchers among which, in South Africa, Duvel and Botha (1999), in Ethiopia, Habtemariam (2004), Ebrahim (2006) and Mekonnen (2007) did research on the psychological aspects of the technology transfer and adoption. Perception with the way the attribute of innovation is perceived and the respondent's perception of the technology attributes such as (I) awareness of relative advantages, (II) awareness or concern of disadvantages. Then the differences between the two are taken as total perceived attribute of the package.

Duvel and Botha, (1999) confirm the positive and significant relationship between adoption behaviour and perception of technology attributes in South Africa. Studies conducted by Habtemariam (2004) and Ebrahim (2006) showed that there was positive and significant relationship between adoption behaviour and need compatibility in Ethiopia. In addition, researches by Enderias (2003) and Taha (2007) showed that farmers' perception of technology attributes have positive and significant influence on adoption of technologies.

The findings of the various empirical studies show little harmony suggesting that the adoption and diffusion of agricultural innovations are influenced by a number of interwoven and interacting sets of socio-economic, bio-physical, technological, institutional and demographic factors as well as characteristics of the farmers' operational environment. In fact, the different studies reviewed in this section indicate that the factors which influence adoption of technologies differ from one area to another and from one technology to another technology.

2.6.2 Empirical studies on the impacts of agricultural technologies adoption

Several studies in Ethiopia and Africa have showed that adoptions of improved agricultural seed varieties, though variably and incompletely, had positive impacts on income, food security and poverty reduction. Below are reviews of some of the recent studies who have applied PSM in program evaluations in Ethiopia and elsewhere.

In assessing the impact of the Productive Safety Net Program (PSNP) in Ethiopia on livestock and tree holdings of rural households, Andersson *et al.* (2009), have applied PSM model. They found that there was no indication that participation in PSNP leads households to disinvest in livestock or trees. In fact, the number of trees increased for households that participated in the program. It could be the case that participation in the

PSNP, leads to households becoming more skilled in forestry, and that they switch to increased forest planting as a result.

Kassie *et al.* (2010) used propensity score methods to assess the ex- post impact of adopting groundnut on welfare in Uganda. The results showed that the adoption of high yielding improved varieties has a positive effect in improving the smallholder farmers' wellbeing. In the same vein, Kassie *et al.* (2012) analysed the impact of the intensity of improved maize varieties adoption on food security and poverty in rural Tanzania. The aforementioned authors used a continuous treatment approach using generalized propensity score matching and parametric error correction approaches to reduce potential biases stemming from difference in observed characteristics. The results indicate that maize technology adoption has generated a significant positive impact on food security and that the impact varies by the level of adoption.

Similarly, a research conducted by Kijima *et al.* (2008) on the impact of New Rice for Africa (NERICA) in Uganda found that NERICA adoption reduces poverty without deteriorating the income distribution. Diagne (2006) also assessed the impact of NERICA adoption on rice yield in Cote d'Ivoire. The results show a positive and significant increase in yield particularly on the female farmers. Setotaw *et al.* (2003) found that adoption of improved agricultural technologies (improved varieties and agronomic practices) have positively and significantly affected household's food security in Ethiopia. Most importantly, Solomon *et al.* (2011) evaluated the adoption determinants and casual impact of adoption of improved chickpea technologies on market integration in rural Ethiopia. They estimated the causal impact of technology adoption on market integration by utilizing treatment effect model; regression based on propensity score as well as matching techniques to assess results robustness. Results of the analysis revealed that the

adoption of improved agricultural technologies has a significant positive impact on marketed surplus and the findings are consistent. The results also confirmed the potential direct role of technology adoption on market integration among the rural households, as higher productivity from improved technology translates into higher output market integration.

Studies conducted in Asia also revealed similar results. Using a propensity score matching method, Mendola (2007) examined the impacts of agricultural technology adoption on poverty reduction in rural Bangladesh. Findings show a robust and positive impact of agricultural technology adoption on farm households' well-being. Similarly, Wu *et al.* (2010) conducted an impact study in rural China and found that adoption of agricultural technologies had a positive impact on farmers' well-being thereby improving household income.

2.7 Ethiopian Agricultural Development Policy

Ethiopia presents one of the most important global challenges in agricultural development. It is among the poorest countries in the world. Despite its importance in the livelihood of the people and its potential, the sector is still dominated by smallholder subsistence production; and traditional technologies are predominant. The sector is not yet adequately commercialized to bring about rapid change in production in line with increasing population pressure. Food production and productivity do not keep pace with the ever-increasing population, which is 3.3% per annum and characterized by the prevalence of poverty and food insecurity (Yenealem, 2006).

Therefore, the level of productivity in agriculture is very low due to, among others, low rate of the adoption of improved technologies. Consequently, the agricultural sector has failed to meet adequately its primary objectives such as providing food, raw materials,

exports earnings, and resources inevitable in itself and other sectors of the economy. The poor performance in agriculture coupled with rapid population growth which aggravated the problem of low export commodities, food insecurity and per capita food production. Consequently, this has forced the country to be one of the major recipients of food aid and importer of commercial food grain in the third world countries (Million and Belay, 2004).

Solomon *et al.* (2011) stated that governments of developing countries have recently 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 smallholders only if the marketing activity (aggregation and trading) is well-developed (IFPRI, 2008).

Low crop productivity in SSA including Ethiopia is 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).

The capacity of seed supply and seed dissemination is highly influenced by a country's seed system development stage (Maredia *et al.*, 1999). The transition from one stage to another stage, however, is not linear but dictated by economic, agricultural development

and seed system development stage of a particular country and crop. For instance, some crops attract commercial enterprise while others do not; hence, seed system development requires policy intervention (Tripp and Louwaars, 1998).

Seeds of improved varieties are regarded as effective tools in enhancing crop productivity since they dramatically changed the productivity of crops during the Green Revolution of the 1960s to 1980s in South East Asian countries. Such productivity increase did not happen yet in SSA countries such as Ethiopia where the agro-ecology is diverse and farming is a risky enterprise particularly in drought-prone areas (Spielman *et al.*, 2010; Alemu *et al.*, 2008). Therefore, the issue of improved crop varieties is an important element in agricultural development policy in Ethiopia. The government has established development policies emphasizing agriculture as an engine for economic growth. In this respect, the Agricultural Development Led-Industrialization (ADLI) has been an umbrella strategy since 1994 and has had the ongoing influence in providing a framework for long-term economic growth. Agriculture has been considered as a base for enhancing structural transformation in economic growth because the largest human and land resources are located in rural areas where farming is predominantly practiced. Within agricultural sector, the focus has been placed on the improvement of smallholder farmers' crop productivity (Rahmato, 2008). The provision of improved agricultural technologies primarily seeds of improved varieties and agro-chemicals were assumed to be the most important inputs (Government of Ethiopia (GoE), 2001).

Another important national development program, Accelerated and Sustainable Development to End Poverty (PASDEP) of 2004/5 to 2009/10, was also built on the experience of implementing ADLI. The novel approach of the PASDEP was its recognition of the need to tailor agricultural interventions according to specific economic

and agro-ecological conditions. PASDEP emphasized food insecurity reduction in drought-prone areas through diversification away from reliance on food crop production by increasing off-farm income opportunities (Teshome, 2006). However, given that the mass of the population living in drought-prone area is agrarian, the envisaged shift from food crop production to off-farm activities did not have a clear impact.

The country's current development plan, the Growth and Transformation Plan (GTP), is based on the experiences that have been drawn from implementing development policies and strategies of the previous years. During the GTP (2010 to 2015), agricultural has been stipulated to continue playing its key roles as an economic growth source. For this purpose, the application of improved seeds variety has been emphasized with the assumption that the formal seed enterprises will deliver the required seeds in quality and amount (MoFED, 2010).

The GTP and agricultural and rural development policies of the country place crop production and productivity enhancement at the heart of agricultural growth where improved crop varieties are given high emphasis. The GTP reads, "Since technology multiplication, supply and distribution system is crucial to increase crop production and productivity, this system will be strengthened to make it effective. In the five years [2010 to 2015] the required fertilizer, improved seeds, and small farm machineries will be made available with the requisite quality and quantity" (MoFED, 2010).

2.8 Conceptual Framework of the Study

Agricultural technology adoption often varies from location to location. In general, the variations in adoption patterns proceed from the presence of disparity in agro ecology, institutional and social factors (CIMMIYT, 1993). Moreover, farmers' adoption behavior,

especially in low-income countries, is influenced by a complex set of socio-economic, demographic, technical, institutional and biophysical factors (Legesse, 1998).

Adoption rates were also noted to vary between different group of farmers due to differences in access to resources (land, labor, and capital), credit, and information as well as differences in farmers' perceptions of risks and profits associated with new technology (Tesfaye *et al.* 2001). The direction and degree of impact of adoption determinants are not uniform; the impact varies depending on type of technology and the conditions of areas where the technology is to be introduced (Legesse, 2001).

Practical experiences and observations of the reality have shown that, one factor may enhance adoption of one technology in one specific area for certain period of time while it may create hindrance for other locations (Tesfaye *et al.*, 2001). Because of these reasons, it is difficult to develop a one and unified adoption model in technology adoption process for all specific locations. Hence, the conceptual framework presented in Figure-1 shows the most important variables expected to influence the adoption of improved maize varieties in the study area. It further shows how adoption results in production and productivity increase. An increase in production in turn helps farmers to have a surplus which in turn help them to participate in output markets.

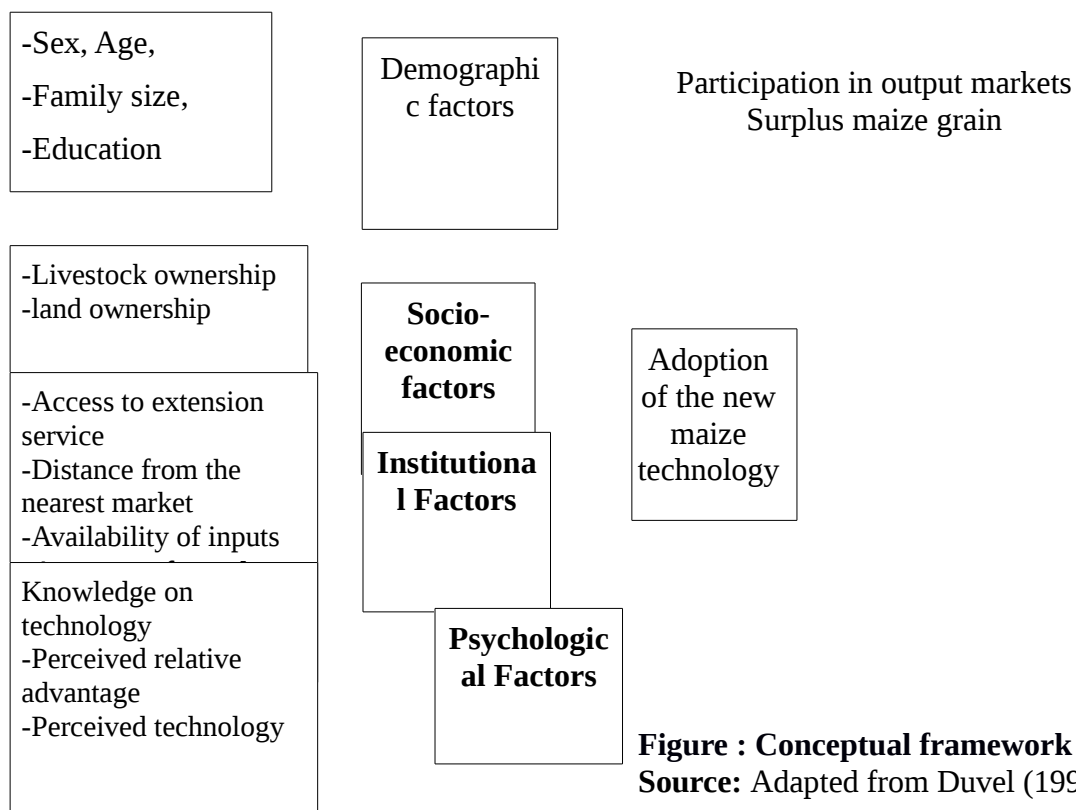


Figure : Conceptual framework
Source: Adapted from Duvel (1990).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the Study Area

The present study was conducted based on data collected during the 2012/13 cropping season. The dataset contains 300 farm households selected from three *woredas*¹ of two adjacent *zones*² of the [Oromia Regional state](#), [Ethiopia](#). The *woredas* were selected because the *woreda* are potential for maize production. The *woredas* are namely Dugda, Adami Tulu and Shalla.

