Effect of Agricultural Extension Program on Smallholders' Farm Productivity, Efficiency and Women Farmers' Empowerment: A Case Study in North West Ethiopia

(小規模農場の生産性・効率性および女性農業者の能力向上に対する農業普及プログラムの効果ーエチオピア北西部における事例研究ー)

ASRES ELIAS BAYSA

The United Graduate School of Agricultural Sciences

Tottori University, Japan

March 2015

Effect of Agricultural Extension Program on Smallholders' Farm Productivity, Efficiency and Women Farmers' Empowerment: A Case Study in North West Ethiopia

By

Asres Elias Baysa

A Dissertation Submitted to the United Graduate School of Agricultural Sciences

Tottori University, Japan

In partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY IN MANAGERIAL ECONOMICS

Supervisors:

Professor Dr. Makoto NOHMI

Professor Dr. Kumi YASUNOBU

Associate Professor Dr. Norikazu INOUE (October 2014 - March 2015)

Associate Professor Dr. Akira ISHIDA (April 2012 - September 2014)

March 2015

Acknowledgements

I am indebted to many people who have been an integral part of my research and supportive throughout my graduate studies.

First and foremost, I would like to thank Almighty GOD for the patience and perseverance that he has been bestowed upon me during my study, and indeed, throughout my life.

I wish to express my sincere gratitude to the Ministry of Education, Culture, Sports, Science and Technology of the Government of Japan for offering me the Japanese government scholarship (monbukagakusho) to pursue higher studies in Japan. My deepest gratitude goes to my supervisors: Prof. Makoto Nohmi, Prof. Kumi Yasunobu and Prof. Akira Ishida who greatly contributed to this study. I am thankful for all their insights, constructive comments and suggestions to produce this research work. Prof. Makoto Nohmi, I sincerely appreciate your kindness; I could get your prompt response and assistance whenever I need and for providing the necessary financial support during the different phases of this research work. I am also greatly indebted to Prof. Atsushi Tsunekawa for recommending me to my major supervisor.

I am also grateful to the contribution of agricultural extension experts and other teams who belong to federal, zonal (East Gojam zone) and district level agriculture and rural development offices for providing me with the necessary information for my study. I owe the success of both the surveys I have undertaken for this dissertation to the dedication and hard work of the data collection team and to the kind cooperation of the respondent farmers in Gozamin district. Special thanks to Mr. Girma for assisting me in conducting the pilot surveys and coordinating the actual surveys. Though he is not alive I will always remember his kindness and helpfulness. May God rest his soul in peace!

I gratefully acknowledge the support of Wubshet Abebe and his wife Lidya for their hospitality during our stay with them and commitment to take care of my daughter while I am at field work. Great thanks are also due to Hibret Belete for his insights, guidance and unreserved support to make me familiar with the different tools of econometrics.

I wish to thank the following, for their assistance during my stay in Tottori: Dr. Dagnachew Aklog, Dr. Derege Tsegaye, Hanna Mesfin, Hiwot Aklilu, Michael Yohannes, Fantahun Aklog, Naoko Sato and for all my laboratory members for their encouragement and sharing social life with all happy and bad times which made my life tolerable. I enjoyed all our social gatherings and made me to feel like at home.

The contribution of my ever loving and caring family is colossal. The support, motivation and encouragement of my father, mother and brothers make my life comfortable during all my education carriers and their prayers are the roots of my success.

Last but not least I would like to thank my loving husband Dr. Nigussie Haregewein (Babi) and my beloved daughter Hana Nigussie. Babi, I have no words to explain what you mean for me. You always encouraged me and played a pivotal role in achieving higher goals of life. I could not be here without your support. Babi and Hanye thank you for your endurance, unconditional love and patience throughout the achievements of my study.

Thank you God for answering my prayers in a period of endless great need!!!

Asres Elias

Dedication

This work is dedicated to my parents, whose good examples have taught me to work hard for the things that I aspire to achieve. This dissertation is also dedicated to my husband, who has been a persistent source of support and encouragement during the challenges of graduate school and life. I am truly thankful for having you in my life.

Table of Contents

List of Tables

List of Figures

Acronyms and abbreviations

ADLI	Agricultural Development Led Industrialization
AISCO	Agricultural Input Supply Corporation
AISE	Agricultural Input Supply Enterprise
ARDU	Agricultural
ASE	Amhara Seed Enterprise
ATA	Agricultural Transformation Agency
ATT	Average Treatment effect on the Treated
BoARD	Bureau of Agriculture and Rural Development
CADU	Chilalo Agricultural Development Unit
CIA	Conditional Independence Assumption
CIA	Central Intelligence Agency
CSA	Central Statistics Agency
DEA	Data Envelopment Analysis
EEA	Ethiopian Economics Association
EIAR	Ethiopian Institute of Agricultural Research
EMTP	Extension Management Training Plot
ERSS	Ethiopian Rural Smallholder Survey
ESE	Ethiopian Seed Enterprise
GDP	Growth Domestic Product
GoE	Government of Ethiopia
GTP	Growth and Transformation Plan
Ha	Hectare
IFAD	International Fund for Agricultural Development
IFPRI	International Food and Policy Research Institute
IRIN	Integrated Regional Information Networks
Kg	Kilogram
LR	Likelihood Ratio
Masl	Meters Above Sea Level
MEDaC	Ministry of Economic Development and Cooperation

MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MPP	Minimum Package Project
Mt	Metric Ton
NAIA	National agricultural Input Authority
NEIP	New Extension Intervention Program
NFIA	National Fertilizer Industry Agency
NGO	Non-Governmental organization
NSIA	National Seed Industry Agency
OLS	Ordinary Least Square
OoARD	Office of Agriculture and Rural Development
OSE	Oromia Seed Enterprise
PA	Peasant Association
PADETES	Participatory Demonstration and Training Extension System
PADEP	Peasant Agriculture Development Program
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PIF	Policy and Investment Framework
PSM	Propensity Score Matching
SDPRP	Sustainable Development and Poverty Reduction Program
SFPF	Stochastic Frontier Production Function
SG	Sasakawa-Global
SNNPR	Southern Nations Nationalities and people's region
SRSE	Southern Nations Nationalities and people's region Seed Enterprise
SSA	Sub-Saharan Africa
TGE	Transitional Government of Ethiopia
TE	Technical Efficiency
TLU	Tropical Livestock Unit
WADU	Welayta Agricultural Development Unit
WDR	World Development Report

Chapter 1

Introduction

1.1 Background of the study

Three out of four poor people in the developing world live in rural areas, and most of them depend directly or indirectly on agriculture for their livelihoods (World Bank, 2010). Especially in Sub-Saharan Africa (SSA), agriculture is the sector in which the majority of the region's people draw their livelihood, and their welfare is tied directly to the productivity of the resources at their disposal (USDA, 2013). Agriculture in SSA (excluding South Africa) employed 62 percent of the population and generated 27 percent of the GDP of these countries in 2005 (Staatz and Dembele, 2007). These agricultural production systems are largely based on smallholder farms possessing two hectare or less, represent 80 percent of all farms in SSA, and contribute up to 90 percent of the production in some SSA countries (Wiggins, 2009). As a result, improving rural livelihoods and achieving household food security among small and marginal farm families has become an increasingly important national goal in most developing countries in general and in SSA in particular (FAO, 2011).

Agricultural extension is one of the policy instruments to stimulate agricultural development through promoting the adoption and diffusion of improved technologies. The presence of efficient and effective agricultural extension system helps farmers to identify and overcome agricultural production problems, increases agricultural production and productivity, efficiency and household income in a sustainable way that paves the way to agricultural development (Anderson, 2007; Kassa, 2008; Christoplos, 2010). Thus, many developing countries have been established their agricultural extension systems in order to realize their national food security goals and improving rural livelihood (Swanson, 2006; Hu et al., 2009), through providing knowledge for improved agricultural productivity, linking smallholder farmers to high-value and export markets, and promoting environmentally sustainable production techniques (Andorson, 2007).

With a population of about 92 million and 3.17 percent growth rate per year (CIA, 2012), Ethiopia is the second most populous country in SSA (United Nations, 2012). Like in many other

SSA countries, agriculture is the most important sector for sustaining growth and reducing poverty in Ethiopia. It accounts for 85 percent of employment, 90 percent of exports, and 47 percent of gross domestic product (GDP) (FAO, 2010; CIA, 2014). Within the agricultural sector, the crop subsector is the most important in terms of contribution to GDP. In 2006/07 the crop sub-sector contribution to GDP was 30 percent while its share to the agriculture GDP was 65 percent. Although the Ethiopian economy is heavily reliant on agriculture, agricultural production is yet characterized by low productivity, dominated by smallholders who are subsistence, small-scale and resource poor farmers, fragmented and small plots of land (World Bank, 2010) and almost entirely rain-fed agriculture. The country has the potential to irrigate about 4.3 million ha, out of which only an estimated 6 percent is currently being utilized (PIF, 2010).

On the other hand, Ethiopia has great agricultural potential because of its vast areas of arable land (with approximately 51.3 million ha), diversified agro-climatic zone, relatively adequate rainfall in most parts and large labor pool. Despite this potential, however, the country's agricultural performance has been dismal. This is further exacerbated by severe land degradation, recurrent drought, low level of technology adoption, low productivity, weak infrastructure and overpopulation (Falco et al., 2010; PIF, 2010). Smallholders' crop productivity is still below potential in Ethiopia and food security remains a critical issue for many households and for the country as a whole. For instance, between 1998 and 2012 the average number of Ethiopians in need of food assistance through a social welfare scheme fluctuated between 3 million and 14 million (IRIN, 2012). Moreover, the country ranks at 173th out of 187 nations in terms of Human Development Index (UNDP, 2013).

In an effort to curb the challenges facing the agricultural sector and achieve faster agricultural growth and food security, the Government of Ethiopia (GoE) launched a new development strategy-Agriculture Development Led Industrialization (ADLI) in 1993 that sets out agriculture as a primary stimulus to generate increased output, employment and income for the people, and as the spring board for the development of the other sectors of the economy (Kassa and Abebaw, 2004; Gebremedhin et al., 2009). Subsequently, agriculture has become the main focus of the GoE's poverty reduction strategy, which includes the Sustainable Development and Poverty Reduction Program (SDPRP) approved in 2002, the 2004 Food Security Strategy (FSS), the

2006 Plan for Accelerated and Sustained Development to End Poverty (PASDEP), and, most recently, the 2011 Growth and Transformation Plan (GTP) (MoFED, 2002, 2007, 2010). The core goal of all these strategies was to increase yield and improve rural livelihoods through a centralized extension-based service known as Participatory Demonstration and Training Extension System (PADETES) focusing on technological packages that combined credit, fertilizers, improved seeds and better management practices. The goal of PADETES are to improve incomes via increasing agricultural productivity; ensure self-sufficiency in food production; establish farmer organizations; to increase the production of industrial and export crops; conserve and rehabilitate natural resources; to empower farmers to actively participate in the development process and to encourage the participation of female farmers in agricultural development (Kassa, 2003; EEA/EEPRI, 2006; World Bank, 2010).

In spite of the numerous national policies and development strategies that placed high priority on boosting agricultural production and productivity, Ethiopia has yet to see payoffs in terms of higher and more stable cereal yields, lower consumer prices for food staples, and reduced dependence on food aid (Alene, 2003; Spielman et al., 2011; Mitik and Engda, 2013). At national level gross crop yield is lingering behind the national food demand despite the implementation of extension programs that aim to expand the use of modern agricultural input technologies like chemical fertilizers, improved seed, herbicides, pesticides and new or improved agronomic practices (Gebre-Selassie, 2003; World Bank, 2007; Yu et al., 2011). Despite the major reform measures, including market and trade liberalization, economic policy and a development strategy giving agriculture the lead role, the growth of the agricultural sector remains a major policy challenge for the current government. The growing demand for food and agricultural products to feed nearly 92 million people, the growing income gap between urban and rural areas, dwindling natural resources, vulnerable to recurrent food shortfalls and national food insecurity (Devis et al., 2010; Abate et al., 2011) are among the challenges confront policy makers and other agents of change.

1.2 Statements of the research problem

As previously stated, one of the major programs in the rural development in general and the Ethiopian agriculture in particular is the agricultural extension package program that supported the promotion of modern agricultural technologies and intensifies agricultural growth

(EEA/EEPRI, 2006; Kassa, 2008). The provision of agricultural extension services is especially important issue for agrarian countries like Ethiopia, where agriculture dominates the economy, over 80 percent of the country's people live in rural areas (FAO, 2010; CIA, 2012), and most are extremely poor, with a daily per capita income of less than $0.50, and access to one hectare or less of land (IFAD, 2011). To tackle these shortcomings, over the past two decades, policy makers in Ethiopia have pursued a range of policies and investments to boost agricultural production and productivity, particularly with respect to the food staple crops that are critical to reducing poverty in the country. A central aim of this process has been to increase the availability of improved seed, chemical fertilizers, and advisory services for small-scale, resource-poor farmers, particularly those cultivating food staple crops (Spielman et al., 2011). However, despite the implementation of a range of policies and strategies, the rate of return of the agricultural sector remains relatively low and production is growing unsatisfactorily. Average productivity was 12 quintal per hectare of land before the PASDEP period and it showed a slower improvement and reached 15.7 at the end of PASDEP (2009/10) (Mitik and Engda, 2013). In fact, with the special attention and significant investment made by the GoE on agricultural extension service, agricultural production and productivity would have been increased more from year to year.

While there is a large literature dealing with agricultural extension issues in developing countries including Ethiopia, rigorous impact evaluations of agricultural extension interventions on expected outcomes are less common (Waddington et al., 2010; Spielman et al., 2010). In this regard, factors influencing effectiveness of agricultural extension services in fostering improved outcomes for farmers and the reasons for different levels of effectiveness in different contexts need to be investigated (Birner et al., 2006). Quantitative estimates of effect of extension intervention related to intermediate outcomes such as knowledge acquisition, farmers' empowerment, adoption and diffusion of technologies, and final outcomes such as agricultural yield, household income and poverty status also need to be evaluated (Waddington et al., 2010). This evaluation can help to answer the question "why, how and in which contexts agricultural extension interventions are effective?" (Noyes et al., 2008), the answer of which could help policy makers and practitioners in designing effective extension programs.