Dugda *woreda* is one of the [woredas](#) in the [Oromia Region](#) of [Ethiopia](#). Part of the [east Shewa Zone](#) located in the [Great Rift Valley](#), Dugda is bordered on the southeast by [Lake Zway](#), on the south by [Adami Tulu and Jido Kombolcha](#), on the west by the [Southern Nations, Nationalities and Peoples Region](#), on the northeast by [Koka Reservoir](#) which separates it from [Adama](#), and on the east by the [Arsi Zone](#). The *woreda* is located at about 134 km South of Addis Ababa, capital of Ethiopia.

The altitude of this *woreda* ranges from 1 500 to 2 300 metres above sea level. A survey of the land in this *woreda* shows that 36.9% is arable or cultivable, 8.7% pasture, 9.6% [forest](#), 0.4% swampy and the remaining 44.3% is considered degraded or otherwise unusable. Fruits and vegetables are important cash crops (CSA, 2007a). The long rainy season in the area is between June and October, while the long dry season lasts from October to February. The mean minimum and maximum temperatures in the area ranges

¹ *Woreda* is the fourth-level administrative division in Ethiopia.

² *Zone* is the third-level administrative division in Ethiopia.

from 14 to 27°C, with an average annual rainfall of 716mm (Agricultural Office, 2010). Crop production is rain-fed with limited irrigation for long-cycle crops. Crops produced are: maize, haricot beans and teff (CSA, 2007a).

Adami Tulu woreda is located in central rift valley of Ethiopia at 160 km away from Addis Ababa, capital of Ethiopia. The woreda lies at latitude of 7.58°N and 38.430E longitudes. Its agro-ecological zone is semi-arid and sub-humid in which 90% of the area is lowland while the remaining 10% is intermediate with altitude ranging from 1500-2000 meter above sea level. The mean annual rainfall ranges from 750- 1 000mm and the distribution is highly variable between and within years. The mean annual temperature ranges from 22-28°C. Mixed crop-livestock farming system characterizes the agriculture of the woreda and crop production is dominated by maize, sorghum and wheat (ATARC, 1998).

A survey of the land in this woreda shows that 27.2% is arable or cultivable, 21.6% pasture, 9.9% forest, 15.7% swampy and the remaining 25.6% is considered degraded or otherwise unusable (CSA, 2007a). The 2007 national census reported a total population for this woreda of 141 405, of whom 71 167 were men and 70 238 were women; 20 923 or 14.8% of its population were urban dwellers (CSA, 2007b). The economically active (15-64 years) were 50% of the total population. Children below 15 years were 48%, while the elderly (65 years and above) were only 2%. Females were 49.3% of the urban and 50.3% of the rural population.

Shalla woreda is part of the [west Arsi Zone](#) located in the [Great Rift Valley](#) and is bordered on the south by [Seraro](#), on the west by the [Southern Nations, Nationalities and Peoples' Region](#), on the north by [Shalla Lake](#) which separates it from [Arsi Negele](#), and on the east by [Shashamene Zuria](#); its western boundary is defined by the course of the [Bilate River](#). The administrative center of this woreda is [Aje](#).

The 2007 national census reported a total population for this woreda of 149 804, of whom 74 930 were men and 74 874 were women; 7 680 or 5.13% of its population were urban dwellers (CSA, 2007b).

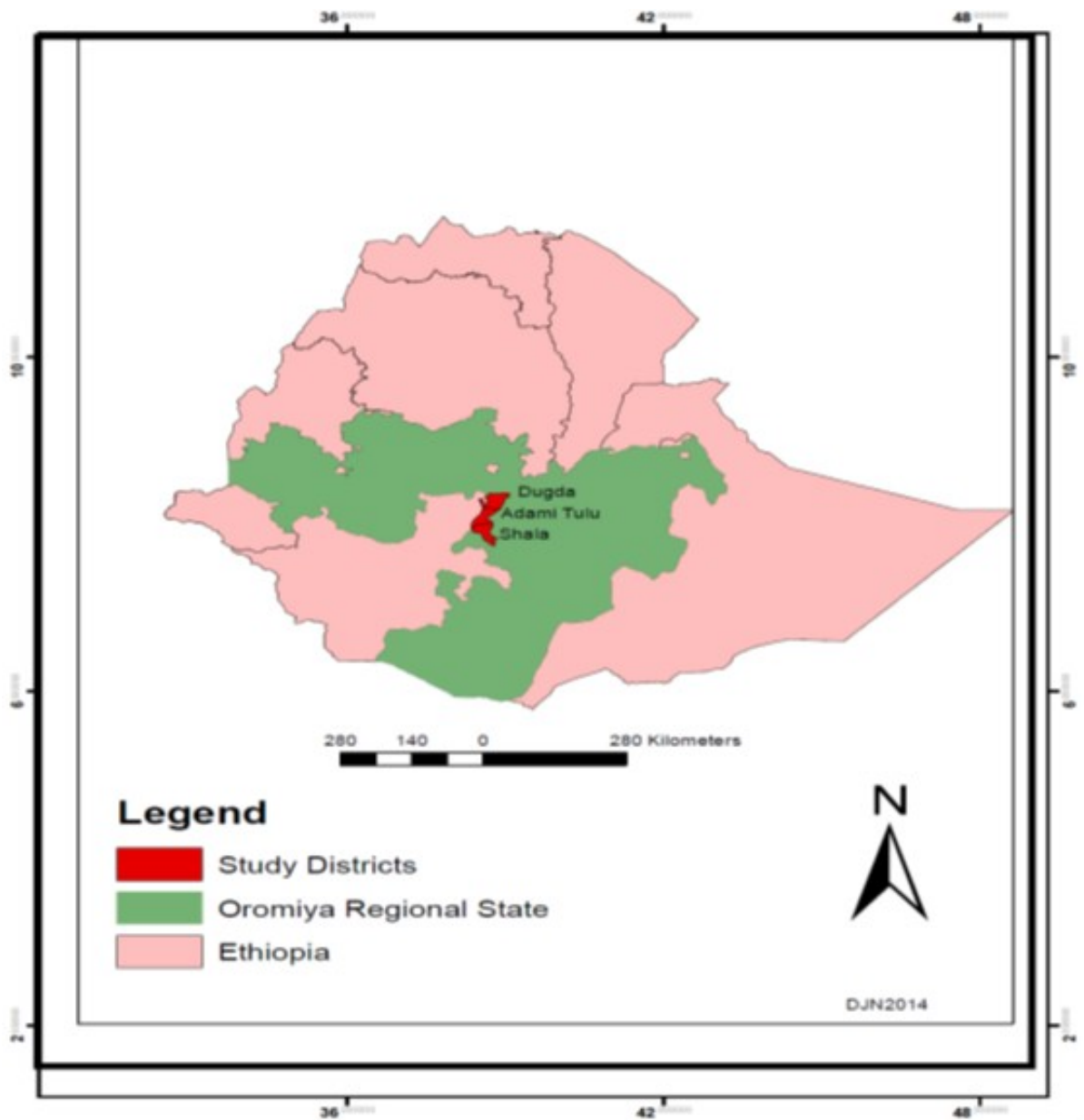


Figure : Map of the study area

Source: The Ethiopian National Mapping Agency

3.2 Survey Design and Data

3.2.1 Nature of data and sample size

The data which were used in this study originate from a survey conducted by International Maize and Wheat Improvement Centre which is known as *Centro Internacional de Mejoramiento de Maíz y Trigo* (CIMMYT) under the SIMLESA project. The household survey was carried out in 2012/13. A formal survey instrument was prepared and trained enumerators collected the information from the sampled maize producing households in face-to-face interviews in maize-producing systems.

The survey collected information on several factors including household composition and characteristics, land and non-land farm assets, livestock ownership, household membership in different rural institutions, varieties and area planted, costs of production, yield data for different crop types, indicators of access to infrastructure, household market participation, household income sources and major consumption expenses. The economic traits and preference for different improved maize producers and reasons for adoption and dis-adoptions of new varieties were also included in the data collection.

Hence, 300 households were randomly picked from the database for data analysis in this study. Only 300 respondents were assumed because the sample size can give a precise picture of the level of improved maize adoption and the impacts of adoption on market integration in the study area. 101, 100 and 99 sample respondents were randomly selected from Dugda, Adami Tulu and Shalla respectively.

3.2.2 Improved maize varieties

For improvement in production and productivity of maize, a lot of efforts have been made by the researchers in developing different types of improved varieties with appropriate

agronomic practices. Among the released maize varieties katumani, bh-543, melekasa 1&2, shaye, bh-660, awasa 511, bh-540 varieties were introduced to the farmers of the study area through government and NGOs such as CIMMYT. Thus, in this study the term improved maize varieties refers to any one of the above maize varieties.

3.3 Data Analysis Procedure

3.3.1 Descriptive analysis

Descriptive statistics were used to provide a summary statistics related to variables of interest. Chi-square test was used to identify categorical variables that vary significantly between adopters and non-adopter. Similarly, the t-test was used to see if there is any statistically significant difference between the mean of the respective adopters and non-adopters with respect to continuous variables. The descriptive statistics in such a way gave some insight about the characteristics of sampled units for the present study.

3.3.2 Empirical models

The model specifications for this dissertation were treated into two parts. First, to address objective (ii) of the study, the logit model was used. Decisions whether to adopt or not and how much to adopt were assumed to be estimated jointly by this model. Hence, the factors affecting the two level decisions were taken to be the same³. Second, in attempting objective (iii), the causal impact of technology adoption on market participation (marketed maize surplus) was analysed by utilizing average treatment effect model: regression based on propensity score matching and using different matching algorithms. Computer program software STATA12 was used to estimate the models.

³ Considered based on CIMMYT/SIMLESA instrument, which is the input of this study.

3.3.2.1 Empirical framework of the logit model for adoption

To deal with the determinants of adoption, the logit model was employed. The dependent variable which was used with logit model is adoption, taking the values 1 or 0. The value 1 indicates a farmer who adopted the improved maize varieties while the value 0 indicates a farmer who did not. Adopters of improved maize varieties were defined as farmers who planted at least one of the improved maize varieties at least for the 2012/13 cropping season and non-adopters were defined as farmers who did not plant the improved varieties in the given cropping season.

Thus, the following simple regression model is considered:

$$Y_i = \beta_0 + \beta_i X_i + u_i \quad \dots\dots\dots (1)$$

Where;

Y_i stands for adoption of improved maize varieties with a value of 1 for adopters and 0 for non-adopters.

X_i refers to farmer's characteristics *e.g.* age of household head for the *i*th farmer.

u_i refers to the error term which is an independently distributed random variable with a mean of zero.

Equation (1) looks like a typical linear regression model but, because the dependent variable is binary, it is called a Linear Probability Model (LPM). In the regression model, however, because the dependent variable is adoption taking the value 1 or 0, the use of LPM is a major problem. The predicted value can fall outside the relevant range of 0 to 1 probability value. Therefore, to overcome the problem associated with the linear probability model, the logit model was used as it has been recommended by Gujarati (2004). The model was, therefore, estimated by using Maximum Likelihood Estimation

(MLE) procedures. Therefore, the logistic cumulative probability function for adopters is represented by:

$$P_i = \frac{1}{1+e^{-Z}} = \frac{e^Z}{1+e^Z} \dots\dots\dots$$

(2)

Where; P_i is the probability that the i^{th} farmer adopted the new varieties and that P_i is nonlinearly related to Z_i (i.e. X_i and β_s).

$$Z_i = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n \text{ and } e \text{ represents the base of natural logarithms.}$$

Then, (1-P), the probability of non-adopter of improved maize varieties is presented as:

$$1 - P_i = \frac{1}{1+e^Z} \dots\dots\dots (3)$$

Therefore, by dividing equation 2 by equation 3, the odds ratio in favour of adopting the improved variety was obtained as follows:

$$\frac{P_i}{1 - P_i} = \frac{e^Z}{1} \dots\dots\dots (4)$$

Again in order to estimate the logit model, the dependent variable was transformed by taking the natural log of Equation 4 as follows:

$$L_i = \left(\ln \frac{P_i}{1 - P_i} \right) = Z_i = \beta_0 + \beta_1 X_1 + \dots + \beta_n X_n \dots\dots\dots (5)$$

Where:

L_i is the log of the odds ratio, linear not only in the explanatory variables but also in the parameters. L is the logit, and hence it is the logit probability model. It is, thus, noted that the logistic model defined in Equation 5, is based on the logit of Z_i which is the stimulus index. This verifies that as Z_i ranges from $-\infty$ to $+\infty$, P_i ranges between 0 and 1.

3.3.2.2 Econometric model specification for adoption

Literature on adoption suggests that farmer's decision to adopt agricultural technology depends on household's socio-economic, institutional and environment factors (Mariano *et al.*, 2012; Feder *et al.*, 1985).

However, there is no firm economic theory that dictates the choices of specific independent variables in adoption studies. They could vary from context to context. As a result, the explanatory variables assumed in this model are those included in the CIMMYT/SIMLESA baseline survey questionnaire.

Following Menard (2002), the Logit Model for the log odds of improved varieties adoption of improved maize varieties was specified as follows:

$$Y_i = \beta_0 + \beta_1 G + \beta_2 MAR + \beta_3 AGE + \beta_4 FAMSZ + \beta_5 LITE + \beta_6 LSTOCK + \beta_7 LAND + \beta_8 FASN + \beta_9 OMKT + \dots \quad (6)$$

Where:

The dependent variable (Y_i): The dependent variable of the model (binary logistic analysis), has dichotomous in nature representing farmer's adoption decision on improved maize varieties. The variable takes value of 1 for the household that cultivated improved maize varieties during survey time and 0 for household that did not cultivate improved maize varieties.

Independent variables

It is hypothesized that the decision to adopt improved maize varieties is influenced by a set of independent variables. Based on the review of adoption literature, past research findings and considering the information from informal survey, among the large number of factors which were expected to influence to farmers' adoption decision, only eighteen (16) potential explanatory variables were considered for this study and examined for their effect in farmers' adoption decision on improved maize varieties. These are presented as follows.

Gender (G): It is a dummy variable which takes a value of 1 if the respondent is male and 0, otherwise. In most cases male headed households have better access to information on improved technologies and are more likely to adopt new technologies than female. Sex is therefore expected to positively influence adoption.

Marital status (MAR): It is a dummy variable which is represented by 1 if the respondent is married, 0 if otherwise. It is assumed that married households can handle and manage their overall livelihood (social duties and farm activities) better than households who are not that enabled them to produce more and generate more income. Therefore, married households are more likely to adopt than the non-married. Thus, this variable was hypothesized to have positive relationship with adoption of the improved maize varieties.

Age (AGE): This variable refers to the chronological age of household head at the time of the survey, measured in years. As the age of the household head increases, the probability of adopting is likely to decrease. Because, with age, a farmer can become more risk averse and then tend to be reluctant to new technologies. Therefore, age was hypothesized to negatively influence adoption.

Family size (FAMSZ): Total family size in this study refers to the number of members who are currently living within the family. Large family size is an indicator for availability of labor provided that the majority of the family members are within the age range of active labor force. Availability of labor in the household is again one of the important resources in maize production. Based on this assumption, this variable was hypothesized to have positive relationship with adoption of the improved maize varieties.

Adult-literacy (LITE): It measures formal education of household head in the family. It is a dummy variable, which takes a value 1 if the farm household is literate (can only read and write), and 0 illiterate. Education enhances farmers' ability to perceive, interpret and respond to the new events. Therefore, in this study education was expected to positively influence adoption of improved maize varieties.

Livestock ownership (LSTOCK): In rural context, livestock holding is an important indicator of household's wealth position. Livestock serves as an important source of cash. In the study area, they rear livestock. Therefore, livestock could be used as insurance for such kind of fearing. Based on this assumption this variable was hypothesized to have positive relation with adoption.

Land holding (LAND): It is an indicator of wealth and social status and influence within a community. It was expected to be positively associated with the decision to adopt improved maize. This means that farmers who have relatively large landholding would be more initiated to adopt the improved varieties.

Farmer Associations (FASN): It is a dummy independent variable represented by 1 if the household head participates in a membership in the farmer organization during the study year and 0, otherwise. Belonging to an association or cooperative as

member can influence farmer's decision to adopt improved maize varieties. Farmers who get the chance to acquire timely and vital information from associations are more likely to adopt. Thus, being a participant in farmer associations was expected to affect adoption of improved maize varieties positively.

Access to output market (OMKT): It is a dummy independent variable represented by 1 if the household head had the access to output markets and 0, otherwise. Having access to output markets means, farmers can sell their agricultural products without extra expenses. This motivates farmers to adopt new varieties to produce more. Hence, this access to output markets was hypothesized to positively affect the adoption process.

Access to input market (IMKT): It is a dummy independent represented by 1 if the household head has access to input markets and 0, otherwise. Having access to input market means farmers get agricultural inputs such as improved varieties and modern fertilizer which have positive impact in adoption process. Thus, access to input market was hypothesized to positively influence the adoption decision of a farmer.

Extension service (EXT): Access to extension service: Extension service here refers to advice, training, information, demonstration and distribution of agricultural input. It is a dummy variable which takes the value 1 if the farm household has access to extension service and 0 otherwise. Many adoption studies such as Mekonnen (2007) and Taha (2007) have showed that access to extension service increases farmers' adoption decision of improved technologies. Thus, in this study, access to extension services was one of the institutional characteristics hypothesized to positively influence farmers' decision to adopt improved maize varieties.

Credit Services (CRD): This variable is measured in terms of whether respondents have access to credit. It is a dummy variable, which takes a value 1 if the farm households have used credit or 0, otherwise. Farmers who have access to credit may overcome their financial constraints and therefore be able to buy farming inputs. Farmers without cash and do not have access to credit may find it very difficult to attain and adopt new technologies (Taha, 2007 and Tigist, 2010).

Distance to markets (DIST): It is a continuous variable measured as the waking distance in minutes that the household travel to reach the nearby market. Those farmers having access to agricultural market have better market information. It was hypothesized to have a positive contribution to the adoption of improved varieties.

Adami Tulu (ADT): Farmers living in Adami Tulu are expected to be better adopters due to the influence of demonstration, farmer-to-farmer seed dissemination.

Dugda (DGD): Farmers living in Adami Tulu are expected to be better adopters due to the influence of demonstration, farmer-to-farmer seed dissemination.

Shalla (SHA): Farmers living in Adami Tulu are expected to be better adopters due to the influence of demonstration, farmer-to-farmer seed dissemination.

3.3.3 Empirical framework for impact evaluation analysis

3.3.3.1 Treatment effect model

To assess the impact of adoption of improved maize varieties on market participation of smallholder farmers due to surplus maize grain, Average Treatment Effect (ATE) was implemented. The treatment-effect model across farmers is expressed given the unobserved variable and its observed counterpart as:

$$G_i^c = \beta X_i + U_i \dots\dots\dots (7)$$

$$T_i = \alpha J_i + \gamma G_i + e_t \dots\dots\dots (8)$$

$$\text{Thus, } G_i = \begin{cases} 1 & \text{if } G_i^c > 1 \\ 0 & \text{otherwise} \end{cases} \dots\dots\dots (9)$$

Where:

G_i^* is the unobservable or latent variable for improved varieties adoption, G_i is its observable counterpart (dummy for adoption of new maize varieties), T_i is a vector denoting the commercialization (marketed surplus), J_i are vectors of exogenous variables thought to affect commercialization and X_i are non-stochastic vectors of observed farm and non-farm characteristics determining adoption. e_i and u_i are random disturbances associated with the commercialization and the adoption of new varieties.

The problem with estimating Equation 9 is that treatment assignment is not often random because of the self-selection to adopt the maize technologies. Self-selection could be based on observed characteristics or unobserved factors, or both. In the case of unobserved factors, the error term in the estimating equation contains variables that are also correlated with the treatment dummy T . This cannot be measured and therefore account for these unobserved characteristics in Equation 9, which leads to unobserved selection bias.

This problem is also represented in a more conceptual framework. Suppose, T_i represents the access to market due to surplus maize grain for household i . For adopters,

$G_i=1$, and the value of T_i under treatment is represented as $T_i(1)$. For non-adopters, $G_i=0$, and T_i is represented as $T_i(0)$. Because $T_i(0)$ is used across non-adopting households as a comparison outcome for participant outcomes $T_i(1)$, the average effect of the adoption is represented as follows:

$$D = E(T_i(1) \vee G_i=1) - E(T_i(0) \vee G_i=0) \dots\dots\dots (10)$$

The problem is that the adopters and non-adopters may not be the same prior to the intervention, so the expected difference between those groups may not be due entirely to adoption of the maize technologies. If the expected outcome for non-adopters had they adopted $E(T_i(0) \vee G_i=1)$ is added and subtracted in equation (9), it gets

$$D = E(T_i(1) \vee G_i=1) - E(T_i(0) \vee G_i=0) + E(T_i(0) \vee G_i=1) - E(T_i(0) \vee G_i=1)$$

$$D = ATE + E(T_i(0) \vee G_i=1) - E(T_i(0) \vee G_i=0)$$

$$D = ATE + B \dots\dots\dots$$

(11)

ATE is the average treatments effect $E(T_i(1) \vee G_i=1) - E(T_i(0) \vee G_i=1)$ namely, the average ability to access market of adopters relative to non-adopters, as if non-adopting households were also treated. The *ATE* corresponds to a situation in which a randomly chosen household from the population is assigned to adopt the new varieties, so the adopting and non-adopting households have an equal probability of receiving the treatment *G*. The term *B*, is the extent of selection bias that crops up in using *D* as an estimate of the *ATE*. Because $E(T_i(0) \vee G_i=1)$ is not known, the magnitude of selection bias cannot be calculated. As a result, if it is not known the extent to which selection bias makes up *D*, it is harder to exactly know the difference in market access between adopter and non-adopters. So in the present study while dealing with impact assessment, due concern has been given to get rid of the selection bias by using the propensity score matching.

3.3.3.2 Propensity score matching (PSM) method

For correcting the selectivity bias, one of the ways suggested by Greene (1997) is PSM method. The PSM approach tries to capture the effects of different observed covariates X on adoption in a single propensity score or index. Then, outcomes of adopters and non-adopters with similar propensity scores are compared to obtain the adoption effect. PSM constructs a statistical comparison group that is based on a model of the probability of participating in the treatment G conditional on observed characteristics X , or the propensity score: $P(X) = \Pr(G = 1|X)$. Under certain assumptions, matching on $P(X)$ is as good as matching on X (Rosenbaum and Rubin, 1983).