A number of useful published and unpublished materials are available concerning agricultural extension in Ethiopia. Many of them deal with the type of extension approaches followed (for example, Training and Visit System, Participatory Demonstration and Training Extension System), challenges facing extension agents, role of extension service in commercialization, and challenges of seed and fertilizer policies in cereal intensification (see Kassa, 2003; Kassa and Abebaw, 2004; Gebremedhin et al., 2006; Byerlee et al., 2007; Spielman et al., 2011, among others). Others dealing with issues related to adoption status of improved agricultural technologies (Feleke and Zegeye, 2006; Darcon and Christiaensen, 2007; Gebregziabher and Holden, 2011; Beshir et al., 2012 among others). Even though very few impact studies that evaluate the contribution of agricultural extension in Ethiopia are available (e.g. Alene and Hassan, 2003; Birner et al., 2006; Gebremedhin et al, 2009; Dercon et al., 2009), the results are mixed and other studies as well as government reports so far have been measuring the success of agricultural extension service mainly in terms of the number of farmers taking part or full of the packages and/or physical inputs such as improved seed, chemical fertilizer, herbicides and pesticides. But studies on the effect of the agricultural extension service in terms of agricultural productivity and efficiency as well as its impact on female farmers' empowerment in agricultural development are scanty (EEA/EEPRI, 2006; Gebremedhin et al., 2009, Nega et al., 2010; World Bank, 2010). Moreover, in spite of the huge investment made by GoE, there has been little attention and careful analysis to study rigorous impact evaluations of agricultural extension interventions (Kassa, 2008; Dercon et al., 2009; Spielman et al., 2010). Thus, evidences that focus on the final outcomes of agricultural extension remain important.

In line with the effect of agricultural extension program on final outcomes, previous studies reported contradictory findings. On one hand few evidences available suggest that participation in agriculture extension program has led to improvements in output (Gebremedhin et al, 2009; Bachewe, 2009; Ayele et al., 2005) and technical efficiency i.e., the extent to which the maximum possible output is achieved from a given combination of inputs (Seyoum et al., 1998; Khairo and Battese, 2005). On the other hand, other evidences asserted that the Ethiopian extension program has non-significant effect on productivity (EEA/EEPRI, 2006) as well as technical efficiency (Alene and Hassan, 2008; Alemu et al., 2009; Thangata and Mequaninte, 2011). All these studies however failed to address the problem of selection-bias that comes due to self-selection of farmers into the program and endogenous program placement. The sample selection problem may arise from (1) self-selection where the households themselves decide whether or not to participate in extension program, due to differential resource endowments and/or (2) endogenous program placement where those who administer extension program (such as extension workers) select households with specific characteristics (relatively poor or reasonably wealthy). In the actual situation extension program participants are not selected randomly, as it is often the case with non-experimental data and this leads to a biased result. The estimation will be either overestimate or underestimate.

The main aim of this study is therefore, to contribute towards systematic empirical evaluation of the existing agricultural extension program (PADETES) in terms of its effect on farm productivity, technical efficiency and female farmers' empowerment in agricultural development in a case study conducted in North West Ethiopia.

1.3 Objectives of the study

The specific objectives of the study were:

- to evaluate the effect of participation in agricultural extension program (PADETES) on smallholders' farm productivity;
- to measure the effect of agricultural extension on farm level technical efficiency;
- to identify socio-economic and institutional factors influencing on farm technical efficiency ;
- to analyze the gender division of labour in agricultural production and its implication for agricultural extension service;
- to make policy recommendations based on findings of the study.

1.4 Research questions

1. Does PADETES meet its objective on improving farm productivity of smallholder farmers?

2. How is the effect of PADETES in enhancing smallholders' farm technical efficiency? And what are the determinant factors for inefficiency?

3. Does PADETES pro-poor and gender sensitive?

1.5 Structural organization of the study

In order to address the main objective i.e., evaluating the impact of agricultural extension program on farm productivity, efficiency and empowerment of female farmers in Ethiopia, this study address a range of issues in its seven chapters (Figure, 1). The next chapter provides an overview of the GoE's development policy and strategies pursued in the country since 1991with the aim of providing background information and identifying their trend and overall impact on smallholders' farm productivity. Chapter 3 is devoted to the detailed description of the research methodology used in this study. It includes description of the study area, the sampling procedures of the study, the type of data used for analysis and empirical approaches used to investigate objectives of the study. Chapter 4 gives detailed account on the conceptual frame work for the intended analysis i.e., the effect of agricultural extension program on farm productivity, theoretical and empirical issues related to farm productivity. Results of the empirical investigation are also presented in this chapter. Chapter 5 comprises the motivation of performing technical efficiency analysis, empirical approaches used and results on the level and variability of agricultural extension participant and non-participant *teff*[1] producer smallholders' technical efficiency. Chapter 6 deals about the extent of female headed farm households' participation in the current agricultural extension program. Special attention is given for the gender division of labour due to its mainly used as a justification for their low participation level in development intervention programs.

The last chapter brings together the major findings, draws conclusions and makes recommendations with a view to enhance the effect of agricultural extension service in improving farm productivity, efficiency and female farmers' participation in agricultural development in the study areas. Furthermore, future research directions are suggested.

[1] *Teff* is a small grain crop widely consumed in Ethiopia and is the main ingredient in injera (pancake-like staple food).

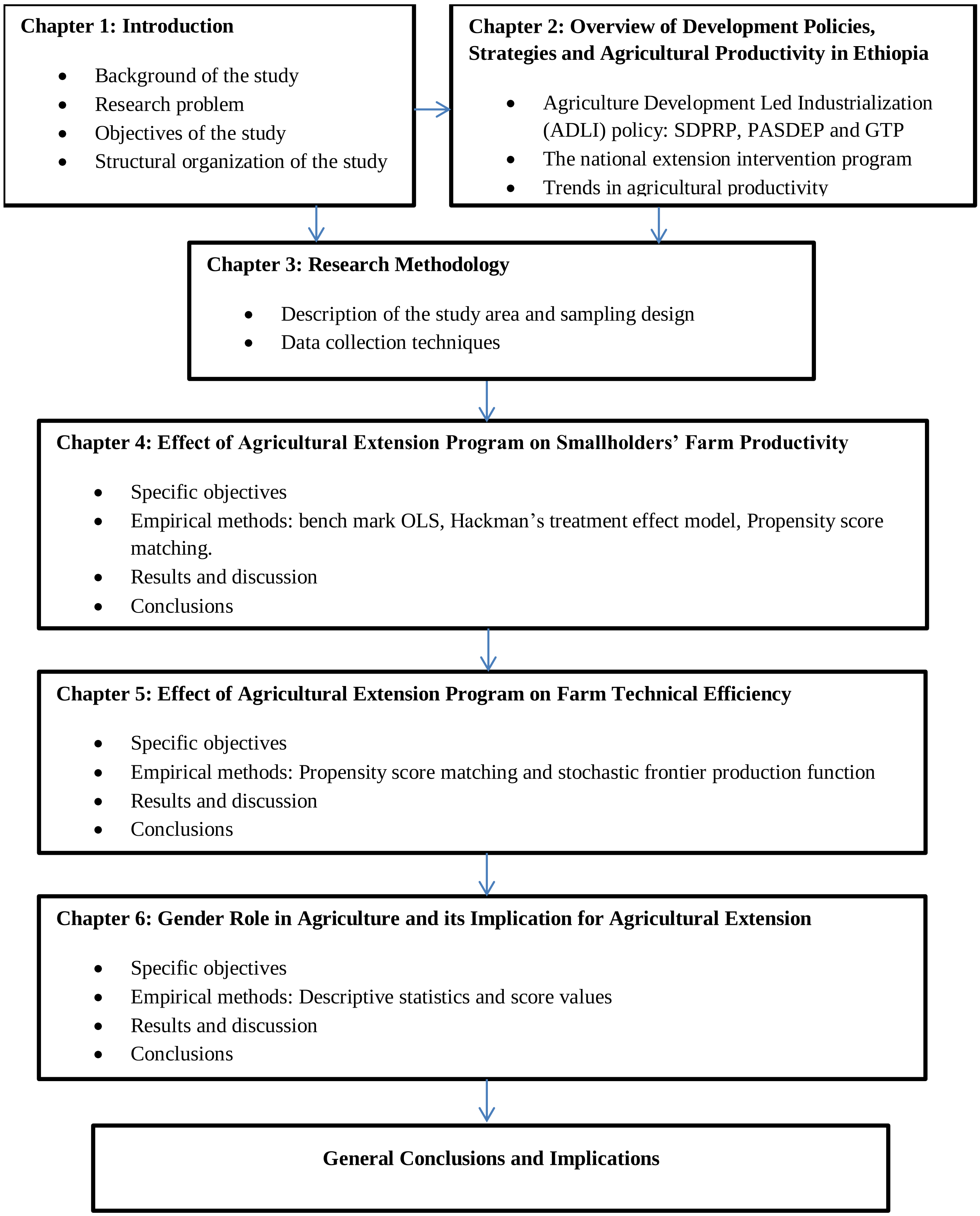

Figure 1.1: Structural organization of the thesis

Chapter 2

Overview of development strategies and agricultural productivity in Ethiopia

2.1 Introduction

Sustained and accelerated development of agriculture is the key to economic development and poverty reduction in most agriculture-based economies. By building up smallholders knowledge in the development of sustainable agricultural practices, smallholder farming can lead to a faster rate of poverty alleviation, by raising the incomes of rural cultivators and reducing food expenditure, and thus reduces income inequality (Magingxa and Kamara, 2003; Diao and Hazell, 2004; Resnick, 2004; Bahram and Chitemi, 2006; Anriquez. and Stamoulis, 2007; World Bank, 2008). However, developing countries encountered challenges related to their capacity to design and implement effective agricultural development policies and strategies that will help improve the livelihood of the rural communities and that promotes overall economic development. Despite the number of agricultural policies adopted by most countries, implementation has been lagging (Salami et al., 2010). Moreover, farming is generally confronted with many risks such as climate change, drought and flood, unstable market condition, increasing prices of agricultural inputs and threat of diseases and pests are only a few of the risk factors with which farmers must contend. Appropriate agricultural policies could help in reducing some of these uncertainties.

There is no doubt that by all measures, Ethiopia is at a low level of social and economic development. A large part of the economy is characterized by subsistence agriculture with exceedingly low income and hand-to-mouth livelihoods (MOFED, 2003). While agriculture is the backbone of the Ethiopian economy, it is characterized by low performance in terms of production and productivity. Productivity gains are to a large extent due to land expansion and favorable climate. Despite unprecedented economic growth reported over the past consecutive years, Ethiopia remains one of the most food insecure and the poorest countries in the world (WDI, 2009; IFDC, 2012).

Specifically, the share of poor people (poverty head count index) in Ethiopia is estimated to have 45.5 percent in1995, 44.2 percent in 1999 (WDI, 2013), 38.9 percent in 2004/5 (Salami et al., 2010) and declined to 29.6 percent in 2009/10 fiscal year (GTP, 2011). Moreover, poverty is more prevalent in rural (30.4 percent) than urban areas (25.7 percent) (MoFED, 2012).

Agriculture, although the dominant sector of the economy contributing about half of the GDP, is constrained by several factors. It has failed to provide moderate and sustained incomes for many who are engaged in the sector. Indeed, it has even failed to satisfy national food requirements (MoFED, 2003).

The development of the agricultural sector is reflected by its capacity to supply adequate amount of food for the growing population and raw materials for the industries; by its potential to generate adequate foreign exchange; and by its capacity to provide market for industrial output. Judged on the bases of these criteria, the development of the sector has been unsatisfactory and it has not been able to produce surplus production to meet the growing demand for agricultural products (Assefa, 1995; Abate et al., 2011). For instance, between 1998 and 2012 the average number of Ethiopians in need of food assistance through a social welfare scheme fluctuated between 3 million and 14 million (IRIN, 2012). Moreover, the country ranks at 173th out of 187 nations in terms of Human Development Index (UNDP, 2013). The proportion of population undernourished has been 40 percent (32 million people) in 2010 (FAO-food security indicator, 2013).

Thus, the purpose of this chapter is to give a brief account of the agricultural development policy and strategies pursued in the country and their impact on smallholder's farm productivity. Particular emphasis is given to agricultural extension programs which has been formulated and implemented by the current government, Ethiopian People's Revolutionary Democratic Front (EPRDF) as a strategy to provide smallholder farmers with new technologies and improved farming practices that enable them to increase productivity and to boost output.

2.2. Policy reforms during the transitional period (1991-1994)

The Ethiopian economy has had mixed fortunes. It exhibited a situation from one of respectable growth of 1960's to the stagnation and decline of the 1970's and 1980's. GDP grew only by 1.5 percent during 1974-1990. By the dawning of 1990's, the economy showed severe macroeconomic imbalances, severe food deficit, growing indebtedness and increased vulnerability (Alene, 2003). Such social and economic problems of the country have cumulatively become severe and complex mirroring sharp contrast between considerable potential and widespread poverty. Thus, in 1991 by the beginning of the transition period, it was clearly observed that Ethiopia face daunting economic development challenges. Subsequently, like the previous governments who gave greater attention to the sector, Ethiopian agriculture has got once again a new government commitment by the Transitional Government of Ethiopia (TGE) in the 1990s. Since 1992 TGE favor market driven development policy by undergoing important structural adjustments and reforms (European Union, 2002). These include the abolishment of all price controls to agricultural products, the reduction and harmonization of trade tariffs and privatization of state owned enterprises. Moreover, the transitional economic policy had also underscored the need to encourage the peasant sub-sector since it occupies a dominant position in terms of agricultural production (TGE, 1991). It has also been stated that the TGE would allocate more resource to expand and improve their productivity especially through improved agricultural production technologies.