The validity of the outputs of the PSM method depends on the satisfaction of two basic assumptions namely: the Conditional Independence Assumption (CIA) and the Common Support Condition (CSC) (Shahidur, 2010). CIA states that the potential outcomes are independent of the treatment status, given X . Or, in other words, after controlling for X , the treatment assignment is “as good as random”. The CIA is crucial for correctly identifying the impact of adoption, since it ensures that, although adopters and non-adopters differ, these differences may be accounted for in order to reduce the selection bias. This allows the non-adopters to be used to construct a counterfactual for adopters. The common support condition entails the existence of sufficient overlap in the characteristics of the adopters and non-adopters to find adequate matches (or a common support). When these two assumptions are satisfied, the treatment assignment is said to be strongly ignorable. This assumption states that the propensity score can be used as control function to overcome the endogeneity problem of the adoption variable (the decision to adopt may be determined by unobservable variables that may also affect level of market integration). It is represented by:

$$(H_1, H_2) \perp G_i / X \dots\dots\dots$$

(12)

Where: H_1 and H_2 are the outcomes of interest (level of market integration) for adopters and non-adopters, respectively.

The propensity score was estimated using probit model and indicates the conditional probability of adoption given observable regressors X . The structural equation then is expressed as:

$$H_i = \alpha J_i + \gamma G_i + \mu Pscore + e_i \dots\dots\dots(13)$$

Where:

$$Pscore(X) = Pr(G_i = 1 / X) \dots\dots\dots$$

(14)

Where; the output is market participation as a result of surplus maize grain due to adoption. The dependent variable is adoption of the improved maize varieties and the explanatory variables are described in Table 2.

Table : Description of variables used in the estimation of propensity scores:

Variable	Symbol	Unit	Sign	Description
Gender	GND	Dummy	+	Male HHSs are expected to be better adopter than female household heads.
Marital status	MAR	Dummy	+	Married HHHs are expected to adopt.
Age	AGE	Years	+/-	Age of HHH either positively or negatively influences improved variety adoption.
Family size	FAMSZ	Number	+	A larger household provides more labour thus expected to positively influence adoption.
Adult -literacy	LITE	Dummy	+	Educated HHHs are expected to adopt.
Livestock holding	LSTOCK	Number	+	A larger livestock holding is expected to positively influence adoption.
Land holding	LAND	Ha	+	A larger land holding is expected to positively influence adoption.
Farmer association	FASN	Dummy	+	Farmers' associations are expected to positively influence adoption.
Access to output market	OMKT	Dummy	+	It is expected that farmers who have the access to output markets to adopt.
Access to input market	IMKT	Dummy	+	It is expected that farmers who have the access to input markets to adopt.
Extension services	EXT	Dummy	+	The access to extension services is expected to positively influence farmers' adoption
Credit services	CRD	Dummy	+	Getting credit services is expected to positively influence farmers' adoption.
Distance to market	DIST	Minutes	+	It is expected that the closer the grain market is the higher the chance of adoption.
Woreda dummy				
Adami Tulu	ADT	Dummy	+/-	Farmers living in Adami Tulu and are either positively or negatively influenced to adopt.
Dugda	DGD	Dummy	+/-	Farmers living in Dugda and are either positively or negatively influenced to adopt

Shalla	SHA	Dummy	+/-	Farmers living in Shalla and are either positively or negatively influenced to adopt
--------	-----	-------	-----	--

3.3.3.3 Matching procedure

Four commonly used matching algorithms, namely Nearest Neighbour Matching (NNM), Radius Matching (RM), Kernel-based Matching (KM), and Stratification Matching (SM) were employed to calculate the Average Treatment Effect on the Treated (Adopters) (ATT) so as to assess the impact of improved maize varieties on market participation.

The NNM method was used to match each farmer from the adopter group with five nearest farmers from the non-adopter group having the closest propensity score. After each adopter was matched with the five non-adopters, the difference between the outcome of the adopters and the weighted average outcome of the matched non-adopters was computed. The ATT was then obtained by averaging these differences for the whole respondents.

The RM was employed to match each adopter only with the non-adopters whose propensity score falls in a predefined radius of the propensity score of the adopter. To assure the results of matching were consistent and because it is possible that some adopters may not be matched because the radius does not contain non-adopters, two (0.03 and 0.05) dimension of the neighbour-hood or the radius were set. Then the ATT was computed. The KM method was used to match the outcome of each adopter with a weighted average of all the non-adopters. Then the ATT was calculated by computing the differences in outcomes. When kernel matching was used, 0.03 and 0.05 bandwidth parameter were selected.

The SM method was used to divide the range of variation of the propensity score in intervals such that within each interval adopters and non-adopters units have on average the same propensity score. For this case, the same blocks (5 blocks) identified by the algorithm that estimates the propensity score were used. Then, within each block in which both adopters and non-adopters are present, the difference between the average outcomes of the adopters and the non-adopters was computed. The ATT was finally obtained as an average of the ATT of each block with weights given by the distribution of adopters across blocks.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Statistical Description of the Socio-economic Characteristics of Sample

Households

The basic summary statistics of the sample farm households are discussed under this section. The dataset contains 300 farm households and of these, about 26% households were adopters *i.e.* they planted at least one of the improved maize varieties during the 2012/13 cropping season.

4.1.1 Household personal and demographic variables

Characteristics like age, gender, family size and education level of the household heads are very important proxy indicators for individual behaviors and are commonly used as explanatory variables for adoption decisions. This section deals with these variables.

Table 3 shows that the heads of the sample households were, on average, 43 years old. It was found that old aged respondents were observed to adopt the new varieties and were significantly different from non-adopters which suggest that there is positive correlation between adoption and the experience gained by age. This could have facilitated them enough to have the required physical strength in the adoption process. The role of age in explaining technology adoption is somewhat controversial. It is usually considered in adoption studies with the assumption that older people have more farming experience that helps them to adopt new technologies. On the other side, because of risk averting nature, older aged farmers are more conservative than the youngest ones to adopt new technology.

Table 3 also shows that the average family size in the study areas was seven. Adopters were observed to have larger family size (as large as eight) and were significantly different from non-adopters who had around seven. The study result implies that adopters do have more labour than non-adopters and more family size will encourage the intensive use of the improved varieties. The reason might be most maize farming practices do not require more energetic labour which is normally considered economically active labour. Still children and older family members can contribute to the labour requirements of the HH heads equally in the case of small activities such as weeding.

Results in Table 3 further show that farmers were found to have attended school for about 3.2 years or attended till the third grade. Results indicate that the average number of years of education for adopters was about 4.2 years whereas it was 2.9 for non-adopters. This could have facilitated adopters enough in comprehension of technical extension services in the adoption process. Education is the major demographic characteristic explanatory variable that differentiates adopters and non-adopters in all adoption studies. Farmers who are more educated are generally more open to innovative ideas and new technologies that promote technical change (Weir and Knight, 2000).

Table : Household personal and demographic Characteristics of Adopters and Non-adopters (summary statistics for continuous variables)

Variable	Unit	Full		Adopters		Non-adopters		t-value
		Mean	SD	Mean	SD	Mean	SD	
HHH age	Years	43.12	32.65	48.49	59.32	41.23	14.19	-1.69**
HHH Education	Years	3.21	3.42	4.21	3.77	2.86	3.23	-3.00***
Family size	No	7.06	3.05	8.41	3.05	6.58	2.21	-4.70***

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

Table 4 shows that male-headed households constituted about 83% of the total 300 sample farm households. Similar results were found by Degu (2012) that most households were

headed by male in his study factors affecting adoption of improved potato varieties in Haramaya woreda, Ethiopia. Likewise Table 4 shows that about 87% of the respondents were married and living with their spouses and 14% of the households were not *i.e.* either they were divorced, single or widowed. This indicates that the society in the study areas is stable. A stable society in general and stable households in particular can concentrate more on production than unstable society or family. However, there was no observable difference among adopting and non-adopting household heads in terms of their gender and marital status.

Taking education as dummy in Table 4: literate and illiterate, about 65% of the respondents were literates which is much greater than the national figure for adult literacy which was 55% in 2012 (UNICEF, 2012) indicating that the study areas were better off in terms of education. Respondents statistically significantly varied in terms of adult-literacy which implies that educated households are more likely to adopt than the non-educated. Mulugeta (2009) also found that literate household heads tend to adopt old coffee stumping technology in Dale woreda, Ethiopia. This relatively good level of educational achievement in the study areas might be attributed to high number of basic primary school coverage in the study areas.

Table : Household personal and demographic Characteristics of Adopters and Non-adopters (summary statistics for dummy variables)

Variable	Category	Total		Adopters		Non-adopters		χ^2 value
		No	%	No	%	No	%	
HHH sex	Male	251	83.67	65	83.33	186	83.78	0.01
	Female	49	16.33	13	16.67	36	16.22	
HHH Marital status	Married	260	86.67	68	87.12	192	86.49	0.02
	Not	40	13.33	10	12.82	30	13.51	
Adult-literacy	Literate	193	64.33	59	75.64	134	60.36	5.87*
	Illiterate	107	35.67	19	24.36	88	39.64	

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.1.2 Farm characteristics

In this study, the average land holding was found to be 9.3 ha with standard deviation of 8.12. The land holding included cultivated and uncultivated land for annual crops, permanent plants, grazing, and homestead in the cropping year. The average land holding were 11ha and 9ha for adopters and non-adopters respectively. Though traditionally land ownership, in Ethiopia, is mainly gained through inheritance from predecessors or distributed by the government, farmers were statistically significantly different in terms of the farm land they owned at 5% level of significance suggesting the importance of land holding for adoption of the improved maize varieties as it provides extra land for farming (Table 5). In line with the present study, Gezahagn (2008) found significant difference between average landholding of seed producers and non-seed producers in Angacha, Dale and Hula woreda, Ethiopia.

Results in Table 5 further show that average livestock holding including cattle, sheep, goats, pack animals, and poultry in the area was 21. Adopters and non-adopters owned around 29 and 18 respectively. These figures show that the difference in livestock ownership between adopters and non-adopters was statistically significant at $p < 0.01$ level of significance which imply that having large number of livestock is correlated with adopting the new maize varieties in the study areas. Similar results were reported by Mulugeta (2009) that livestock ownership affects farmers in adopting old coffee stumping technology in dale woreda, Ethiopia. This implies that possession of large number of livestock served as a proxy for the capacity of bearing risks in using credit. Livestock may also serve as a proxy for oxen ownership, which could be important for farm operations of small holder farmers.

Table : Farm Characteristics of Adopters and Non-Adopters (Summary Statistics for Continuous Variables)

Variable	Unit	Full		Adopters		Non-adopters		t-value
		Mean	SD	Mean	SD	Mean	SD	
Livestock	No	20.67	18.33	28.679	26.34	17.855	13.49	-4.64***
Land holding	Hectare	9.31	8.116	11.093	7.29	8.68	8.31	-2.27**

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.1.3 Institutional factors

Farmers declared that they had market access to two market places namely: the main market place in their woreda and the village/local market (Table 7). As shown in Table 6, the average walking distance, measured in time, to the village market was about 34 minutes. Adopters and non-adopters were not statistically different in terms of walking distance to the village markets. This implies that it has no an impact in the farmers' adoption decisions. On the other hand, the average walking distance to the main market place was 131 minutes. While adopters had to walk 108 minutes to get into the main market place, non-adopters needed to travel 138 minutes on foot to reach the main market. Respondents were statistically significantly different at ($p < 0.01$) in terms of the average walking distance to main market. This implies that farmers who are close to markets are likely to adopt the improved varieties. The results of this study are consistent with the findings of other researchers who conducted studies in different parts of Ethiopia (Yishak and Punjabi, 2011; Tesfaye, 2006; and Rahmeto, 2007) that distance to market is negatively and significantly associated with adoption of crop technologies.

Table : Institutional Characteristics of Adopters and Non-Adopters (Summary Statistics for Continuous Variables)

Variable	Unit	Full		Adopters		Non-adopters		t-value
		Mean	SD	Mean	SD	Mean	SD	
Distance to main market	Minutes	130.5	94.66	102.9	78.3	140.207	98.098	3.03****
Distance to village market	Minutes	34.17	70.09	28.46	62.7	36.18	72.53	0.84

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

Table 7 shows that about 79% of the farmers had access to extension services concerning about the improved maize varieties and this figure is 86% for adopters and 76% for non-adopters and were statistically significantly different. This finding implies that extension service as a source of information regarding improved maize varieties has a positive influence on the farmers' adoption decision as Alene *et al.* (2000) stated that extension services are among the prime movers of the agricultural sector and have been considered as a major means of technology dissemination.

The adoption process of agricultural technologies depends primarily on access to information and on the willingness and ability of farmers to use information channels available to them. The role of information in decision-making process is to reduce risks and uncertainties to enable households to make the right decision on adoption of improved agricultural technologies. The findings of the present study are consistent with earlier findings by Kassie *et al.* (2009) who found that in Ethiopia, farmers' decisions to adopt agricultural practices, among other things, depend on 'access to information'. Mikiyay (2008) also found similar results that access to extension services helps famers to adopt new irrigation technologies in Ethiopia.

The results also show that 66% of the farmers got extension services about other agricultural inputs such as fertilizer. Moreover, about 56% of households were members of farmer organizations. In contrast to earlier studies Taddesse (2007) and Mulugeta (2009),

non-adopters (57%) were superior to their counterparts (55%) in terms of membership in farmer organizations (Table 7). This could be due to the fact that the farmer associations are not based on the interests of the farmers or may be the farmer associations do not provide members with the necessary facilities which help for the adoption of the improved maize varieties.

Farmers also said they had the access to output markets, input markets and access to credit for purchasing agricultural inputs. On average, about 43% and 47% of the households had access to output markets and agricultural input markets respectively. These market characteristics of the households were statistically significant in differentiating adopters and non-adopters in the process of adoption. Improved access to input and output markets is a key precondition for the transformation of the agricultural sector from subsistence to commercial production and smallholder farmers must be able to benefit more from efficient markets (Salami *et al.*, 2010). This is because these household characteristics are crucial in maneuvering the decision to adopt or not to adopt the improved maize technologies.

The results in Table 7 further show that like farmers in other developing countries, in the study areas, only 50% of the farmers received (had access to) credits for purchasing agricultural inputs such as improved varieties and only 42% of the farmers got credit for buying modern fertilizers. Though the rate of accessing credit for improved maize seeds is low, still respondents statistically varied (at $\chi^2= 12.1854$ and $p<0.1$) in getting credit for buying improved seed. On the other hand, adopters and non-adopters were not statistically different in getting credit for agricultural inputs like fertilizer as clearly shown in Table 7. Accessibility of credit enhanced farmers' capacity to adopt improved production technologies which in turn increases their productivity in the agricultural sector. Most

farmers in developing countries are cash trapped; hence, they need financial assistance to purchase the technologies and their complementary inputs. Access to credit can relax farmers' financial constraints to do things in a way they consider paying.

Table : Institutional Characteristics of Adopters and Non-Adopters (Summary Statistics for Dummy Variables)

Variable	category	Total		adopters		Non-adopters		χ^2 -value
		No	%	No	%	No	%	
Access to output markets	Yes	130	43.33	50	64.10	80	36.04	18.52***
	No	170	56.67	28	35.90	142	63.96	
Access to input markets	Yes	147	49	49	62.82	98	44.14	8.06***
	No	153	51	29	37.18	124	55.86	
Farmer organization	Yes	169	56.33	43	55.13	126	56.76	0.06
	No	131	43.67	35	44.87	96	43.24	
Credit for improved seed	Yes	149	49.67	52	66.67	97	43.69	12.19***
	No	151	50.33	26	33.33	125	56.31	
Credit for fertilizer	Yes	126	42	31	39.74	95	42.79	0.22
	No	174	58	47	60.26	127	57.21	
Extension services on New-variety	Yes	236	78.67	67	85.89	169	76.13	3.28*
	No	64	21.33	11	14.11	53	23.87	
Extension services on other inputs	Yes	198	66	56	71.79	142	63.96	1.58
	No	102	34	22	28.21	80	36.04	

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.1.4 Geographical factors

As given in Table 8, woreda wise, households were categorized according to the woreda they were picked from namely: Dugda, Adami Tulu and Shalla and each contributing respondents of 33.67%, 33.33% and 33% respectively. Majority of the adopters (47.44%) were selected from Dugda woreda followed by 28.21% and 24.36% of adopters who were picked from Adami Tulu and Shalla woreda respectively. In addition, adopters in Dugda and Shalla were significantly different from non-adopters at 1% and 5% level of significance respectively.

However, there was no statistical difference between households in Adami Tulu woreda. This difference could be due to the fact that the woredas are not the same in administrative affairs, which can lead to differences in the delivery of necessary services for the adoption of the improved maize varieties. This has an important implication for targeting areas for further expansion of new maize varieties where adoption is low and scaling up where adoption is in good level.

Table : Characteristics of Adopters and Non-Adopters (Summary Statistics for Dummy Variables)

Variable	Category	Total		Adopters		Non-adopters		χ^2 -value
		No	%	No	%	No	%	
Adami Tulu	Yes	100	33.33	22	28.21	78	35.14	1.25
	No	200	66.67	56	71.79	144	64.86	
Shalla Woreda	Yes	99	33	19	24.36	80	36.04	3.56*
	No	201	67	59	75.64	142	63.96	
Dugda Woreda	Yes	101	33.67	37	47.44	64	28.83	8.95****
	No	199	66.33	41	52.56	158	71.17	

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.2 Determinants of Adoption from the Logit Estimation

The logit model was used to examine the factors affecting the adoption of improved maize varieties using Maximum Likelihood Estimation (MLE) and the results are presented in Table 9. An additional insight is also provided by analyzing the marginal effects, which were calculated as the partial derivatives of the non-linear probability function, evaluated at each variable sample mean. Table 9 shows the parameter estimates (coefficients) and marginal effects at means of the logit regression with their respective robust standard errors. However, to avoid repetition in discussions, the results of the marginal effects are only discussed as they can indicate both the sign and magnitude of each variable in the model. Prior to running the logit model, the presence of multicollinearity among the independent variables was checked using the Variance Inflation Factor (VIF). Since the highest VIF obtained was 3.07 which is far less than the threshold which is 10. The robust

standard errors computed from the logit model are also less than 3 which imply that the heteroskedasticity problem was taken care of.

As presented in Table 9, the logit model is well fitted to the data as shown by the low log pseudo likelihood -117.36 and Wald chi (22) ($p < 0.01$). As a result of this, the hypothesis that adoption of improved maize varieties is not affected by socio-economic and institutional factors for all the variables was rejected at ($p < 0.01$) level of significance since the Wald χ^2 is 63.81 ($P = 0.00$). This indicates that the explanatory variables together influence the probability of adoption of improved maize varieties in the study area. In addition, the model correctly classified the respondents into adopters and non-adopters at 81.67% of correct prediction percentage.

4.2.1 Household personal and demographic characteristics

Table 9 shows that new maize varieties are more likely to be adopted in households headed by married, old aged and female respondents. Though these variables were not significant, their signs were in line with prior expectations.

The results on Table 9 also show that in line with prior expectations, adult-literacy has a positive and significant relationship with the adoption of the new maize varieties. Educated or literate respondents were 14% more likely to adopt at ($p < 0.01$) level of significance, *ceteris paribus*. This suggests that being literate would improve access to information, capability to interpret the information, understanding and analyzing the situation easily better than illiterate farmers. Moreover, education enhances the capacity of individuals to obtain, process, and utilize information disseminated by different sources. On the other hand, educated farmers will find it easy to manage production and marketing activities which need certain skill of management.

The finding is consistent with the findings of Degu (2012) who found that education has a positive relationship with the adoption of improved potato varieties in eastern Ethiopia.

Table 9 further shows a positive and significant parameter estimate associated with family size in line with the prior expectation. For each additional family member in the household, households were 2.7 % more likely to adopt the improved maize varieties, holding other variables constant. This suggests that large family size provides more labour for farm operation and an increased incentive to produce more output on farm.

4.2.2 Farm characteristics

Livestock ownership was expected to affect adoption positively and inline with it, livestock ownership was shown to positively and significantly influence the decision to adopt the improved maize varieties in the study areas. It is estimated that each additional livestock brought 0.4% more probability of the farmers to adopt the new varieties at high level of significance ($p < 0.05$) keeping other variables constant. This might be due to the fact that livestock are source of additional income which supports farmers in buying the improved varieties and farm inputs. Similar studies found that owning large livestock size positively affect the adoption decision of new agricultural technologies (Mulugeta, 2009).

4.2.3 Institutional factors

As shown in Table 9, institutional factors such as access to output markets, availability of credit for improved maize varieties, walking distance to main market were statistically significant in affecting farmers' adoption decision as per the prior expectation of each variable. Access to input markets, extension services (new varieties and fertilizer), and walking distance to the village market were observed to show the expected sign but were not significant in affecting the decision to adopt. Participation in farmer associations and availability of credit for fertilizer, on the other hand, were negatively statistically significant and the signs were contrary to the prior expectation.

Distance to the main market was found to be negatively significantly correlated with the likelihood of adoption. Similarly, Shiferaw and Tesfaye (2005) also noted the negative and significant association of market distance with adoption of improved maize in southern Ethiopia. Each additional minute of walking was associated with 0.6% less probability of adoption when other variables were kept constant. This indicates that farmers living at a distance from the main market centers are less likely to adopt the improved maize varieties than those who are located closer. The implication is that the longer the distance between farmers' residence and the market center, the lower will be the probability of improved maize varieties adoption. This may be due to relatively proximity to market also reduces marketing costs. This result is consistent with other studies Tesfaye *et al.* (2001) and Kebede (2006).

Holding other variables constant, farmers who have access to output markets were about 19% more likely to adopt the new varieties at high level of significance ($p < 0.01$). Farmers who had access to credit of maize varieties were about 25% more likely to adopt the new varieties at high level of significance ($p < 0.01$), holding other variables constant. This positive and significant effect implies that farmers who don't have cash and access to credit may find it very difficult to adopt new technologies while those who have access to credit can overcome their constraints and be able to buy inputs (Tigist, 2010).

Farmers who had the access to credit for fertilizer were also 5% less likely to adopt the new varieties of maize while the other variables were held constant. This might be due to the fact that the interest rate is higher than the paying back ability of farmers. In connection with this result, Zelalem (2007) also found that farmers with access to credit were less likely to adopt new fattening technologies.