2.3 Agriculture Development Led Industrialization development policy

The present Ethiopia's macroeconomic development policy has been evolved from the new economic policy of TGE (Mekonnen, 1994). Agricultural Development Led Industrialization (ADLI) policy was introduced in 1993, which has been a central plank of the government's development program to date. The main motivation behind ADLI is the recognition that Ethiopia is predominantly an agrarian society in which the bulk of the population, about 85 percent, resides in rural areas earning a livelihood from land. In addition, agriculture has long dominated the economy in terms of output, employment, and export earnings. The government emphasizes that economic development and structural transformation should be initiated through robust agricultural growth, and that peasant farmers and pastoralists should constitute the main agents of economic growth. Labor and land are the main and abundant factors of production in the nation and their effective use should generate rapid and sustainable development (Gebre-Selassie and Bekele, 2011; Rahmato, 2008). ADLI guides government policies regarding both overall economic development and agricultural development which recognizes the agriculture sector as engine of growth and the prime focus of development policy. Through ADLI, the country plans to end up with rapid and sustainable economic growth and independence from foreign food aid, ensuring maximum benefit for the local population in the context of free and open market. Thus, ADLI focuses on productivity growth on small farms which is attained through improved smallholder agricultural productivity (MEDaC, 1999) as well as industrialization based on utilization of domestic raw materials with labor intensive technology (Mekonnen, 1999) and incorporating existing indigenous farming technologies where suitable (MoFED, 2003).

In order to realize the development goals of ADLI, the Ethiopian government introduced the National Extension Intervention Program (NEIP) strategy, known as the Participatory Demonstration, Training and Extension System (PADETES) in 1995. PADETES aims at improving income and supply of food via agricultural production and productivity, increasing industrial and export crops, ensuring rehabilitation and conservation of natural resources, and empowering farmers, especially female farmers in agricultural development.

Furthermore, ADLI had been supplemented by new development strategies and/or plans, which include Sustainable Development and Poverty Reduction Program (SDPRP), which cover the year 2002/3-2004/5, Plan for Accelerated and Sustained Development to End Poverty (PASDEP), that ran from 2005/6-2009/10 and most recently the 2011 Growth and Transformation Plan (GTP) which ends up in 2015. SDPRP has centered on the principal goal of poverty reduction. In line with this program, the government has introduced fiscal decentralization, judicial and civil service reform, and public sector capacity building. After the continuing evidence of widespread food insecurity in the drought of 2002/03, the government also initiated a strong focus on safety nets, programs to build the assets of food insecure households, resettlement, and soil and water conservation (especially water harvesting).

The main objective of PASDEP was to accelerate the transformation from subsistence to commercialization of smallholder agriculture through attaining increased productivity and increased share of marketed production and continued support to pro-poor basic agriculture within the framework of the national food security program. Elements of the PASDEP program in the agricultural sector include capacity building through training, development and adoption of a high yielding technology through strengthened agricultural research and extension service delivery mechanism, promotion of increased diversification of agriculture through high value added commodities, promotion of commercialization of agriculture and establishment of a marketing system, development of small-scale irrigation and water harvesting technologies and sustainable use and management of natural resources (MoRAD, 2006).

Currently the GTP has been adopted and implemented considering the priority to intensify productivity of smallholders and strongly supports the intensification of market-oriented agriculture, either at national or international level, and promotes private investments. The plan includes scaling up of best practices to bring average farmers' productivity closer to those of best farmers, expanding irrigation coverage and shifting to production of high value crops to improve income of farmers and pastoralists, with complementary investments in market and infrastructure development (GTP, 2011). By and large, all these strategies have given high priority and special attention for agriculture and rural development. As a result, the agricultural extension service is one of the major institutional support services that have a central role to play in the transformation process.

Development and implementation of agricultural extension programs was not a new practice when the current Ethiopian government adopts PADETES. Ethiopia has had long history in implementing government agricultural extension services since the 1950s, when a model similar to the United States Land Grant approach was used, in which universities reached out to communities with research-based knowledge and through adult education (Kassa, 2003, Kassa, 2008). The Imperial Ethiopian College of Agriculture and Mechanical Arts (IECAMA) provided extension services in addition to research and teaching. In 1963, the Ministry of Agriculture was established, and the mandate of extension provision was transferred to this institution. The Ministry of Agriculture established extension departments at the headquarters and provincial levels (Abate, 2007). During this time, several national development plans were devised, the last of which supported small-scale farmers through comprehensive package programs (Comprehensive Integrated Package Projects, or CIPPs), the most prominent of which were the Chilalo and Wolayita Agricultural Development Units (CADU and WADU). CADU was established in Arsi to improve living standards through increased production and infrastructure. The WADU program, based in Wolayita, although still focused on improving living standards, based on its approach on agro-ecological zones (Abate 2007). A minimum package (Minimum Package Program MPP1 and MPP2) approach then followed these programs, to help to scale up the CIPPs. MPP1 lasted from about 1971 to 1975. The country then moved into a socialist period. During this time the government implemented "quasi-participatory extension approaches" and continued with the MPP2 program until 1985. Much of the focus during this time was on land reform. The MPP2 program ended around 1985 (Abate 2007). In the mid-1980s, various new programs were implemented, such as the National Program for Food Self Sufficiency (1986–1989), the Modified Training and Visit (T&V) Approach, and the Peasant Agriculture Development Extension Projects (PADEP) (1986–1995) (Abate, 2007). Detail historical analysis about models and approaches of extension used since 1950's are found in other reviews (see, Kassa, 2003; Abate, 2007; Kassa, 2008).

2.3.1 The National Extension Intervention Program

The T&V approach continued as the national extension approach until the mid of 1990,s. In formulating PADETES, a task force was set up to evaluate and screen out shortcomings of previous extension approaches. Accordingly the task force concluded the following points as shortcomings of past extension approaches: extension service was organized by commodity rather than by function; the extension service was given on the sense of transmitting information without adequate or no input supply; less attention was given in organizing farmers; the service was limited only to high potential areas; the link between research and extension on the one hand and with credit and marketing agencies on the other were extremely weak; problems of coordination and integration among programs and projects remained apparent; and the participation of farmers remained low (MoA, 1994). In response to these limitations, NEIP was designed to improve farmers' production and productivity through better access to technologies.

The new extension program (PADETES) was formulated based on the experience of a pilot extension program of the SG-2000. The Sasakawa Africa Association and Global 2000 of the Carter Center initiated a pilot extension service program in 1993 which lasted for two years and was implemented by SG-2000 and the ministry of agriculture extension staffs. During this time, available agricultural technologies were assessed and technology packages for maize, wheat, sorghum and *teff* were developed and tested in Oromiya; Southern Nations, Nationalities and Peoples Region (SNNPR); Tigray and Amhara Regions. In 1993, 160 farmers were involved in maize and wheat on-farm Extension Management Training Plots (EMTP), while this number grew to 1600 farmers in 1994 and included additional demonstrations for sorghum and *teff*. The remarkable yield increases demonstrated under the SG-2000 pilot extension program convinced the government to adopt it as a national extension intervention program - PADETES in 1995.

PADETES involved the use of Extension Management and Training Plots (EMTP), usually half hectare on-farm demonstration plots which were managed by farmers and used to train farmers and extension workers on appropriate agronomic and farm management practices (Alene, 2003; Alemu and Demese, 2005). PADETES also follows package approach for agricultural development that incorporates information on agricultural technology, provision of inputs and credit, and communication methods (Kassa, 2003; Ibrahim, 2004; Alemu and Demese, 2005). The program initially started in seven regions with technology packages for wheat, maize, sorghum and *teff* in high rainfall areas. Later, the program expanded its area coverage and number of technology packages, and included technology packages for crop production for moisture stress areas, livestock, high value crops, post-harvest technology, and agro-forestry, among others. The number of participant farmers increased from 32 thousand in 1995 to about 12.7 million at the end of PASDEP period (2009/10). The number of extension agents also increased from 2500 in 1995 to about 60 thousand in 2009/10 (GTP, 2011).

2.3.1.1 Structural organization of agricultural extension service

The current extension service is almost exclusively funded and provided by the government through its *woreda* level Offices of Agriculture and Rural Development (OoARD) (Gebremedhin et al, 2006). All agricultural finances are handled by the ministry of finance and economic development (Davis et al, 2010). The Ministry of Agriculture and Rural Development (MoARD) at the federal level is responsible for developing and refining the overall national agricultural and rural development strategies and policies for the country. Several agencies sit beneath the MoARD: the agricultural marketing and inputs sector, the natural resources sector, and the agricultural development sector. In turn, the agricultural extension department, and the training and vocational education department, falls under the agricultural development sector.

Next to the federal MoARD, regions are responsible for agricultural and rural development policy implementation, coordination, and evaluation. Each Bureau of Agriculture and Rural Development (BoARD) has a head and a number of technical and administrative staff, including department heads. These personnel provide technical and administrative support, as well as supervision and monitoring for the *woreda* and *kebele*[2] level extension offices. Each region's

[2] *Kebele* is the lowest administrative unit in Ethiopia and often translated as peasant association.

agricultural advisory support is internally divided according to major agro-ecological zones, providing more detailed technical and administrative support.

Under the regions are zonal offices, which mainly operate as liaison offices between regions and *woredas*. However, the *woreda* offices of agriculture and rural development are the main frontline administrative structures implementing agricultural extension. The *woreda* level OoARDs are composed of five main sectors: agricultural development, natural resources, environmental protection and land administration, water supply and rural roads, and input supply and cooperative promotion (Gebremedhin et al, 2006). The largest sector, agricultural development, is responsible for extension services and is usually divided into crop production, livestock production, natural resource management, and extension teams (Gebremedhin et al, 2006).The extension team is expected to have a team leader and extension supervisors, all based at the *woreda* level. Each extension supervisor is responsible for the supervision of extension activities in several PAs (*kebeles*). Generally, the *woreda* level OoARD represents a more operational level in terms of reaching smallholder farmers and pastoralists.

2.3.1.2 Farmers training centers

In Ethiopia, where public agricultural extension remains dominant and pluralism in the service delivery is just emerging, strengthening public agricultural extension has received due policy attention. Since 2004, more than 60,000 development agents were trained in 25 agricultural technical and vocational education and training colleges to serve in the public extension. Thousands of farmer training centers (FTCs) have been established by government with substantial contributions from rural communities. The ministry of agriculture and rural development planned to establish at least 15, 000 FTCs, one in every rural *kebele*. About 8,500 FTCs have been built so far and about 45, 000 development agents are engaged as service providers in these FTCs (MoARD, 2009). FTCs were designed as local-level focal points for farmers to receive information, training, demonstrations, and advice, and included both classrooms and demonstration fields. The FTCs are expected to form an important node between extension and farmers in the agricultural sector. FTCs are managed at the *kebele* level, but funding for capital, operational, and salary costs come from the *woreda* level.

The establishment of FTCs and the accompanying strategy and guidelines of the Ethiopian MoARD suggest the beginning of a strategic shift towards knowledge based approach to smallholder agricultural development as well as a shift from a sole focus on the transfer of technology to emphasis on human resource and social capital development. This approach, if effectively implemented, it can empower smallholder farmers and in the long run can enable rural households and communities to solve their own problems.

While FTCs and the assignment of thousands of graduates as staff in these centers represents huge resource and opportunity to move forward, making the FTCs functional, responsive, effective and dynamic remains a real challenge (Lemma, 2011). According to MoARD (2009), about 2, 500 (30 percent) out of 8, 500 FTCs were somewhat functional.

2.4 Trends in agricultural inputs distribution and utilization

2.4.1 The nature of the seed system

Seed systems in Ethiopia can be divided into two broad types: the formal system and the informal system. Both systems are operating simultaneously in the country and difficult to demarcate between the two. There is however, a fact that the formal system is the original source of improved seeds in the informal system (Atilaw and Korbu, 2011). According to Alemu et al. (2010), the informal seed system under Ethiopian context is defined as seed production and distribution along with the different actors where there is no legal certification in the process. This includes retained seed by farmers, farmer-to-farm seed exchange, cooperative based seed multiplication and distribution, Non-Government Organization (NGO) based seed multiplication and distribution etc. The formal seed system on the other hand is a system that involves the production and distribution of basic seed mainly by the research system or certified multipliers like the Ethiopian Seed Enterprise (ESE), the Regional Seed Enterprises etc.

Like the previous governments who gave attention for the development of the seed sector, the current GoE has also realized the importance of further strengthening the seed system and established a National Seed Industry Agency (NSIA) in 1993 along with a National Fertilizer Industry Agency (NFIA) with the support of International Development Association (IDA) and International Fund for Agricultural Development (IFAD) seed system development project (Alemu, 2010). For the purpose of creation of institutional synergy, the NSIA and NFIA were merged in 2003 and established the National Agricultural Input Authority (NAIA), which was functional only for about one year (Alemu et al., 2008). In 2004, the NAIA was integrated to the agricultural input quality control and inspection department and the agricultural input market department of the MoARD.

Currently the Ethiopian seed system is governed by policies stipulated in the public proclamations and regulations that were put in place in the early 1990s (Alemu et al., 2010). The main responsibility of implementing these policies is given to MoARD at the federal level and to BoARDs at the regional level. The national research system headed by the Ethiopian Institute of Agricultural Research (EIAR) and comprised of a range of federal research centers, regional research centers, agricultural universities and faculties are responsible for developing improved varieties, breeder and pre-basic seed needed by other players in the industry (Spilman et al., 2011). Regulatory functions such as varietal release reviews and seed certification are performed by various departments of the MoARD. Basic and certified seed production is carried out by the Ethiopian Seed Enterprise (ESE), which relies on its own farms alongside private companies, private subcontractors, state farms, and cooperatives, to bulk up seed that is supplied to the regional extension and input supply systems. Recently, state owned regional seed enterprises are established such as Oromiya Seed Enterprise (OSE), Amhara Seed Enterprise (ASE), and Southern Nations nationalities and Peoples Region Seed Enterprise (SRSE) and entered in to the formal seed system (Alemu et al., 2010).

Improved certified seed is supplied to Ethiopian smallholders primarily through regional, state-run extension, and input supply systems that operate with a degree of guidance from the federal MoARD. This regional system is made up of regional bureaus of agriculture and rural development, their *woreda* offices, and extension agents (termed “development agents” in Ethiopia) working at the *kebele* (peasant association) level. These organizations collaborate closely with farmers’ cooperatives and regional credit and savings institutions in both supplying inputs and disbursing credit.