Table : Maximum Likelihood estimates for factors affecting improved maize varieties

Variables	Coef.	Robust Std. Err.	dy/dx	Delta method St. Er.
HH head's sex(1=male)	-0.496	0.587	-0.070	0.083
HH head's marital status(1=married)	0.0339	0.644	0.005	0.091
HH head age(years)	0.0128	0.028	0.002	0.004
AGE1: 20-35(1=yes)	2.307	1.581	0.326	0.229
AGE2: 36-50(1=yes=)	2.143	1.354	0.303	0.195
AGE3: 51-65(1=yes)	2.193	1.243	0.310*	0.177
AGE4: >=66(1=yes)	Ref.		0	Ref.
Family size of HH(heads)	0.194	0.059	0.027***	0.008
Adult literacy (1=literate)	1.017	0.409	0.144**	0.059
Total livestock in the HH(no)	0.0290	0.011	0.004**	0.002
Total land in the HH(hectare)	0.005	0.020	0.001	0.003
Participation in farmer association(1=yes)	-0.034	0.388	-0.005	0.055
Access to output markets(1=yes)	1.310	0.341	0.185***	0.048
Access to input markets(1=yes)	0.749	0.510	0.106	0.072
Extension services: new varieties(1=yes)	0.227	0.584	0.032	0.082
Extension services: fertilizer use` (1=yes)	0.248	0.454	0.035	0.064
Credit access for new varieties (1=yes)	1.751	0.387	0.248***	0.054
Credit services for other inputs(1=yes)	-0.983	0.413	-0.139**	0.059
Walking distance to village market (minutes)	0.001	0.003	0.0001	0.001
Walking distance to main market(minutes)	-0.006	0.002	-0.001***	0.003
Adami Tulu(1=yes)	-0.654	0.445	-0.092	0.065
Dugda(1=yes)	0.497	0.581	0.070	0.081
Shalla(1=yes)	Ref.		0	Ref.
Constant	-6.76	2.567		
Number of obs	300			Prob>chi2 0.000
Log pseudo likelihood	-117.36			Pseudo R ² 0.317
Correctly predicted	81.67%			Wald chi(22) 63.81

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.3 Impacts of Varieties Adoption on Farmers' Output Market Participation

4.3.1 Propensity score matching results

To estimate the impact of adopting the improved maize varieties on adopters' marketed surplus maize grain, the propensity score matching technique was employed. For the sake of the complete application of the propensity score matching, both probit and logit regression were estimated in which the dependent variable, adoption, taking the values one if a farmer adopts at least one improved maize variety, and zero if they do not. Both logit and probit models were estimated to check if the results were consistent and the estimated results from both of the regressions were similar. Thus, to avoid redundancy, only the results of the probit model have been discussed in this study. The importance of estimation of the propensity score using the binary probit model is twofold: first, to estimate the ATT and, second, to obtain matched treated and non-treated observations.

In addition, the balancing test of the propensity score was satisfied in block 5 for all the variables which implies that the mean propensity score is not different for adopters and non-adopters in each block. On the other hand, the balancing test is normally required after matching to ascertain whether the differences in the covariates in the two groups (adopters and non-adopters) in the matched sample have been eliminated, in which case, the matched comparison groups can be considered a plausible counterfactual (Ali and Abdulai, 2010). As Sianesi (2004) proposed, a comparison of the pseudo- R^2 and p-values of the likelihood ratio test of the joint significance of all the explanatory variables obtained from the probit analysis before and after matching the samples was made. As it is shown in Table 10, before matching, the pseudo- R^2 and the p-values of the joint covariates were 0.304 and 0.00 ($p < 0.01$) respectively. The mean standardized bias before matching was also 26.9. After matching, the pseudo- R^2 dropped to 0.035 in kernel caliber (0.03) to 0.029 in single nearest neighbour matching and to 0.029 in radius (0.05). Besides, the p-

value rose to insignificant level ($p=0.998$, 0.225 , and 0.999) with respect to the aforementioned algorithms respectively (Table 10). After matching, the mean standardized bias also fell on average to around seven which is somehow tolerable. This low pseudo R^2 , low standardized bias, and the insignificant p -values of the likelihood ratio test after matching suggest that the specification of the propensity is successful in terms of balancing the distribution of covariates between adopters and non-adopters. These results imply that there were no systematic differences in the distribution of covariates between adopters and non-adopters after matching. This in turn implies that the impact evaluation can be made.

Table : Propensity score matching quality indicators before and after matching and sensitivity analysis

	Before	After Matching				
	Matching	Kernel (0.03)	Kernel (0.05)	Neighbour (5)	Radius (0.03)	Radius (0.05)
Pseudo R^2	0.304	0.035	0.029	0.021	0.029	0.026
LR X^2 ($p>chi2$)	104.42 (0.00)	6.49 (0.994)	5.74 (0.997)	4.61 (0.999)	5.41 (0.998)	5.21 (0.998)
Mean bias	26.9	6.8	8.1	7.5	5.8	8.5

Also, the common support assumption is satisfied in the region $[0.028$ to $0.984]$ with a mean of 0.299 and standard deviation of 0.251 (fig.2). The common support leads to the removal of 6 adopters and 42 non-adopters and from the analysis in some of the matching algorithms. The importance of the common support is to improve the quality of the match by ensuring that matches are formed only when the distribution of the density of the propensity scores overlaps adopters and non-adopters observations (Heckman *et al.*, 1999). This in turn implies that the impact evaluation can be made using the matching algorithms.

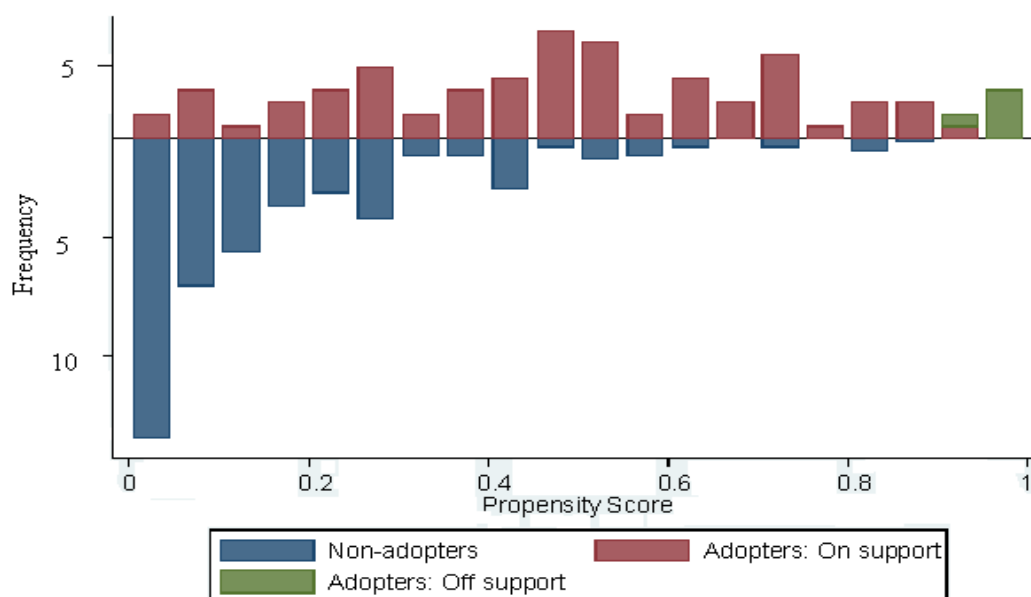


Figure : Propensity score distribution and common support for PS estimation

4.3.2 Determinants of market participation

Table 11 provides the results of the propensity score matching and indicates that family size, adult literacy, livestock holding, access to output markets, and access to credit services (maize varieties) positively and significantly determine farmers' propensity to adopt of improved maize technologies. These variables, other than adoption, also affect marketed surplus.

As shown in Table 11, those households with big family size are expected to have higher productivity, and therefore be more likely to participate in market at higher intensity. The degree of market participation is positively influenced by literacy of household heads. Literate household heads were more likely to adopt and to participate in output markets. The coefficient of livestock ownership is positive and significant, which suggests that farmers with more livestock tend to have higher market integration. The income from livestock production may help farmers to minimize their liquidity constraint to adopt new technologies that increases productivity and sales. Farmers who had access to output markets and credit services were more likely to participate in surplus maize market.

This is because access to credit and availability of output markets provide farmers with the probability and motivation to produce more agricultural produce. Farmers from Adami Tulu woreda were also less likely to participate in output markets compared to farmers from Shalla woreda, probably due to some favourable conditions in the woreda.

Table 11 further illustrates that distance to main market places is negatively correlated with marketed surplus which may be due to the high transaction costs associated with marketing of farmers' agricultural produce. Participation in farmer associations also negatively and significantly affects the propensity to adopt and thus the tendency to participate in marketing.

Table : Impact of adoption on market participation: propensity score results from the probit model

Adoption	Coef.	Std. Err.
HH head's sex(1=male)	-0.306	0.335
HH head's marital status(1=married)	0.017	0.361
HH head's age(years)	0.003	0.003
Family size of HH(heads)	0.115***	0.033
Adult literacy (1=literate)	0.581**	0.224
Total livestock in the HH(n ₀)	0.017***	0.006
Total land in the HH(hectare)	3.8x10 ⁻⁵	0.014
Access to output markets(1=yes)	0.781***	0.201
Access to input markets(1=yes)	0.408	0.272
Extension services: new varieties(1=yes)	0.138	0.290
Extension services: fertilizer use(1=yes)	0.100	0.254
Credit access for new varieties (1=yes)	1.002***	0.233
Credit services for other inputs(1=yes)	-0.512**	0.237
Participation in farmer association(1=yes)	-0.025	0.218
Walking distance to village market (minutes)	3.9x10 ⁻⁴	0.002
Walking distance to main market(minutes)	-0.004***	0.001
Adami Tulu(1=yes)	-0.439*	0.264
Dugda(1=yes)	0.203	0.325
Constant	-2.423***	0.657
Number of obs	300	
Log likelihood	-119.51146	
LR chi2(18)	104.81	
Prob>chi2	0.0000	
Pseudo R ²	0.3048	

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.3.3 Estimation of treatment effect analysis based on matching algorithms

The Average Treatment effect on the Treated (ATT) was computed based on the four alternative matching methods namely: nearest neighbour, stratification, radius and kernel matching methods. Table 12 shows the estimates of ATT from these four matching algorithms. The outcome variable is marketed surplus maize grain in kilograms. In each of the algorithms, the t-statistics were computed based on bootstrapped standard errors with 100 replications which were used to verify whether the observed effect was significant or not. The results show that adoption of improved maize varieties positively and significantly affect marketed surplus maize grain of farmers. Generally speaking, the increase in maize grain per household ranged from around 442kg in the case of kernel-based matching at bandwidth (0.05) to 483 kg in the case of radius matching at a radius of 0.03 in the study area in the given cropping season. As a result of these, the null hypothesis “Improved maize varieties adoption does not have a significant impact on small holders’ grain market participation.” was strongly rejected at $p < 0.01$.

Specifically, the results from Table 12 show that adopting the new improved maize varieties had a significant impact on the marketed surplus maize grain using the five nearest-neighbour matching method with no replacement. The ATT on marketed surplus maize grain was about 473kg. The impact is significant at the $p < 0.01$ level of significance. The results of the radius matching algorithm also show similar outcomes. Using a radius of 0.03, adopters were better than non-adopters by about 483kg of maize increase in marketed surplus because of adopting the improved maize varieties. The impact was significant at the $p < 0.01$ level ($t = 4.32$). Using a radius of 0.05 matching method, the estimated average marketed surplus maize grain of adopters again was significantly greater than that of non-adopters by about 479kg of maize. The difference is also statistically significant at $p < 0.01$ level ($t = 3.91$).

Table 12 further shows that the results of the kernel based matching algorithm using 0.03 bandwidth also confirm significant difference (453kg) between the adopters and the non-adopters in terms of the marketed surplus maize grain. The difference was highly significant at $p < 0.01$ level of significance. Results are consistent with earlier findings even with bandwidth increasing from 0.03 to 0.05. Adopting the improved maize varieties increases the marketed surplus maize grain by 469kg at ($t = 2.75$) and at ($p < 0.01$) level of significance. This indicates that assuming there is no selection bias due to unobservable farmer characteristics, the marketed surplus maize grain for adopters is significantly higher than the non-adopters. This marketed surplus maize grain also implies that market integration level of smallholder farmers who adopted improved maize varieties is significantly higher than the non-adopters.

These findings are consistent with previous studies on the impact of improved crop varieties on farmers' day to day lives. Kijima *et al.* (2008) showed that NERICA rice adoption reduces poverty without deterioration in income distribution in Uganda. Kassie *et al.* (2011) using PSM methods found that adoption of improved groundnut varieties in rural Uganda increase crop income and reduce poverty. Simtowe *et al.* (2012) also found similar findings on welfare effects of Agricultural Technology adoption of improved groundnut varieties in rural Malawi.

Table : Impact of Improved Maize Adoption on Marketed Surplus Maize Grain

Algorithm	Adopter s	Non-adopters	ATT	BSE	t-value
Nearest neighbour	78	222	472.99	105.23	4.19***
Radius matching(0.03)	71	222	483.05	112.05	4.32***
Radius matching(0.05)	72	222	478.99	122.57	3.91***
Stratification Matching	78	180	470.71	181.49	3.07***
Kernel bandwidth(0.03)	78	184	453.86	163.11	2.77***
Kernel bandwidth(0.05)	78	184	442.70	171.15	2.58***

***, **, * significant at 1%, 5% and 10% levels of significance respectively.

4.3.4 Checking robustness of average treatment effect

There are several ways to check robustness of the findings. One approach is to estimate the propensity score equation and then use the different matching methods previously discussed to compare the results. The findings with different matching techniques are quite consistent. Another way to check robustness is to apply direct NNM instead of estimating the propensity score equation first.

Thus, as shown in Table 13, results are again consistent with the results of the matching algorithms in Table 12. The marketed surplus maize was 285kg in favour of adopting households which shows a positive impact at a 5% significance level. The implication is the adoption of any of the improved maize varieties results in a positive increment of the maize yield which in turn helps farmers to participate in output markets. Because both methods give similar results, it can be concluded that the findings from the Average Treatment Effect (ATE) regression based on Propensity score matching are robust and reliable.

Table : Checking Robustness of Average Treatment Effect

Surplus	Coef.	Std. Err.	Z	P>z	[95% Conf. Interval]	
SATT	285.49	143.6168	1.99	0.047	4.003349	566.971

Number of obs = 300

Number of matches (m) = 5

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The present study focuses on evaluating the potential impact of adoption of improved maize on farmers' output market integration in the study sites. Cross-sectional data collected from a randomly selected 300 households by CIMMYT in 2012/13 were used in this study. To estimate the impact of adopting improved maize varieties on smallholder farmers' integration into output market, average treatment effect regression based on the propensity score matching and matching algorithms were employed. Moreover, using the logit model, the study assessed factors that affect the adoption of improved maize varieties in the study area.

The results from the logit model show that only 26% of the farmers adopted at least one of the improved maize varieties in the cropping season under consideration. Adoption of the improved maize varieties among households was found to be influenced, among other things, by adult-literacy, family size, livestock wealth, access to output market, and credit access for the improved varieties. Not-adopting the new varieties, on the other hand, was associated with farmer associations, distance to main markets and access to fertilizer credit. As a result, the null hypothesis that the improved maize varieties adoption is not influenced by demographic and socio-economic and institutional characteristics was rejected at ($p < 0.01$).

Moreover, the average treatment effect model, regression based on propensity score as well as matching algorithms, were used to compare adopter households with non-adopters in terms of their marketed surplus maize measured in kilogram per households. Results of

the propensity score matching show that family size, adult literacy, livestock holding, access to output markets, and access to credit services (maize varieties) positively and significantly determine farmers' propensity to, other than adoption, surplus market participation.

The results of the four matching algorithms (*i.e.* nearest neighbour matching, radius matching, kernel matching and stratification matching) show that adoption of the improved maize varieties had a robust and positive impact on farmers' marketed surplus maize which leads to the active market participation. The results reveal that compared to non-adopters, the increase in maize grain per household of adopters ranged from around 442kg in the case of kernel-based matching at bandwidth (0.05) to 483kg in the case of radius matching at a radius of 0.03 at $p < 0.01$ level of significance. This leads to rejection of the null hypothesis which states "Improved maize varieties adoption does not have any significant impact on small holders' grain market participation." at $p < 0.01$. To conclude, the results from this study suggest the potential and significant impact of the maize varieties adoption on improving the farmers' integration to output markets.

The implications of the findings are straight forward that though the adoption of improved maize varieties is relatively low in the study areas, those households who adopted the improved maize varieties were able to participate in output markets and sell their surplus produce.

5.2 Recommendations

In view of the major findings and the above conclusions, the following recommendations are drawn:

The government (local or/and country) and other Non-Governmental Organization (NGOs) should do their part in creating awareness, facilitating the access and mobilizing farmers to adopt the improved varieties so that farmers can improve their agricultural productivity and then change their livelihood.

The government should improve farmer associations which can play an important role in the process of adoption. The farmer associations should also target the farmers' need and should provide them with the necessary information about the associations. The government should also improve the output market environment at least by constructing roads to markets where farmers can sell their products, so they will have the incentive to adopt the new varieties and be more productive.

Adoption of the improved maize varieties was observed to improve the productivity of the adopting farmers which provides them with marketed maize surplus. This marketed maize surplus also facilitated these farmers to participate in output markets. Therefore, GOs and NGOs should facilitate the non-adopters to adopt the new varieties through creating market opportunities while supporting the adopters to continue adopting. Hence, farmers can produce more and by connecting to markets and selling their products, they can improve their livelihood.

5.3 Areas for Further Research

- i. This study only assessed the factors which affect the adoption of improved maize varieties in the study area. However, it didn't analyse intensity of adoption of improved maize varieties in the study area. Thus, further studies are recommended to provide empirical evidence about the intensity of adoption of improved maize varieties in the study area.

- ii. This study succeeded to find the empirical evidence as to what extent adoption of the improved maize varieties help farmers to produce surplus production and participate in output markets. Nevertheless, this study didn't analyze the effect of adoption to farmers' income, so it is recommending further study on it. Therefore, further study is recommended to evaluate the impact of adoption if it really improves the farmers' income and their livelihood in the study area.
- iii. According to the existing literature (Mulugeta, 2009), farmer associations positively influence agricultural technology adoption. Farmer's associations are helpful in minimizing transaction costs, disseminating information, getting loans among others. Despite these facts, in this study it was found that farmers who members in associations were less likely to adopt improved maize varieties in the study area. Thus, further study is recommended to come up with tangible evidence as to why farmer's associations in the study area are functioning to the contrary of principles and facts.

REFERENCES

- Abrahaley, G. (2006). Farmers' perception and adoption of integrated striga management technology in Tahtay Adiabo Woreda, Tigray, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 120pp.
- Adami Tulu Agricultural Research Center (ATARC), (1998). *Thirty years of research Experience*. Oromia Agricultural Research Coordination service. Bulletin. pp 1.
- Adesina, A. A. and Chianu J. (2002). Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria. *Agroforestry System* 55: 255-265.
- Alemu, D., Wilfred, M., Mandefro, N. and David, J.S. (2008). The maize seed system in Ethiopia: challenges and opportunities in drought prone areas. *African Journal of Agricultural Research* 3 (4): 305-314.
- Alene, A., Poonyth, D. and Hassan, R. (2000). Determinants of adoption and intensity of use of improved maize varieties in the Central Highlands of Ethiopia: A Tobit Analysis. *Agrekon* 39(4): 633-643.
- Ali, A. and Abdulai, A. (2010). The adoption of genetically modified cotton and poverty reduction in Pakistan. *Journal of Agricultural Economics* 61(1): 175-192.
- Andersson, C., Alemu, M. and Stage, S. (2009). Impacts of the productive safety net program in Ethiopia on livestock and tree holdings of rural households. Discussion Paper Series. Environment for Development (EfD) Initiative. EfD DP 09-05.

- Asnake, F., Gowda, C. L., Demissie, M., Legesse, D., Bantiln, M., Gaur, P. M. and Senait R. (2005). Adoption of improved chickpea varieties in Ethiopia. Ethiopian Agricultural Research organization, Addis Ababa, Ethiopia.
- Bahadur, K. and Siegfried, B. (2004). Technology adoption and household food security. Analyzing Factors Determining Technology Adoption and Impact of Project Intervention: A Case of Smallholder Peasants in Nepal, Paper prepared for presentation at the Deutscher Tropentag, 5-7 October 2004, Humboldt University, Berlin.
- Balagtas, V.J., Coulibaly, Y.J., Jabbar, M. and Negassa, A. (2007). Dairy market participation with endogenous livestock ownership: evidence from Côte d'Ivoire. In: *Proceedings of AAEC annual meeting*. P July 29-August 1, 2007, Portland, Oregon TN.
- Becerril, J. and Abdulai, A. (2010). The impact of improved maize varieties on poverty in Mexico: A propensity score matching approach. *World Dev.* 38(7): 1024-1035.
- Becker, S. and A. Ichino (2002). Estimation of average treatment effects based on propensity scores. *The Stata Journal* 2(4): 358 -377.
- Bekele, H. K., Verkuijl, H., Mwangi, W. and Tanner, D. (2000). Adoption of improved wheat technologies in Adaba and Dodola Woredas of the Bale Highlands, Ethiopia. Mexico, D.F.: International Maize and Wheat Improvement Center (CIMMYT) and Ethiopian Agricultural Research Organization (EARO).

- Bellemare, M. and Barrett, C. (2006). An ordered tobit model of market participation: Evidence from Kenya and Ethiopia. *Am. J. Agric. Econ.* 88(2): 324-337.
- Berhanu, G. and Swinton, S.M. (2003). Investment in soil conservation in northern Ethiopia: The role of land tenure security and public programme. *Agric. Econ.* 29: 69-84.
- Berhanu, B. (2002). Analysis of factors affecting the Adoption of crossbred Dairy cows in the central Highlands of Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia, 132pp.
- Central Statistical Agency (CSA) (2007a). Agricultural Sample Survey 2006/07 (1999 E.C) Report on Area and Production of Crops (Private peasant holdings meher season). Addis Ababa Ethiopia. *The FDRE Statistical Bulletin* 1: 388.
- Central Statistical Agency (CSA) (2007b). Population and Housing Census of Ethiopia : Results for Oromia Region, Vol. 1
- Central Statistical Agency (CSA) (2008). Agricultural sample survey: Report on area and production of crops, Addis Ababa, Ethiopia. pp 126.
- Central Statistical Agency (CSA) (2011). Agricultural Sample Survey 2010/11 (September – December 2010), Vol. 1, Report on Area and Production of Major Crops, Addis Ababa.

- Central Statistical Agency (CSA) (2011). Federal Democratic Republic of Ethiopia Agricultural Sample Survey 2010 / 2011 (2003 E.C.) (September- December 2010) Report On Area and Production of Major Crops (Private Peasant Holdings, Meher Season), April 2011, Vol. I, Addis Ababa.
- Cragg, J. (1971). Some statistical models for limited dependent variables with application to the demand for durable goods. *Econometrica* 39: 829-844.
- Degu, W. (2012). Factors Affecting Adoption of Improved Potato Varieties: The Case of Haramaya Woreda, East Hararghe, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia, 101pp.
- Dercon, S., Hoddinott, J. and Woldehanna, T. (2005). Shocks and consumption in 15 Ethiopian Villages, 1999–2004. *J. Afr. Economies* 14: 559–585.
- Diagne, A. (2006). Diffusion and adoption of NERICA rice varieties in Cote d’Ivoire. *The Development Economics* 44(2): 208-231.
- Doss, C. R. (2003). Understanding farm level technology adoption: lessons learned from CIMMYT’s micro surveys in Eastern Africa. CIMMYT Economics Working Paper 03-07. Mexico, D.F., CIMMYT.
- Dunn, D. W. (1984). *Applied Decision Analysis*. McGraw-Hill Book Company, New York.

- Düvel, G.H. and Botha, A.J. (1999). Human constraint to sustainable agriculture in the arid regions of South Africa. *The Journal of Agricultural Education and Extension* 6(1): 47-60.
- Ebrahim, J. (2006). Adoption of Dairy Innovation: Its Income and Gender Implication in Adami Tulu Woreda, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia, 113pp.
- Edmeades, S. (2006). Varieties, Attributes and Marketed Surplus of a Subsistence Crop: Bananas in Uganda. IAAE annual conference, Gold Coast, Australia, August 12-18, 2006.
- Endrias, G. (2003). Adoption of improved sweet potato varieties in Boloso Sore Woreda, Southern Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 104pp.
- Feder, G., Just, R. and Zilberman, D. (1985). Adoption of agricultural innovations in Developing Countries. *Economic Development and Cultural Change* 33(2): 255-298.
- Federal Democratic Republic of Ethiopia/FDRE (2010). Growth and Transformation Plan 2010/11-2014/15. Volume I: Main Text. Ministry of Finance and Economic Development. November 2010. Addis Ababa.
- Gebre-Mariam, Y. K. (2012). *Holistic Analysis of Household Decision-Making*. Lanham, Maryland: University Press of America.