2.4.2 Trends in improved seed supply and utilization

Seed is a key input for improving crop production and productivity. Increasing the quality of seeds can increase the yield potential of the crop by significant folds and thus, is one of the most economical and efficient inputs to agricultural development (FAO, 2006). In recent years, there has been a growing recognition in some policy circles of the existence of agricultural technologies that can considerably improve productivity and the limited access of these technologies to farmers. In addition, there is a substantial improvement in the level of farmers' awareness about the use of those improved technologies.

With considerable variability among the different crops, the total supply of improved seed in Ethiopia was only 27 percent of the officially estimated demand in 2005 (Byerlee et al., 2007; Alemu and Spielman, 2006) and with a 72 percent shortfall in 2008 (Speilman et al., 2011). The overall annual average seed requirement for cereals, pulses and oil crops is estimated to be over 400,000 tons (Marja H. et al., 2008). However, the average yearly supply of improved seed doesn't exceed 20,000 tons since the establishment of ESE (Atilaw and Korbu, 2011). The supply still is far below the increasing demand even though there are many efforts under way aimed at increasing production and distribution by strengthening the public and private sectors. The limited production capacity at ESE for certified seed, combined with insufficient provision of breeder and pre-basic seed from the research system, contribute much to these shortfalls (Speilman et al., 2011).

Furthermore, due to the shortage of supply of certified seed, the allocation of the produced certified seed among the different regions is normally made by the policy makers. The most important criteria used for the allocation are the regional importance in the national production of the crop, the size of the revealed demand, and also regional equity (Alemu et al., 2010). For instance, the same report indicated that, in 2008 agricultural season Oromiya's share from the total cropped areas is about 45 percent and from area allocated for cereals is about 46 percent, which is similar to its total seed received. On the other hand, Amhara, Somali and Benishangul-Gumuz seem to get lower proportion and Tigray and SNNP receive a higher proportion as compared to their share in the total cropped area and area allocated for cereals.

On the other hand, adoption of improved seed in Ethiopia is very low while the total quantity of improved seed supplied nationally has been increasing during the PADETES period (Byerlee et al., 2007; Spielman, 2011), though not the required level. The nationally representative Ethiopia Rural Smallholder Survey (ERSS) conducted in 2005 indicated that the adoption rate is only 3

Percent. This figure is until recently unchanged. For instance according to Atilaw and Korbu (2011) the total cultivated area covered by improved seed from 2005/6 to 2010/11 at national level ranges 3.97 percent, 3.05 percent, 3.48 percent, 3.72 percent and 3.44 percent respectively. This indicated that most farmers still rely primarily on farmer-to-farmer exchanges or saved seed.

2.4.3 Trends in fertilizer distribution and utilization

In 1993, the GoE had issued the national fertilizer policy, which supported fertilizer market development. The GoE had launched the national fertilizer sector project with financial support from the World Bank and other donors in 1996. This project supported fully liberalized pricing, the abolition of subsidies, and the regulation of fertilizer standards. Subsequently the Agricultural Input Supply Corporation (AISCO) which was established in 1984 was renamed as the Agricultural Inputs Supply Enterprise (AISE). Policy changes that fully liberalized fertilizer pricing and the removal of subsidies followed in1997/98. The private sector's initial response to market liberalization was rapid. By 1996, several private firms were importing fertilizer, and 67 private wholesalers and 2,300 retailers had taken over a significant share of the domestic market (Spielman et al., 2011). However, since 1999 the private sector that had initially responded to the reforms has largely exited the fertilizer market. In the case of imports, the share of private firms operating in the market went from 33 percent in 1995 to zero in 1999. Since then, the AISE has taken the majority share, followed by "private" companies closely affiliated with or owned by the governing party and, more recently, cooperative unions (Jayne et al., 2003; Byerlee et al., 2007). These days due to the entrance of cooperative unions in fertilizer import market with considerable technical assistance from the ministry of agriculture, the share of party affiliated companies are declined.

The public sector that accounted for over 70 percent of distribution and cooperatives have become almost the sole distributors of fertilizer since early 2000 (DSA, 2006). The current government policy is to target at least 80 percent of fertilizer sales through cooperatives, which are eventually intended to replace the public sector involvement in retail distribution of fertilizers (Byerlee et al., 2007). However, difficulties are observed in the estimation of demand and distribution of fertilizer. Estimations of demand are compiled through official channels and aggregated to the national level. Importers respond to official demand estimates and organize distribution through the regional bureau of agriculture or cooperatives, depending on the region (DSA, 2006).

Regarding the uptake and use of chemical fertilizer in Ethiopia, it can be assessed in several ways in terms of total fertilizer imported, percentage of cultivated land under fertilizer application, and household-level estimates of fertilizer application per hectare.

When measured in terms of quantity imported, over the last one decade, total fertilizer imports have increased by more than 50 percent, from less than 370,000 metric-tons (mt) in 2002 to almost 570,000 mt in 2011, with a spike of 627,000 mt in 2009. Fertilizer carryover stocks averaged 33 percent of imports between 2002 and 2011, with a high of 61 percent in 2002 and a low of 12 percent in 2007. These stocks, resulting from the mismatch between actual fertilizer demand and imports, accentuate the year-to-year variability in fertilizer import levels. Consumption levels vary across the country with Oromia, Amhara, SNNP and Tigray regions, using an average of 92 percent of total fertilizer sales between 2003 and 2011 (IFDC,2012).

According to CSA (2011) ninety percent of fertilizer consumed in Ethiopia is used on cereals, 4.7 percent on pulses and 1.8 percent on oil seeds. Non-grain crops account for only 3 percent of fertilizer use. From total fertilizer use in cereals, *teff* receives the highest share with almost 40 percent of fertilizer use, followed by wheat (26 percent), maize (17 percent), barley (9 percent) and sorghum (3 percent).

The amount of fertilizer applied to crops in 2010/11 is estimated at 550,500 mt, an increase of 30 percent compared with about 426,700 mt in 2009/10. For 2010/11, 4.8 million ha of cultivated land were fertilized, compared with 3.2 million ha in 2009/10, a 53 percent increase. These figures suggest that the average fertilizer application rate per hectare of cultivated land decreased from 133 to 115 kg/ha. Among major cereal crops, maize has a higher average application rate of 175 kg/ha by 2011, while the lowest application rate was for sorghum with 97 kg/ha (CSA, 2011). These statistics indicate that the national level intensity of fertilizer use is still lower than the recommended rate of 200 kg per ha (100 kg of DAP and 100 kg of Urea) (Demeke et al. 1998 in Alem et al. 2008; Fufa and Hassen, 2005). Moreover, different types of data on application rates indicate a slightly different, and often confusing, story about the intensity of fertilizer use in Ethiopia (Spielman et al, 2011).

2.5 The state of crop production and productivity

Data on national crop production levels and trends are controversial. Changes in government and methodologies have coincided with distinct breaks in the data, making it difficult to distinguish between actual changes and statistical artefacts (Taffesse et al., 2011). Thus, independent data sources who can compile nationally representative data are highly needed regardless of government change and its political ideology to understand the actual change in agricultural production and productivity.

During the 1990s the performance of crop production showed an improvement over the 1980s. Performance throughout in the 1980s was low with cereal production increasing at a rate of 1.7 percent annually compared to a population growth rate 2.9 percent (Alene, 2003). In the 1990s, growth in cereal production accelerated to about 5 percent per year according to both FAO and CSA data. The rise was entirely due to very good weather and increases in area cultivated (by almost 6 percent per year), while yields continued to decline by 0.5 – 0.7 percent per year (Alene, 2003; Taffesse et al., 2011). But the contribution of increased use of improved agricultural technologies was argued to have been minimal mainly because yield of most cereals remained stagnant (Mulat, 1999).

On the other hand, according to CSA data which is compiled by Taffesse et al., (2011), growth in cereal production accelerated further to 7 percent per year from 1999/2000 to 2007/08. Average cereal production increased to 10.94 million ton per year during this time period. Though growth in area cultivated slowed to 3.1 percent per year, yields increased by 3.5 percent per year. Cereal production and yield growth was particularly rapid from 2004/05 to 2007/08 (12.2 and 6.2 percent, respectively), while cereal acreage recorded an annual growth rate of only 4.8 percent. During the same time period, cereal production on average involved 11 million holders. Cereal acreage and cereal output averaged 8.2 million hectares and 12.1 million tons, respectively.

However, in contrast to the increasing trend observed in cereal production and yield during 2000/01- 2007/08 crop seasons, a declining trend in yield has been observed since 2007/08. CSA data compiled by IFDC (2012) revealed that planted area has been increasing steadily since the 2007/08 crop season with a 13.7 percent increase by 2010/11 season, driven by oil crops and, to a minor scale, by pulses and by cereals. As depicted in Table 2.1, in terms of grains production, the upward trend between 2007/08 and 2010/11 was again driven by cereals along with a substantial percentage increase in oil crop production from a low base. The increase in production between 2007/08 and 2010/11 is clearly attributable to the increase in cultivated area. Yield performance between 2007/08 and 20010/11 was stagnant to negative except for oil crops, which increased slightly.

Table 2.1: Averages and growth rates of grains planted area, production and average yield (2007/08-2010/11)

		Crop seasons				Percent change
		2007/8	2008/9	2009/10	2010/2011	2007/08-2010/11
Total area in ha (x10^3)	Cereals	9,690.7	9,951.8	10,457.8	10,807.5	11.5%
	Pulses	1,357.5	1,803.9	1,727.4	1,582.0	16.5%
	Oil crops	774.5	1,006.5	978.0	1,058.6	36.7%
	Total grains	11,822.8	12,762.2	13,163.2	13,448.1	13.7%
Total production in mt(x10^3)	Cereals	17,761.3	15,606.8	17,320.8	19,180.7	8.0%
	Pulses	1,953.2	2,060.5	2,065.0	2,065.7	5.8%
	Oil crops	634.0	777.7	860.3	935.7	47.6%
	Total grains	20,348.5	18,444.9	20,246.1	22,182.1	9.0%
Average yield (mt/ha)	Cereals	1.8	1.6	1.7	1.8	-3.2%
	Pulses	1.4	1.1	1.2	1.3	-9.2%
	Oil crops	0.8	0.8	0.9	0.9	8.0%
	Total grains	1.7	1.4	1.5	1.6	-4.2%

Source: Adapted from IFDC, 2012.

Chapter 3

Research methodology

3.1 Description of the study area

This study was conducted in Gozamin *woreda* (district), East Gojjam Zone of the Amhara regional state, North West Ethiopia. Amhara regional state is the second largest region next to Oromia region. Gozamin is one of the 17 administrative *woredas* in the zone (Figure 3.1). It is found at about a distance of 265 km far from Bahir Dar city, the regional capital, and at about 300 km from Addis Ababa city, the national capital. The *woreda* is bordered by Sinan *woreda* to the North, Machacle and Debre Eliyas *woreda* to the West, Abay river gorge to the South and Basoliben and Anedede *woreda* to the East.

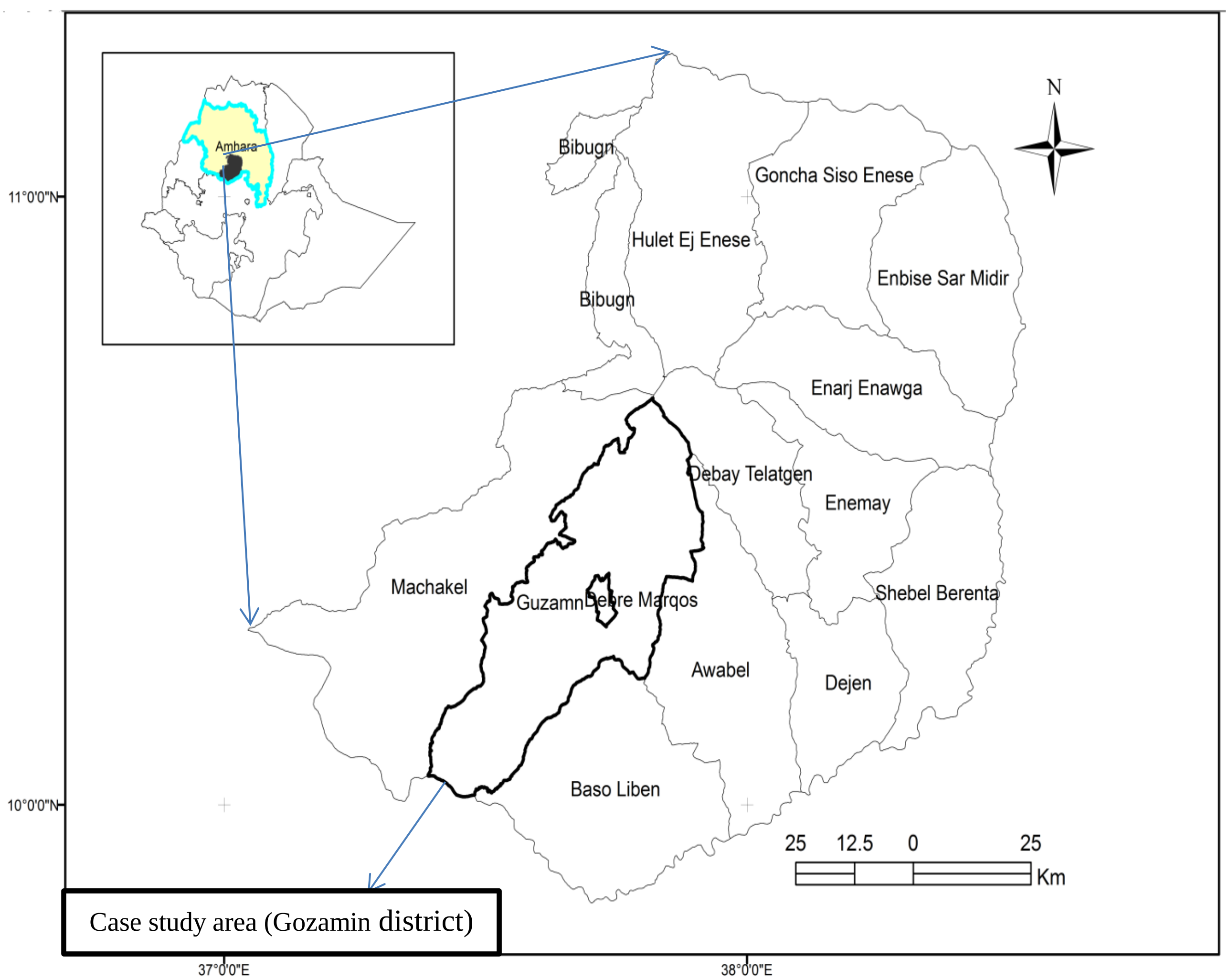

Figure 3.1: Location map of the study area

The *woreda* has a total area of 1,217.8 km^2 and an estimated population of 133, 856, out of which 98 percent are living in rural areas (CSA, 2008). The *woreda* comprises 14 sector offices and 25 rural *Kebeles* surrounding Debre Markos town.