- Gebreselassie, S. (2006). Intensification of smallholder agriculture in Ethiopia: options and scenarios. Paper presented for the Future Agricultures Consortium Meeting at the Institute of Development Studies, 20-22 March 2006. DFID.
- Gezahagn, W. (2008). Determinants and role of farmers' seed and seedling multiplication in the SNNP Region Seed System. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.
- Greene, W. (1997). *Econometric Analysis*, 3rd ed. Upper Saddle River, Prentice- Hall, NJ.
- Guerrem, E. and Moon H. R. (2004). A study of semi-parametric binary choice model with integrated covariates. LSTA, Universite Paris 6 and CREST.
- Gujarati, D. (2004). *Basic Econometrics*. Fourth Edition. McGraw-Hill Companies.
- Gujarati, D. and Porter, D. C. (2009). *Basic Econometrics*. Fifth Edition. McGraw-Hill Companies.
- Habtemariam, A. (2004). The Comparative influence of intervening variables in the adoption behavior of maize and dairy farmers in Shashemene and Debre Zeit, Ethiopia. Dissertation for Award of PhD Degree at University of Pretoria, Pretoria, South Africa, 292pp.
- Heckman, J., LaLonde, R. and Smith, J. (1999). The Economics and Econometrics of Active Labour Market Programs. in: *Handbook of Labour Economics*, Vol. III (Edited By Ashenfelter, O. and Card, D.), Elsevier, Amsterdam. pp.1865-2097.

- Heinrich, C., Maffioli, A. and Vázquez, G. (2010). A Primer for Applying Propensity-Score Matching: Impact-Evaluation Guidelines. Inter-American Development Bank.
- IFPRI (2008). Cereal Availability Report on Ethiopia, 2008. Report Submitted to the Joint Research Center of the European Union.
- Kassie, M., Shiferaw, B. and Geoffrey, M. (In press) Agricultural Technology, Crop Income, and Poverty Alleviation in Uganda. *World Development*.
- Kassie, M., Bekele, S. and Muricho, G. (2010). Adoption and Impact of Improved Groundnut Varieties on Rural Poverty. Evidence from Rural Uganda. Environment for Development : Discussion Paper Series.
- Kassie, M., Moti, J., Bekele, S., Frank, M. and Hugo, D. (2012). Improved maize technologies and welfare outcomes in smallholder systems, Tanzania: Evidence from Application of Parametric and Non-Parametric Approaches: the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.
- Kassie, M., Zikhali, P., Manjur, K. and Edwards, S. (2009). Adoption of sustainable agricultural practices: evidence from a semi-arid region of Ethiopia. *Natural Resources Forum* 33: 189-198.
- Kebede, M. (2006). Farmers' Perception and determinants of land management practices in Ofla Woreda, Southern Tigray, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 98pp.

- Kijima, Y., Otsuka, K. and Serunkuma, D. (2008) Assessing the impact of NERICA on income and poverty in central and western Uganda. *Agricultural Economics* 38 (3): 327–337.
- Legesse, D., Mulugeta, E. and Belay, K. (2001). Determinants of adoption of soil conservation measures in Central Highlands of Ethiopia. The Case of Three s of North Shoa. *Agrekon* 40(3): 44.
- Mariano, M., Villano, R. and Fleming, E. (2012). Factors influencing farmers’ adoption of modern rice technologies and good management practices in the Philippines. *Agricultural Systems* 110: 41-53.
- Mekonnen, S. (2007). Assessment of factors influencing adoption of integrated striga management technologies of sorghum in Habro and Fedis Woredas, Oromia region. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 120pp.
- Menard, S. (2002). *Applied Logistic Regression Analysis*. Sage Publications, Inc.
- Mendola, M. (2007). Agricultural technology adoption and poverty reduction: a propensity-score matching analysis for Rural Bangladesh. *Food Policy* 32: 372–393.
- Mendola, M. (2007). *Farm Household Production Theories: A Review of “Institutional” and “Behavioral” Responses*. Asian Development Review, *Asian Development Bank* 24(1): 49-68.

- Mignouna, D. B., VManyong¹, V.M., Mutabazi, K. D. and Senkondo, E. M. (2011). Determinants of adopting imazapyr-resistant maize for Striga control in Western Kenya: A double-hurdle approach. *Journal of Development and Agricultural Economics* 3(11/12): 572-580.
- Mikinay, H. (2008). Social networks and gender dimensions in use of irrigation by farmers in Alamata Woreda, Southern Tigray, Ethiopia. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.
- Million, T. and Belay, K. (2004). Ethiopian Agricultural Research Organization, Addis Ababa, Ethiopia. 21-30pp.
- Ministry of Agriculture and Rural Development (MoARD) (2008). Crop Variety Register. Animal and Plant Health Regulatory Directorate Crop Development Department. Addis Ababa: Ministry of Agriculture and Rural Development (MoARD), Addis Ababa, Ethiopia. 190 pp.
- Minyahel, F. (2008). Analysis of Factors Influencing Intensity of Adoption of Improved Bread Wheat Production Package In Jama Woreda, South Wollo, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 120pp.
- Mulugeta, A. (2009). Determinants of intensity of adoption of old coffee stumping technology in Dale Woreda, Ethiopia. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.

- Mwanga, J.R., Mugashe, C.L., Magnussen, P., Gabone, R.M. and Aagaard-Hansen, J. (1998). Experience from video-recorded focus group discussion on schistosomiasis in Magu, Tanzania. *Qualitative Health Research* 8:707-717.
- Najib, A. (2010). Gender Disparities in Adoption of Improved Sorghum Package: The case of Agro-Pastoral System of Jijiga Woreda, Somali Regional state. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.
- National Bank of Ethiopia (2011). *Annual report VII*. Addis Ababa, Ethiopia.
- Ouma, J.O., DeGroot, H. and Owuor, G. (2006). Determinants of improved maize seed and fertilizer use in Kenya. Paper presented at the International Association of Agricultural Economists' Conference, Gold Coast, Australia, August 12-18.
- Rahmeto, N. (2007). Determinants of adoption of improved haricot bean production package in Alaba special woreda, southern Ethiopia. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.
- Rashid, S., Getnet, K. and Lemma, S. (2010). Maize value chain potential in Ethiopia: Constraints and opportunities for enhancing the system, IFPRI, Working Paper.
- Rogers, E.M. (1962). *Diffusion of innovation*. New York Free Press, New York. pp.376.
- Rosenbaum, P. R. and Rubin, D. B. (1983). The central role of the propensity score in observational studies for causal effects. *Biometrika* 70(1): 41–55.
- Salami, A. Kamara, A. and Brixiova, Z. (2010), *Smallholder Agriculture in East Africa: Trends, Constraints and Opportunities*, Working Papers Series No 105 African Development Bank, Tunis, Tunisia.

- Setotaw, F., Gezahegn, A. And Hailemariam, T. (2003). Impact of Technology on Households Food Security in Teff and Wheat Farming Systems of Moretna- Jiru woreda. Ethiopian Agricultural Research Organization (EARO), Research Report No.48.
- Shahidur, R. K, Koolwal, G.B. and Samad, H.A. (2010). Handbook on Impact Evaluation: Quantitative Methods and Practices. The World Bank. Washington, D.C.
- Shiferaw, F. and Tesfaye, Z. (2005). Adoption of improved maize varieties in Southern Ethiopia: Factors and strategy options. *Food Policy* 31: 442–457.
- Sianesi, B. (2004). An evaluation of the Swedish system of active labour market programmes in the 1990s. *Review of Economics and Statistics* 86 (1): 133–155.
- Simtowe, F., Kassie, M., Solomon, A., Bekele, S., Monyo, E. and Siambi, M. (2012). Welfare Effects of Agricultural Technology adoption: the case of improved groundnut varieties in rural Malawi. Selected Paper prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.
- Solomon, A., Shiferaw, B., Simtowe, F. and Haile, M.G. (2011). Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. *Journal of Development and Agricultural Economics* 3(9): 436-447.
- Spielman, D., Byerlee, D., Alemu, D. and Kelemework, D. (2010). Policies to promote cereal intensification in Ethiopia the search for appropriate public and private roles. *Food Policy* 35: 185-194.

- Srinivasan, G. and Pandey, S. (2011). Partnership for progress: EARO and CIMMYT working together to promote sustainable maize systems for Ethiopia: Enhancing the Contribution of Maize to Food Security in Ethiopia Proceedings of the Second National Maize Workshop; 12-16 November 2001 Addis Ababa, Ethiopia.
- Tadesse, A. M. (2008). Farmers' evaluation and adoption of improved onion production package in Fogera District, Ethiopia. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.
- Taha, M. (2007). Determinants of Intensity of Adoption of Improved Onion Production Package In Dugda Bora Woreda, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 120pp.
- Taher, S. (1996). Factors influencing smallholder cocoa production: a management analysis of behavioural decision-making processes of technology adoption and application. Dissertation for Award of PhD Degree at Wageningen University, Wageningen, Holland. 250pp.
- Techane, A. (2002). Determinants of Fertilizer Adoption in Ethiopia: The Case of Major Cereal Producing Areas. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 120pp.
- Teferi, W. (2003). Trends in and determinants of fertilizer use in Gozamin Woreda, Amhara Region. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 132pp.

- Tesfaye, W. (2006). Analyzing factors affecting adoption of rainwater harvesting technology in Dugda Bora Woreda, Ethiopia. Dissertation for Award of MSc Degree at Haramaya University. Haramaya, Ethiopia. 127pp.
- Tesfaye, Z. and Alemu, H. (2001). Adoption of improved maize technologies and inorganic fertilizer in Northwestern Ethiopia. Ethiopian Agricultural Research Organization (EARO). Research report No.40, Addis Ababa, Ethiopia. pp51.
- The RATES centre, (2003). Maize market assessment and baseline study for Ethiopia: Ethiopia maize sector value chain analysis.
- Tigist, P. (2010). Adoption of Conservation Tillage Technologies in Metama woreda, North Gondar Zone , Ethiopia. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.
- Weir, S. and Knight, J. (2000). Education externalities in rural Ethiopia: evidence from average and stochastic frontier production function. Center for the study of African economics, university of Oxford, United Kingdom.
- World Bank (2013). World Development Report: Ethiopia at a glance. [http://devdata.worldbank.org/AAG/eth_aag.pdf] site visited on 10/12/2013.
- Wu, H., Ding, S., Pandey, S. and Tao, D. (2010). Assessing the Impact of Agricultural Technology Adoption on Farmers' Well-Being in Rural China. *Asian Economic Journal* 24 (2): 141–160.

- Yenealem, K. (2006). Gender disparities in adoption of improved maize varieties between Male Haded and Femal Headed Households in Kuni Woreda, Western Harerge Zone, Ethiopia. An unpublished MSc thesis submitted to School of Graduate Studies of Haramaya University. Haramaya, Ethiopia.
- Yishak, G. and Punjabi, N.K. (2011). Determinants of adoption of improved maize technology in Damot Gale, Wolaita, Ethiopia. *Raj. J. Extn. Edu.* 19: 1-9.
- Yu, B., Alejandro N., José, F. and Asrat, G. (2011). Cereal Production and Technology Adoption in Ethiopia. ESSP II Working Paper 31.
- Zelalem, T. (2007). Adoption of small ruminant' fattening package in agropastoral areas, Meisso Wereda, Eastern Oromia. IPMS theses [www.ipms-ethiopia.org] site visited on 02/06/2014.