Average annual rainfall of the *wereda* ranges from 1400 mm to 1800 mm and have an annual daily average temperature ranging between 11°C and 25°C. It covers three agro-ecological zones with 19 percent highland (2300 to 3200 meter above sea level), 65 percent midland (1500 to 2300 meter above sea level) and 16 percent lowland (below 1500 meter above sea level) (Gozamin *woreda* administration sector office, 2010). About 95 percent of total crop production is rainfall dependent (Benin, 2006). Generally, the district has a big potential for agricultural activities due to its agro-ecological diversification and dependable rainfall and optimum temperature.

The economy of the *woreda* is based on plough-based and labour intensive agriculture, which depends mainly on *meher* rain (main rainy season). Cultivation of annual and perennial crops and rearing of livestock are the common farming practices. Main crops grown in the *woreda* in order of abundance include *teff*, wheat, maize, barely, check pea, soya bean, oats, niger seed (*Neug*) and lentil.

3.2 Sampling procedures and sample size

In principle, accurate information about a given population could be obtained only from a census study. However, due to financial and time constraints, in many cases a complete coverage of the population is not possible. Thus sampling is one of the methods, which allow the researcher to study a relatively small number of units representing the whole population (Saratnakos, 1998). In order to draw valid inferences from the sample and to ascertain the degree of accuracy of the results, the sample needs to be drawn following the rules of probability. The appropriateness of a sampling method depends on how it will successfully meet study objectives. Thus, this study followed a multi-staged stratified random sampling procedure in selecting farmers to be surveyed.

In the first stage sampling Gozamin *woreda* was selected purposively for satisfying the following criteria; where crop production is widely practiced, where extension program have been implemented for relatively longer period of time, the availability of different agro-ecologies and its representativeness to the Ethiopian highlands. The Ethiopian highlands comprise nearly 45 percent of the total land area of 1.12 million square km, and support over 85 percent of the country's 92 million population that are overwhelmingly rural. In the second stage sampling three *kebele*s namely, Enerata, Kebi and Wonka based on their adequate representation of distinct agro-climatic zone were randomly selected out of the total 25 *kebele*s found in the *woreda.*

Because of the complexity of data requirements, financial and time constraints sample sizes are usually small and cannot be expected to produce highly reliable estimates for all parameters. Nevertheless, it is possible to improve this situation by stratifying the population in to many sub-populations based on one or more classification variables. Taking these issue in to account, stratified random sampling technique was employed to select a total of 300 (225 male headed and 75 female headed) farm households. First, farmers in each selected *kebele* were stratified into two groups as participant and non-participant of the extension program. The groups were identified from a list made available by the front-line extension workers, and then the information was confirmed by the farmers. Second, the two groups were further stratified in to male and female headed households to ensure, as much as possible, representation of female-headed households in the sample. From each *kebele* a total of 100 households which comprises 50 extension program participant and 50 non participants were randomly selected.

3.3 Data collection techniques

The household survey data was collected during May and June 2011/2012 main cropping season. Data were collected both at household and plot level using structured questionnaire which was pre-tested through a pilot survey to ensure clarity and adequacy of the questions. Based on the results of the pilot survey, the questionnaire was revised and finalized for actual data collection. The actual data collection was done by the researcher and selected enumerators, who were living and working with the farmers as well as having acquaintance with socio economic concepts and knowledge of the culture of the society. The selected enumerators received an intensive training before and after the pilot survey on the objectives, content and methods of the survey.

The household data consists of demographic and socio-economic characteristics of household head, resource endowment, use of credit, training access, extension participation experience, membership in farmers' organization, involvement in *kebele*-administration[3] and leadership position. The plot level data consists of information on the intensity of input use (improved seed, inorganic fertilizer, compost and agro chemicals for pest and weed control), plot soil quality, plot slope, farm management practice (such as ploughing frequency), labor time disaggregated by field operation and amount of yield obtained for all types of crops grown during the 2011/12 main agricultural season. Unfortunately, neither farm records nor adequate disaggregated time series data on inputs and outputs particularly those relating smallholder agriculture exist in Ethiopia. As a result farmers respond mainly based on recall for up to the past one year, since respondents rarely had written records. Due to the lack of keeping records, especially data that were related to land use and inputs for individual crops were difficult tasks to collect. However, whenever possible, cross checking was done simultaneously with the help of individual farmers, head of the village and using land holder certificate, to minimize the straight forward recall error. Output and input price information was collected from nearby markets and Gozamin district marketing office. Moreover, area measurements, quantity of input and output were taken in local units and these were later converted to standard units.

Interviews and focus group discussions (consisting of nine groups, each of the group consists of 8-15 farmers) were used to compliment the data obtained through the field survey.

Figure 3.2: Focus group interview as research instrument (photo taken by author, June 2012)

[3] *Kebele*-administration consists of an elected *kebele* council, a *kebele* cabinet, a social court and security persons posted in the *kebele*. The *kebele* council and executive committee's main responsibilities are preparing annual *kebele* development plan, ensuring the collection of land and agricultural income tax, organizing local labour and in kind contributions to development activities, resolving conflicts with in the community (Yilmaz and Venugopal, 2008).

Chapter 4

Effect of agricultural extension program on smallholders' farm productivity in North West Ethiopia

4.1 Introduction

The agricultural growth rate over the past two decades has been quite low in spite of implementing the national extension package program-PADETES. The impacts of the implemented technologies have been mixed, with increased use of fertilizer but poor productivity growth (World Bank, 2006). The low agricultural production and productivity growth has been raising a growing concern about the effectiveness of the extension program in enhancing farm productivity. However, rigorous impact evaluations of agricultural extension interventions on farm production and productivity are scanty (Anderson & Feder, 2007; Gebremedhin et al., 2009; Nega et al., 2010; World Bank, 2010).

Therefore, the aim of this chapter is evaluating the impact of agricultural extension program (AE) participation on smallholders' farm productivity using a plot-level data and identifying determinants of extension participation. The three crops, maize, wheat and *teff* are selected for this analysis due to mainly targeted by the extension program as well as among cereal crops, these crops including barely and sorghum represent 95 percent of total cereal planted area and 96 percent of total cereal production. We started with a baseline model to estimate the impact of AE participation on farm productivity using Ordinary Least Square (OLS). Then we employed Heckman Treatment Effect Model (HTEM) and Propensity Score Matching (PSM) methods to address the problem of selection-bias due to self-selection of farmers into the program and endogenous program placement.

4.2. Conceptual framework

The conceptual framework illustrates how agricultural extension program that is expected to enhance farmers' knowledge and skills, as well as promote and expand improved technologies affect farm productivity of Ethiopian smallholders. It is a general fact that, agricultural extension and/or advisory services play an important role in agricultural development and can contribute to improve the welfare of farmers and other people living in rural areas. In spite of this, there are many factors that condition the relationship between extension inputs and outcomes, and these factors act in complex ways.

According to Anderson and Feder (2003) productivity improvements are only possible when there is a gap between actual and potential productivity. They suggest two types of ‘gaps’ that contribute to the productivity differential, the technology gap and the management gap. Extension can contribute to the reduction of the productivity differential by increasing the speed of technology transfer and by increasing farmers’ knowledge and assisting them in improving farm management practices (Feder et al., 2004).

To make it understandable and consistent with the objective of this paper and the design of agricultural extension program in Ethiopia, the pathways showing how the extension program impact agricultural productivity are illustrated in Figure 4.1.

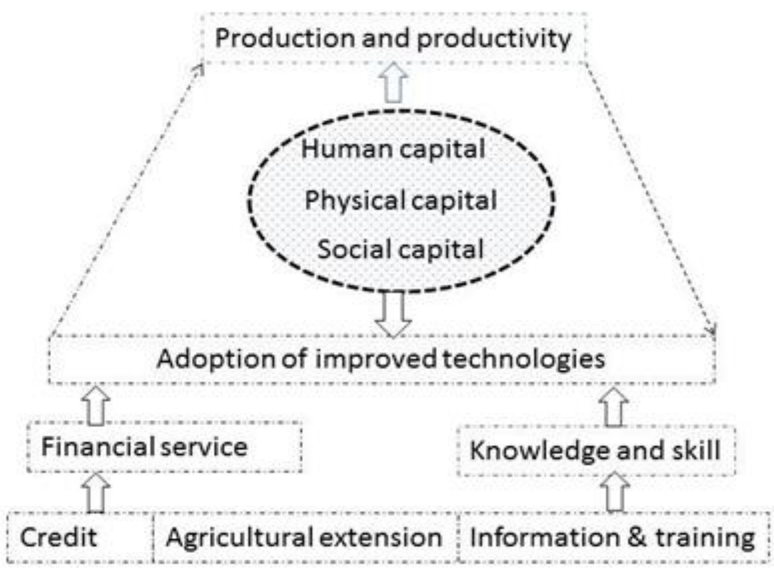

Figure 4.1: Impact pathway of agricultural extension on farm

The mechanism to increase production and farm productivity through agricultural extension services are mainly tied with adoption of improved seeds, inorganic fertilizers, agro chemicals (herbicide and pesticide) and credit for the Ethiopian smallholders.

By facilitating credit services via cooperatives and microfinance institutions (e.g., credit in cash or in kind), the extension program enhances farmers' financial capacity which leads farmers to adopt improved technologies as well as practices that will ultimately meet their local farm production. Equally important, the extension service facilitates the adoption of improved technologies through awareness creation, acquiring knowledge and skill with dissemination of information and providing training that will ultimately help increase agricultural productivity. However, whether farmers actually adopt improved technologies and practices being promoted by the program is conditioned by several other household and farm level factors as well, such as human capital (sex, age, education level, and labour), physical capital (land size, livestock ownership), social capital (membership in farmers' organizations) and others (soil type, slope of the land, and farm management practices like intensity of ploughing frequency). The possible effect of each variable on land productivity has been hypothesized in Section 4.3

4.3 Model specifications

This study uses a combination of three methods (a benchmark Ordinary Least Square, Heckman's Treatment Effect and Propensity Score Matching) to assess the effect of participation in agricultural extension program on farm productivity.

4.3.1 The "benchmark" OLS model

We start with a baseline model by estimating the impact of agricultural extension program (AE) participation on productivity using OLS.

The model is specified as follows:

$$Y_{ij} = \beta x_i + \psi x_j + \delta AE_i + \epsilon_{ij} \qquad (4.1)$$

where, i and j denotes household and plot level characteristics, the dependent variable Y_{ij} denotes the natural logarithmic transformation of gross value of crop produced per hectare (expressed in Ethiopian Birr[4]/ ha), x_i is a vector of household level explanatory variables (sex, age, education level, labor, livestock ownership, membership in farmers' organization), x_j refers plot level explanatory variables (plot size, slope, soil fertility, amount of agrochemicals and

[4] Birr is Ethiopian currency and during the survey period 1US$ = 17 Birr.

inorganic fertilizer, compost, seed type, tenure type, draft power ,plot distance from home stead and ploughing frequency), β, ψ and δ are vector of parameters to be estimated, AE_i is a dummy variable indicating whether or not the ith household participate in the agricultural extension program and ϵ_{ij} is the error term. In this "benchmark" specification, the dummy has a constant coefficient, which gives the average treatment for the treated (ATT). The parameter δ measures the effect of AE program participation on farm productivity.

The effect of explanatory variables on the dependent variable has been hypothesized as follows. The variable age can be considered as an indicator of farming experience, on the other hand, those who are aged households may be reluctant to take up and apply improved technologies as a result the effect of age on crop productivity is ambiguous. Higher level of household education is likely to be associated with higher productivity because education enhances the ability of individuals to utilize technical information and such households would have better use of technologies and farming practice via access to information. On the other hand, there could be cases that educated households have high chance of engaging themselves in other non-farm related activities such as sideline business, involvement in *kebele* administration that would leave them with little time to spend on their farming activities. Regarding the sex of household head, most studies in developing countries report that female-headed households are the poorest and marginalized people due to their resource and other constraints such as access to credit, market information, assets, technical knowledge, cultural taboos and the likes. Hence we expect male-headed households would have better crop productivity than female headed households.

Physical capital or asset ownership which is usually used as a proxy to explain the wealth status of rural households can be explained by different variables. These are land and livestock which have been shown to overcome credit constraints in rural areas (Thirtle et al., 2003). The estimated coefficient is thus expected to be positive.

Social capital such as membership in farmers' organization might have indirect influence on productivity. This type of organization is mostly targeted by extension workers to disseminate information about improved technologies and farm practices. Therefore those farmers who are members of farmers' organizations might have greater chance to adopt technologies that lead to increase productivity.

OLS estimate of the coefficient for AE participation dummy is unbiased as far as participation is random. However, if the sample of the participants and non-participants is non-random, as it is often the case with non-experimental data like the data this study used, OLS estimates of δ lead to a biased result. There are several approaches to deal with this problem (e.g. Heckman & Robb, 1985; Rosenbaum & Rubin, 1985; Angrist & Imbens, 1995; Wooldridge, 2010). The sample selection problem may arise from (1) self-selection where the households themselves decide whether or not to participate in extension program, due to differential resource endowments and/or (2) endogenous program placement where those who administer extension program (such as development agents) select households with specific characteristics (relatively poor or reasonably wealthy). As a result, extension participation may not be random that could give us a biased OLS result. To address the possible sample selection bias this study employed Heckman Treatment Effect and Propensity Score Matching techniques as discussed below.

4.3.2 Heckman's treatment effect model

One of the most widely used approaches to deal with selection bias is the Heckman treatment effect model. The Heckman correction, a two-step statistical approach, offers a means of correcting for non-randomly selected samples. The model can be specified in two steps:

Outcome equation:

$$Y_{ij}=\beta x_i + \psi x_j + \delta AE_i + \epsilon_{ij} \quad (4.2)$$

This is the same as the OLS equation in Eq. (4.1)

Selection equation:

$$t_i^*=Z_i\gamma + \upsilon_i,\ t_i = 1 \text{ if } t_i^* > 0 \text{ and } t_i = 0 \text{ otherwise.} \quad (4.3)$$

Where t_i^* is the latent endogenous variable i.e. extension participation, υ is error term of the selection equation, Z_i is a set of exogenous variables predicting the selection of households into the extension program, ϵ_i and υ_i are bi-variate normal with mean zero and covariance matrix$\begin{bmatrix} \sigma_\epsilon & \rho \\ \rho & 1 \end{bmatrix}$. Where ρ is the correlation between ϵ and υ, and σ_ϵ is the variance of ϵ. The inverse mills ratio, λ, is a product of this two i.e. $\hat{\lambda} = \hat{\sigma}_\epsilon\ \hat{\rho}$[5].

Selection equation: Probit model is estimated in which extension participation is regressed on a set of household characteristics Z_i. Variables included in the selection equation are: age of the household head (Age), total land holding of the household (LSize), owned livestock (TLU), family labor in adult equivalent (Adequv), distance from plot to extension center (Pdadist), number of oxen used (Oxenday) and a set of dummies indicating (i) whether the household head is educated (Educ) (ii) whether the household is member of *kebele* administration (Kebadm) and (iii) whether the household is member of farmers' organization (Frorg). Each of these variables is expected to only affect farm productivity through their impact on participation. The extension program participation equation is given by:

$$\Pr(\text{AEParticipation}_{i=1}) = \Phi[\gamma_o+\gamma_1\text{Kebadm} +\gamma_2\text{ Frorg} +\gamma_3\text{Age}+\gamma_4\text{Educ}+ \gamma_5\text{Pdadist}+\gamma_6\text{LSize} + \gamma_7\text{ Adequv}+\gamma_8\text{TLU}+\gamma_9\text{Oxenday}+ \upsilon_i] \quad (4.4)$$

The choice of the explanatory variables included in Z is guided by previous empirical literature on the decision of participation in development intervention programs.

Age can influence participation negatively or positively. Older farmers are often viewed as less flexible, and less willing to engage in a new or innovative activity due to fear of risk whereas young farmers may be more risk averse to implement new technologies on their farm. Hence, the influence of age on participation decision is ambiguous. Education might have positive contribution for participation in two ways. Either the farmers select the program due to their ability to understand the cost and benefit of participation in the program as well as easily understand how to implement new technologies (Doss and Morris, 2001) or extension program might target farmers who are educated due to their capacity of investing in improved technologies through participation in the non-farm sector (Barrett et al., 2001; Cunguara and Moder, 2011).

[5] The treatment effect assumes non-zero correlation between ϵ and υ and hence violation of this assumption can lead to biased estimation.

Wealth (land, livestock ownership, and family size in adult equivalent scale) might help farmers mitigate incomplete credit and insurance markets (Zerfu and Larsony, 2011; Ayalew and Deininger, 2012). Extension program may also target wealthier farmers due to their financial capacity to adopt improved technologies, and thus extension workers might want to deal with them to implement improved technologies promoted by the program.

In the study area, a hard-working and productive farmer is often described by the locals by how well he/she does the different farm activities starting from land preparation to post-harvest. The quality of doing these activities can better be estimated from the number of oxen days a farmer used at plot level, which was collected during our survey. Hence this study used number-of-oxen days to characterize each farmer's commitment to farming and such kind of farmers might have high probability of participation in the extension program.

Membership in farmers' organizations can influence participation positively due to either extension workers might find it cheaper to target farmers group which helps them maximize the payoffs from efforts to build farmers capacity to demand advisory service (Benin et.al., 2011; Cunguara and Moder, 2011) or membership in a social group provides opportunities to discuss and observe practices of other members at no cost or time intensity (Gebreegziabher, et al., 2011).

Involvement in *kebele* administration could influence participation positively. One *kebele* consists of four to seven villages and these villages are often relevant units for government initiatives and program. A village consists of *limat budin*, or development team for the implementation of a range of government activities, including mobilizing household labor for community projects. They also have political functions, such as mobilizing support and votes for the ruling party. Extension workers often work closely with *limat budin* (Cohen and Lemma, 2011; Birhanu, 2012). Hence, being in a position to involve in *kebele* administration with such kind of network system might increase the probability of participation in government sponsored extension program. We do not expect involvement in *kebele* administration to be correlated with farm productivity hence it might function as an identifying variable in the sample selection model.

The productivity equation is estimated in which farm productivity is regressed on a set of household and plot level characteristics. This is similar to those variables used in the OLS regression with additional regressor the Inverse Mill's Ratio (IMR) or Lambda **(**the residuals produced by the first-stage estimate of HTEM) included as a control variable in the productivity equation.

Outcome (farm productivity) equation is given by:

$$Yield_{ij}=\alpha+\delta AEParticipation_i+\beta_1 Sex_i+\beta_2 Age_i+\beta_3 Educ_i+\beta_4 TLU_i+\psi_1 PlotSize_{ij}+\psi_2 Slope_{ij}+\psi_3 Soilfertility_{ij}+\psi_4 Agrochemical_{ij}+\psi_5 Compost_{ij}+\psi_6 Fertlizer_{ij}+\psi_7 Seedtype_{ij}+\psi_8 Dist_{ij}+\psi_9 Tenuretype_{ij}+\psi_{10} Oxenday_{ij}+\psi_{11} Labour+\psi_{12} Ploughingfrequency_{ij}+\psi_{13} Cropdummy_{ij}+\psi_{14} Sitedummy_{ij}+IMR+\epsilon_{ij} \quad (4.5)$$

where, i is household characteristics and j denotes plot characteristics.

However, a major limitation of the Heckman treatment model is that it imposes a linear form on the productivity equation and it extrapolates over the regions of no common support, where no similar participant and non-participant exist. But economic theory suggests that imposing such distributional and functional restriction may lead to biased result (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002; Heckman and Navarro-Lozano, 2004). Therefore, this study complements the analysis with semi-parametric matching approach (Rosenbaum and Rubin, 1985) to ensure the robustness of our previous model estimations.

4.3.3 Propensity score matching method

Matching is a widely used non-experimental method of evaluation that can be used to estimate the average effect of a particular program (Smith and Todd, 2005; Caliendo and Kopeinig, 2008). This method compares the outcomes of program participants with those of matched non-participants, where matches are chosen on the basis of similarity in observed characteristics. Suppose there are two groups of farmers indexed by participation status P = 0/1, where 1 (0) indicates farms that did (not) participate in a program. Denote by y_i^1 the outcome (farm productivity) conditional on participation (P = 1) and by y_i^0 the outcome conditional on non-participation (P = 0).

The most common evaluation parameter of interest is the mean impact of treatment on the treated, $ATT = E(y_i^1 - y_i^0 \mid p_i = 1) = E(y_i^1 \mid p_i = 1) - E(y_i^0 \mid p_i = 1)$, which answers the question: ‘How much did farms participating in the program benefit compared to what they would have experienced without participating in the program?’ Data on $E(y_i^1 \mid p_i = 1)$ are available from the program participants. An evaluator’s main problem is to find $(y_i^0 \middle| p_i = 1)$, since data on non-participants enables one to identify $E(y_i^0 \middle| P = 0)$ only. So the difference between $E(y_i^1 \middle| P = 1)$ and $E(y_i^0 \middle| P = 1)$ cannot be observed for the same farm.

The solution advanced by Rubin (1977) is based on the assumption that given a set of observable covariates X, potential (non-treatment) outcomes are independent of the participation status (conditional independence assumption-CIA): $y_i^0 \perp S_i \mid$ X. Hence, after adjusting for observable differences, the mean of the potential outcome is the same for P = 1 and P = 0, $(E(y_i^0 \middle| P = 1, X) = E(y_i^0 \middle| P = 0, X))$. This permits the use of matched non-participating farms to measure how the group of participating farms would have performed, if they had not participated.

Like the Heckman treatment effect model, propensity score matching has two-step. First, the propensity score (pscore) for each observation is calculated using logit model for AE participation (estimating a first-step equation similar to equation 3). The second step in the implementation of the PSM method is to choose a matching estimator. A good matching estimator does not eliminate too many of the original observations from the final analysis while it should at the same time yield statistically equal covariate means for treatment and control groups (Caliendo and Kopeinig, 2008). Hence, a kernel matching algorithm is used to pair each AE participant to similar non-participant using propensity score values in order to estimate the ATT. This study also analyzed the data using alternative matching estimators to check the robustness of the results.

As explained above, the main assumption of PSM is selection on observables, also known as conditional independence or unconfoundedness assumption. Therefore, the specification of the propensity score is crucial because the logit model results depend on the unconfoundedness and overlap assumptions among others. Unconfoundedness assumption implies that adjusting for differences in observed covariates removes bias in comparisons between the two similar groups that only differ by AE participation. In other words, beyond the observed covariates, there are no unobserved characteristics that are associated both with the potential outcome and the treatment (Imbens and Wooldridge, 2009). Although unconfoundedness is formally untestable, there are ways to assess its plausibility. To address the unconfoundedness assumption in this study, different measures are taken such as inclusion of many covariates in the propensity score specification to minimize omitted variables bias following the suggestion in (Smith and Todd, 2005), then matching is implemented on the region of common support (Heckman et al., 1997). In addition, a placebo regression was employed (Imbens and Wooldridge, 2009) as a robustness check of the impact estimates to unobserved selection bias. This approach was also used by Abebaw and Haile (2013) and Cunguara and Moder, (2011) to test unobserved bias in the impact estimate.

The overlap assumption implies that the conditional distributions of the covariates of AE participants overlap completely with non-participants (Dehejia and Wahba, 2002; Imbens and Wooldridge, 2009). There are two formal methods of testing the overlap assumption. The first is to plot the distribution of the propensity scores of AE participants and non-participants and visually assess whether the overlap assumption holds or not. The second method is to compute normalized differences between the two groups (Imbens and Woolridge, 2009). The normalized difference is given by:

$$\Delta x = \frac{\bar{x}_1 - \bar{x}_0}{\sqrt{\sigma_1^2 + \sigma_0^2}} \tag{4.6}$$

where $\overline{x_i}$ is the mean, and σ_i^2 is the sample variance.

4.4 Empirical results

4.4.1 Descriptive analysis of bio-physical and socio-economic conditions

Tables 4.1 and 4.2 indicate a summary of descriptive statistics for household and plot level data respectively. Regarding demographic characteristics, the result revealed that, the average age for participant farmers were slightly less than nonparticipants. Literacy rate is significantly high for participant (68 percent) household heads than those who did not participate (24 percent). The average family size is 6.35 and 4.89 for participants and non-participants respectively. Available active family labor in adult equivalent for participants is 3.22 and 2.61 for non-participants. Average land holding size for participants is 1.53 and 1.05 hectare for non-participants. The average owned livestock size in TLU is 8.91 and 4.48 for participants and non- participants respectively.

Access to credit remains very low for majority of sample households. Only 17 percent of participants and 16 percent of non-participants had access to credit. About 96 percent of participants and 58 percent of non-participants were members of farmers' organization.

Table 4.1: Descriptive statistics of household level data (n = 300) used in the econometric analysis

	All sample		Participant		Non- participant		
Variables	Mean	S.D	Mean	S.D	Mean	S.D	P-value
Age of Household head (HH) (years)	45.70	10.07	45.45	10.02	46.09	10.14	0.303
Sex of HH (1 = male,0 = female)	0.82	0.38	1.00	0.00	0.54	0.49	0.000
Education of HH(1 = literate, 0 = illiterate)	0.50	0.50	0.68	0.47	0.24	0.43	0.000
Family size	5.77	1.92	6.35	1.81	4.89	1.74	0.000
Available family labor (adult equivalent)	2.98	1.06	3.22	1.03	2.61	1.01	0.000
Owned land size (hectare)	1.34	0.63	1.53	0.60	1.05	0.57	0.000
Owned livestock (Tropical Livestock Unit, TLU)	7.14	3.92	8.91	3.83	4.48	2.18	0.000
Use of credit previous year(1 = yes, 0 = no)	0.16	0.37	0.17	0.37	0.16	0.37	0.839
Number of training received for the last three years.	3.79	5.31	5.72	6.08	0.89	1.10	0.000
Membership in farmer's organizations (1 = yes, 0 = no)	0.81	0.39	0.96	0.21	0.58	0.49	0.000
Involvement in *kebele* administration work (1= yes, 0= no)	0.25	0.44	0.46	0.49	0.01	0.10	0.000

Note: S.D: Standard deviation

Source: Own survey, 2012

Table 4.2: Descriptive statistics of plot level data (n = 1112) used in the econometric analysis

Variables	All sample		Participant		Non-participant		
	Mean	S.D	Mean	S.D	Mean	S.D	P-value
Value of crop produced per hectare (Birr/ha)*	12114	4721	13657	4834	9801	3431	0.000
Seed type (1 = improved, 0 = local)	0.43	0.49	0.53	0.50	0.27	0.44	0.000
Fertilizer used per hectare(kg/ha)	129.8	91.55	154.1	95.48	93.15	71.1	0.000
Compost used (1 = yes, 0 = no)	0.18	0.39	0.23	0.42	0.10	0.31	0.000
Chemical used per hectare(lit/ha)	0.29	0.55	0.36	0.63	0.18	0.39	0.000
Plot size (hectare)	0.28	0.15	0.29	0.15	0.25	0.14	0.000
Fertile soil (1 = fertile, 0 = otherwise)	0.24	0.43	0.24	0.43	0.23	0.42	0.725
Medium fertile (1 = medium fertile, 0 = otherwise)	0.58	0.49	0.58	0.49	0.58	0.49	0.874
Flat slop (1 = flat, 0 = otherwise)	0.32	0.47	0.32	0.47	0.33	0.47	0.779
Medium slop(1 = medium flat, 0 = otherwise)	0.54	0.50	0.52	0.50	0.58	0.49	0.057
Tenure type (1 = Owned, 0 = otherwise)	0.83	0.37	0.79	0.41	0.89	0.30	0.000
Plot distance from homestead (Walking minutes)	16.70	15.52	17.44	15.36	15.58	15.7	0.050
Amount of labor used per plot(person days/ha)	29.98	10.41	31.98	11.39	26.97	7.84	0.000
Amount of draft power used per plot(oxen days/ha)	20.03	10.21	22.45	10.83	16.39	7.96	0.000
Number of Ploughing frequency	4.92	1.41	5.11	1.41	4.63	1.38	0.000

Notes: *Average market prices were used to estimate aggregate crop production at the plot level, therefore production estimates are not affected by variation in local price.

S.D: Standard deviation.

Source: Own survey, 2012

Moreover about 46 percent of participant farmers are involved in *kebele* administration whereas the non-participant's involvement in *kebele* administration is only 1 percent.

The average value of crop produced per hectare is 13,657 birr for participants and 9,801 birr for non-participants. The amount of inorganic fertilizer, chemical (pesticide and herbicide), and seed inputs used per hectare were computed from the actual amounts of those inputs used on each plots standardized to a per hectare level. Accordingly, the average intensity of fertilizer used per hectare by the sample households is 129 kg, 154 kg and 93 kg for all sample plots, plots of participant and non-participants respectively, which is lower, compared to the recommended rate 200 kg per hectare. Our result is consistent with findings of Zerfu and Larsony (2011). The average intensity of chemical use rate by participants was 0.36 liters per hectare whereas non-participants used 0.18 liters per hectare. Average plot size is 0.28, 0.29 and 0.25 for all farmers, participants and non-participants respectively.

Generally the descriptive statistics result indicates that there is significant difference between participants and non-participants in terms of household characteristics, resource endowment, input use and productivity without controlling other factors. Therefore, our next question is what would happen if other factors controlled? The different models used in this study could give the answer.

4.4.2. Ordinary least square results

The results presented in Table 4.3 show that participation in extension program leads to increased farm productivity by about 6 percent. However, to measure the benefit of participation in the program in terms of farm productivity, it is necessary to take into account the fact that, individuals those who participated might have produced higher production even if they had not participated. That is, there may be unobserved factors (e.g. ability) that increases the likelihood of participation in the program that in turn increase productivity. When this is the case the impact of the program would be overestimated by simply regressing farm productivity on a binary variable that indicates participation in the extension program. To control this sample selection bias, we estimated equations (4) and (5) together using treatment effect model and the result is presented in the following section.

4.4.3 Heckman treatment effect model results

4.4.3.1 Determinants of extension program participation

The probit model for AE program participation shows that all variables except distance to extension center are significant determinants of participation in the current agricultural extension program. The model correctly predicted 70 percent of observed characteristics of participants and non-participants. The likelihood of participation in the extension program is affected significantly by age, education, livestock ownership, adult equivalent, oxen days, membership in farmers' organizations and involvement in *kebele* administration.

The negative and significant impact of household head age on the probability of joining the extension program indicates the lower likelihood of older farmer's participation in the program.

Table 4.3: Results of OLS and HTEM (Dependent variables: ln (value of crop produced/ha) and AE participation (1/0)

	OLS		HTEM		Probit	
Variables	Coef.	Std.err.	Coef.	Std.err.	Coef.	Std.err
AE participation	0.0606**	0.0265	0.179***	0.0445		
Sex of HH	0.0685***	0.0256	0.0482*	0.0281		
Age of HH (ln)	-0.0847**	0.0427	-0.0753*	0.0418	-0.949***	0.289
Education of HH	-0.0132	0.0189	-0.0425**	0.0210	0.852***	0.116
Owned livestock(ln) (TLU)	0.0403**	0.0165	0.00607	0.0197	1.463***	0.145
Plot size (ln)(ha)	0.0917**	0.0366	0.0729**	0.0358		
Flat slop	0.0778**	0.034	0.0758**	0.0306		
Medium slop	0.0308	0.0323	0.0317	0.0278		
Fertile soil	0.330***	0.0324	0.337***	0.0303		
Medium fertile	0.247***	0.0283	0.250***	0.0244		
Tenure type	0.00343	0.0253	-0.00742	0.0243		
Seed type	0.183***	0.0231	0.175***	0.0222		

Fertilizer (kg/ha)	0.0013***	0.0001	0.0013***	0.0001		
Compost	0.126***	0.0314	0.126***	0.0285		
Agro chemicals(lit/ha)	0.0307**	0.0153	0.0253	0.0161		
Plot distance to home-stead(ln)(walking minute)	0.0028	0.00912	0.0020	0.0088		
Draft power(ln)(oxen day/ha)	0.155***	0.0459	0.150***	0.041		
Labour (ln)(person day/ha)	0.137***	0.0418	0.124***	0.0397		
Ploughing frequency	0.0216**	0.00965	0.0224**	0.0094		
Sitedummy_Enerata (cf:Kebi)	0.0267	0.024	0.0255	0.0225		
Sitedummy_Wonka	0.106***	0.0201	0.105***	0.0212		
Cropdummy_wheat(cf:maize)	0.0599	0.052	0.0523	0.0447		
Cropdummy_t*eff*	0.208***	0.053	0.201***	0.0458		
Adult equivalent					0.178***	0.0615
Owned land (ha)					0.321**	0.118
Kebele administration					1.572***	0.257
Membership in farmers' organizations					1.292***	0.172
Oxen days					0.428***	0.101
Plot distance from extension center(ln)(walking minute)					-0.115	0.0774
Lambda			-0.0904***	0.0279		
Constant	7.477***	0.222	7.534***	0.212	-1.64	1.087
Observations	1,112		1,112		1,112	
R-squared	0.567					
LR test of indep. eqns. (rho = 0): chi2(1) = 8.37 Prob > chi2 = 0.0038						

*** p<0.01, ** p<0.05, *p <0.1

Source: Own survey, 2012

This can be explained by the fact that older farmers are reluctant to accept new information and improved technologies. This result is consistent with studies reported by Genius et al (2006). However, this result is contradicting with observations made by Tiwari et al. (2008); Mendola, (2007). Hence, the impact of farmers' age on extension participation and/or technological adoption is ambiguous as expected. Education increases the probability of joining the extension program. This is consistent with the notion that farmers with better human capital like education are among the early adopters (Gebreegziabher et.al, 2011; Giovanopoulou et al., 2011).

As hypothesized, all wealth indicator variables have significant effect on the probability of participation. One more tropical livestock unit increases the probability of participation in the extension program by about 14 percent. Owned land and family size in adult equivalent scale also increases the likelihood of participation. One of the characteristics of Ethiopian agriculture is its labour intensive nature; hence, households who have large number of family size in adult equivalent scale have high likelihood of participation in the extension program.

As expected, use of intensive oxen power is positively significant with participation. This implies that farmers who are believed to be hard-working have a high chance of joining the extension program and other similar development interventions in a bid to improve their productivity. However, the measurement used to characterize a hardworking farmer is still a subject of refinement in future researches.

Membership in farmers' organization has positive significance for the probability of participation in the extension program as expected and consistent with past findings (Benin et al., 2011; Abebaw and Haile, 2013).

Involvement in *kebele* administration has the highest coefficient value among all the variables which affect the likelihood of participation. This implies that being affiliated with *kebele* administration, which is a nonfarm related activity, increases significantly the likelihood of farmers to join the extension program. This is due to lack of clear boundary between the extension program and the political administration which often share common human and material resources. For instance, as explained in our assumption, development agents often work closely with development team who are the major components of the *kebele* structure established by the government. The development team has also political functions, such as mobilizing support and votes for the ruling party (Cohen and Lemma, 2011; Birhanu, 2012). Hence, it is not surprising that being in a position to involve in *kebele* administration increases the probability of participation in government sponsored extension program. Previous studies show that involving in local administration facilitates access to credit and fertilizer because these supplies are channeled through local agencies (Ayalew and Deininger, 2012; Zerfu and Larsony, 2011). Furthermore other studies show that implementation modalities are given to local agencies, so that the system is potentially open to local influence (DSA, 2006). This fact is confirmed by World Bank (2010) report; politicians provide public services to clients in exchange for political advantage. This, in turn, leads to inequality in service provision, typically to the disadvantage of female and the poor.

4.4.3.2 Effect of extension program participation on farm productivity

The result from HTEM in Table 4.3 shows that participation in AE increases farm productivity by about 20 percent. Unexpectedly the HTEM estimation for the effect of AE participation on productivity is higher compared to OLS estimation (6 percent), which was estimated without treating the endogenity of extension participation. The inverse mills ratio is negatively significant which indicates the presence of serious selection bias, due to the fact that program participants were selected by other nonagricultural related affiliations such as involvement in *kebele* administration (Table 4.3).

Other factors which have positive influence on farm productivity were sex of household head, age, plot size, soil quality, slope of the plot, use of improved seed, amount of inorganic fertilizer, application of compost, ploughing frequency, labour and oxen days. All significant variables have the expected signs. Male headed households have 5 percent higher farm productivity than female headed households. The result is consistent with literatures which deals with the existence of gender variation in productivity (Pender and Gebremedhin, 2007) due to constraints related to labor, resource endowment, access to information and cultural taboo.

According to our result, as age increases farm productivity decreases. This could be attributed to the reason that getting older might pose disadvantages in agriculture because most of the work is physically demanding and also because older household heads might be too conservative to try new and more efficient techniques that could help to increase farm productivity. This result is consistent with the findings of Gul Unal (2008) and Dong et al. (2010).

Despite the importance of education in increasing farm productivity (Alene and Manyong, 2007; Gebremedhin et al., 2009), surprisingly its effect was negatively significant. This could be partly attributed to the fact that educated farmers are involved in non-agricultural related activities (e.g. *kebele* administration in this study context), which would consume much of their farming time. However this is a tentative hypothesis to explain the unexpected result and needs further empirical study.

Plot size is positively significant with farm productivity. An increase in plot size by one hectare could increase yield by about 0.073 percent. This finding is consistent with earlier observations by Sharma et al. (1999), Lundvall and Battese (2000), and Alvarez and Arias (2004), who have all reported a positive relation between average land productivity and land size.

As expected, crop yield on fertile soil is higher due to the good quality advantage of such soils. Ploughing frequency has also significant positive effect for farm productivity. Similarly improved seed use increases productivity by 19 percent, indicating the relative importance of promoting improved seed to increase crop productivity in Ethiopia. Application of compost increases productivity by 13 percent. This reinforces the importance of soil fertility management in the Ethiopian agriculture. An increase in fertilizer use by about 50 kg/ha increases yield by about 7 percent[6].

4.4.4 Propensity score matching results

As shown in Table 4.4, the propensity scores for each observation is calculated using logit model to predict the conditional probability of participation in AE program. The empirical model for AE participation correctly predicts 71 percent of the sample observations. The region of common support for the distribution of estimated propensity scores of participants and non-participants ranges between 0.014763 and 0.900497. Observations whose propensity score lies outside this range are discarded. The distributions of the propensity scores are plotted in Figure 4.2.

[6] Semi-elasticities are estimated using the following formula: $\left[exp^{(\beta_{j} \Delta x_{j})} - 1\right] * 100$.

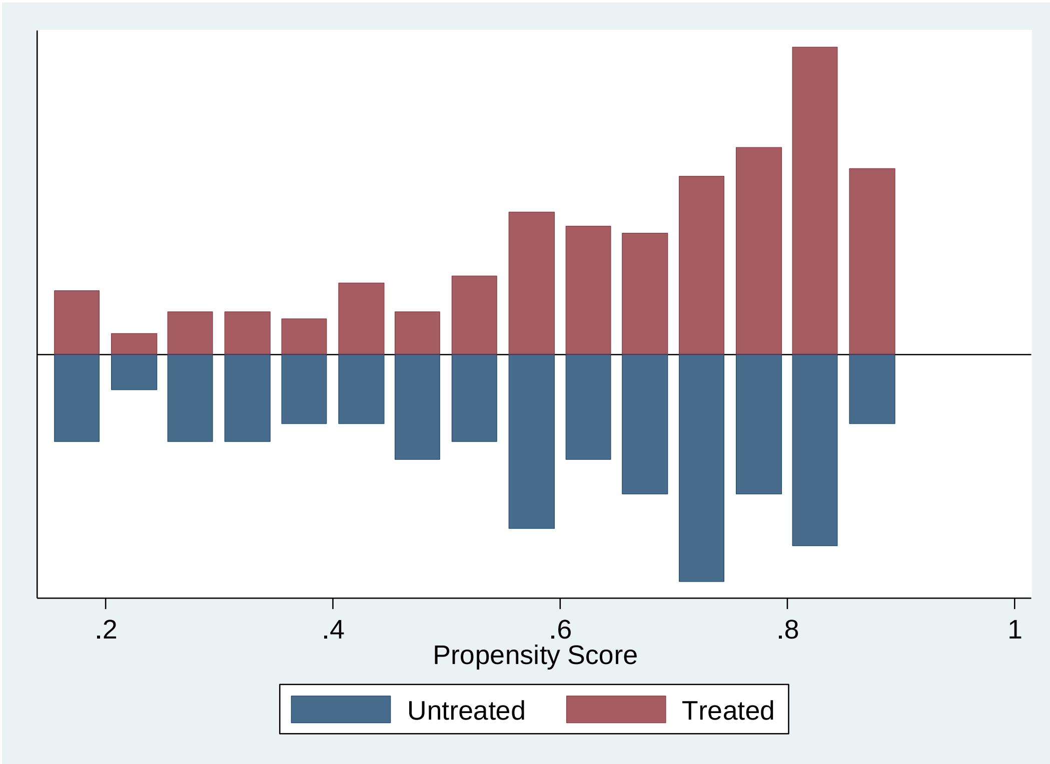

Figure 4.2: Propensity score distribution of matched samples

Most of the covariates in the logit model have the expected sign and comply with our previous result. The estimation results indicate that participation in AE program is strongly associated with the household's demographic characteristics and resource endowment as well as membership in farmers' organization and involvement in *kebele* administration. This result confirms again involvement in *kebele* administration, livestock ownership, and membership in farmers' organizations according to their importance order play a significant role on the likelihood of participation in extension program. From this, it can be generalized that the current agricultural extension program in Ethiopia is not targeting the majority poor. This finding is in line with the work by Lefort (2010) who reported that wealthier farmers are forcibly enrolled in the ruling party and appointed as model farmers who received privileged access to credit, state-controlled agricultural inputs, and technical knowledge spread by development agents.

Table 4.4: Estimation of the propensity score (Dependent variable: AE participation 1/0)

Variables	Coef.	Std.err.
Age of HH(ln)	-1.487***	0.541
Education of HH	1.479***	0.209
Owned livestock(ln)	2.582***	0.272
Owned land	0.419**	0.156
Adult equivalent	0.302***	0.108
Oxen days (ln)	0.745***	0.181
Plot distance from extension center(ln)	-0.154	0.145
Kebele administration	2.987***	0.526
Membership in farmers' organizations	2.348***	0.331
Sitedummy_*Enerata(cf:Kebi)*	-0.009	0.259
Sitedummy_*Wonka*	-0.068	0.243
Constant	-3.820*	2.048
Observations	1,112	
Pseudo R^2	0.5354	

*** p<0.01, ** p<0.05, *p<0.1

Source: Own survey, 2012

4.4.4.1 Average treatment effect on the treated

The PSM method is employed in estimating the impact of participation in agricultural extension on farm productivity. The impacts are estimated using alternative estimators to ensure robustness. As indicated in Table 4.5, all the matching estimators show that participation in agricultural extension program has a positive and statistically significant effect on farm productivity. To ensure the reliability of the estimated results, assessment on the overlap and unconfoundedness assumptions are made.

Table 4.5: Estimating the ATT using different matching methods

Matching estimators	Coefficient	t-statistics
Kernel matching	0.203***	4.738
Stratification matching	0.190***	3.289
Radius matching	0.175***	2.763
Nearest Neighbor matching	0.327***	3.288

Note: Significance levels are based on bootstrapped standard errors with 50 replications.

*** p<0.01

Source: Own survey, 2012

4.4.4.2 Assessment on the overlap and unconfoundedness assumptions

To evaluate the overlap assumptions we checked whether the balancing requirements of PSM are satisfied in our data. The balancing test in Table 4.6 indicates that the covariates of the two matched groups are well balanced in contrast to the unmatched samples presented in Table 4.1. All results of normalized differences between the two matched groups are small, suggesting that the overlap assumption is reasonable. Imbens and Wooldridge (2009) consider a normalized difference greater than 0.25 (in absolute value) to be substantial to detect any lack of overlap. In addition as shown in Figure 4.2 the two groups have substantial overlap in their propensity score distribution.

The placebo regression (Table A.1) were employed using age of spouse of the household head as a dependent variable including AE participation and similar variables used in the estimation of the propensity scores. The dependent variable is known a priori not to be caused by AE participation. The result shows that AE participation does not have influence on the dependent variable, suggesting that there are no significant omitted variables that affect the impact estimates obtained by PSM method. Therefore, the unconfoundedness assumption about 'selection on observables' can be maintained and the causal interpretation of the results is plausible.

Table 4.6: Balancing test of matched samples

Variable	AE participants		Non-participants		Normalized difference (Δx)
	Mean	Standard deviation	Mean	Standard deviation	
Age of HH(ln)	3.823	0.258	3.823	0.206	0.00
Education of HH	0.451	0.498	0.377	0.487	0.07
Owned livestock(ln)	1.955	0.361	1.84	0.336	0.13
Owned land size	1.411	0.539	1.369	0.647	0.03
Adult equivalent	3.148	1.037	3.043	1.004	0.07
Oxen days (ln)	2.897	0.520	2.825	0.521	0.06
Plot distance from extension center(ln)	3.426	0.654	3.354	0.721	0.05
Kebele administration	0.040	0.199	0.018	0.135	0.03
Membership in farmers' organizations	0.977	0.148	0.918	0.275	0.07
Sitedummy_*Enerata(cf:Kebi)*	0.294	0.456	0.295	0.458	0.00
Sitedummy_*Wonka*	0.406	0.492	0.336	0.475	0.13

Source: Own survey, 2012

Generally, all the estimated results obtained from the different models confirm that AE participation in the study area have increased farm productivity. However, the overall level of farm productivity observed in this study for the three case study crops (*teff*, wheat and maize) is still low compared to the target yield set by the regional extension program based on farmers' field conditions and research stations (Table 4.7). For instance average *teff* yield observed form extension participants (16 quintal/ha) is less by half from the extension targets (20-32 quintal/ha). Similarly, the yield levels attained by participant farmers for wheat and maize were less by 1/3 from the set target for the corresponding crops (43-58 quintal/ha and 70-107 quintal/ha). Several reasons could explain these discrepancies. Our field investigation and review of past researches (Abate, 2007; Kasa, 2008) show that the extension implementation in Ethiopia is constrained by a number of factors such as supply-push rather than demand-pull approach, poorly organized technology multiplication system, absence of institutional pluralism, low technology adoption rate, shortage of basic training for extension staff and farmers. For example in our study area, average application of fertilizer, improved seed and compost users were 129 kg/ha, 42 percent and 18 percent, respectively. Besides, credit users in the study area were only 16 percent, influenced by the nature of credit arrangements that reduces the attractiveness of input uptake. To be eligible, a farmer must have repaid all previous loans (Dercon, 2000). Inconvenient payback time and lack of interest due to the tendency of farmers to avoid risk in instances of crop failure are other factors for farmers' low use of credit (Carlesson et al., 2005). Farmers who participated in our group discussion explained lack of quality improved seed, high price of fertilizers, limited technology choices and inconvenient loan system are the major constraints to adopt improved technologies promoted by the extension program. This fact is also observed by Byerlee et al. (2007) who concluded that some of the major factors affecting the results of the intensification program are low technical efficiency in the use of fertilizer, poor performance of the extension service, shortcomings in seed quality and timeliness of seed delivery, promotion of regionally inefficient allocation of fertilizer, no emergence of private-sector retailers negatively affected by the government's input distribution tied to credit. Furthermore our focus group discussion and field survey revealed that no single farmer has been visited by researchers implying the missing link between research and extension.

Table 4.7: Comparative average yields (quintal/hectare) of the three main crops grown in the study area

Type of crops	Participants' yield	Targeted yield on farmers plot	Yield obtained from research stations
Teff	16	20	32
Wheat	21	43	58
Maize	25	70	107

Note: Average yield obtained by participants is calculated from sample plots taken by this study. Average targeted yield on farmers plot and yield obtained by research station is taken from a guideline compiled by Agriculture and Rural Development Office of the Amhara National Regional state (2011).

4.5 Conclusions

This study evaluates the effect of agricultural extension program participation on farm productivity using cross-sectional data collected in three *kebeles* from the Ethiopian highlands. Even though the overall impact of extension program participation cannot be known for certain because of the lack of reasonably accurate baseline data for comparison, this study employs a bench mark OLS, treatment effect model and propensity score matching methods to mitigate some of the challenges in the estimation of effect of agricultural extension participation on farm productivity.

Our model estimations indicate the positive effect of extension participation on farm productivity. However, in spite of its positive effect, our finding clearly shows the existence of selection bias which tends to target relatively wealthier farm households and those affiliated to *kebele* administration, which is not directly related to farm productivity. These make the effect of agricultural extension program on farm productivity to be marginal. Furthermore, the program has been constrained by insufficient and/or poor quality farm inputs, such as improved seeds, and services like credit to buy inputs and training on how to implement the program. As a result, the observed overall farm productivity is less by about half than the target set by the extension program.

Therefore, in order to improve the benefits to be gained through agricultural extension program participation, the following constraints need serious consideration. First, the extension program should avoid entry barriers and this requires maintaining a clear boundary between the program and the local politics which is lacking at the moment. Second, improved access to diversified and quality agricultural inputs still remain critically important. Third, the local government should create the necessary asset portfolio among the poor due to the fact that resource poor farmers in Ethiopia lack the necessary means to implement extension advices.

Chapter 5

The effect of agricultural extension service on the technical efficiency of *teff* (E*ragrostis tef*) producers in North West Ethiopia

5.1 Introduction

The government of Ethiopia has made substantial investments in agricultural research and extension to increase agricultural production and productivity through new technologies. However, despite considerable technological changes attempted through expansion of modern agricultural inputs, agricultural production and productivity in the country remains low and encounter substantial inefficiencies due to farmers' high degree of unfamiliarity with new technology coupled with poor extension, education, credit, and input supply system (Alene and Zeller, 2005), as well as low technical efficiency in the use of modern inputs (Byerlee et al., 2007). According to World Bank (2006), farmers are only achieving on average 60 percent of their potential production, given current levels of input use. Since the introduction of new technologies requires intensive management and information, farmers in developing countries with low literacy rates, poor extension services and inadequate physical infrastructures have great difficulty in adopting new technologies, let alone exploiting their full potentials (Alene and Hassan, 2006). In Ethiopia, as stated above, measures have been taken to achieve high rate of adoption of new technologies, while little or no attention has been given to the question of whether there is appropriate application and efficient use of available resources and technologies.

Efficient utilization of resources is considered to be one of the most important issues in the production process. In microeconomic theory efficiency is decomposed in to technical (the subject of this chapter) and allocative efficiency. A producer is said to be technically efficient if production occurs on the boundary of the producer's production possibilities set, and technically inefficient if production occurs on the interior of the production possibilities set. Therefore, technical efficiency is the extent to which the maximum possible output is achieved from a given combination of available inputs. Any deviation from the maximal output is typically considered as technical inefficiency (Coelli et al., 2005). Hence, the presence of shortfalls in efficiency means that output can be increased without requiring additional conventional inputs and need for new technologies (Binam et al., 2004). If this is the case, then empirical measures of efficiency are necessary in order to determine the magnitude of the gain that could be obtained by improving performance in production with available resources.

Hence, the measurement of technical efficiency has relevance for policy intervention, especially, in countries, like Ethiopia, where resources are meager and opportunities for developing and adopting better technologies are scarce. However, studies that are systematically measuring technical efficiency of farmers who are participants and non-participants of agricultural extension (AE) program are scanty. Though previous studies by Seyoum et al. (1998); Khairo and Battese (2005); Ayele et al. (2006); Alene and Hassan (2008); Thangata and Mequaninte (2011) are available, they did not consider selection bias in agricultural extension participation. This study makes an attempt to go one step further and compare the difference in technical efficiency between the two groups that are similar in their observable covariates. Therefore, the objective of this study is to measure the effects of extension services and other factors on technical efficiency of teff producers and to identify determinant factors of inefficiency in three selected *kebeles* (peasant associations) of North West Ethiopia.

This chapter used data obtained from 578 *teff* plots cultivated by 300 participant and non-participant farm households of the extension program in Gozamin district, North Western Ethiopia.

5.2 Motivation for efficiency analysis of *teff* production in Ethiopia

Teff, (*Eragrostis tef*) is the main Ethiopian cereal crop annually grown on 2.5 million ha, and accounts for 30 percent of total acreage and 19 percent of gross cereal production (CSA, 2008). The crop has both its origin and diversity in Ethiopia, and plays a vital role in the country's overall food security. The straw is an important cattle feed source, and the high market prices of both its grains and the straw make it a highly valued cash crop for *teff* growing smallholder farmers. *Teff* is a highly versatile crop with respect to adaptation to different agro-ecologies, with reasonable resilience to both drought and waterlogging (Assefa et al., 2010). Scientific research on *teff* began in the late 1950s and over the years a number of improved varieties and management practices have been developed. Now a days it is one of the major cereal crops which is promoted by the agricultural extension program in Ethiopia. It has its own recommended rates of chemical fertilizer, seed and management practices (such as plouing frequency, weed control, postharvest activities among others). However, there is little adoption rate by farmers and have brought few impact on *teff* production (Assefa et al., 2011). In addition, despite *teff's* great significance to Ethiopians, its average yield has remained low (1.3 t/ha) and supply has not kept pace with demand. Furthermore, growth in *teff* production has mainly come from expanding the amount of land under cultivation (Agricultural Transformation Agency [ATA], 2012), which is a limited resource in Ethiopia. Therefore, *teff* production growth through land expansion would not be sustainable. Moreover, past studies on TE in Ethiopia were limited to very few crops; it even did not take into account *teff* crop. Therefore, it's important to study technical efficiency level of *teff* producers and identify determinant factors of inefficiency to understand by how much production can be grown through efficient utilization of available technology and resources.

5.3 Empirical framework

Technical efficiency (TE) can be measured by using input or output-oriented approaches. The input-oriented approach addresses the question "by how much can input quantities be proportionally reduced without changing the output quantities produced?" The output-oriented approach (which is the focus of this study, given we are considering developing country settings, the concern is rather not inputs are over-used but output short-fall) addresses the question "by how much can output be increased without increasing the amount of input use by utilizing the given inputs more efficiently?" (Coelli et al., 2005).

Frontier techniques have been widely used in determining the farm-level efficiency in developing countries' agriculture since the publication of a seminal article of Farrell (1957) on efficiency measurement and subsequent development of several approaches to efficiency and productivity measurement. Among the different approaches followed to measure efficiency, the stochastic frontier production function (SFPF) approach involving econometric estimation of parametric function (Aigner et al. 1977; Meeusen and van den Broeck, 1977) and nonparametric programming, known as data envelopment analysis (DEA), are the most popular. The stochastic frontier is considered more appropriate for assessing TE in developing countries' agriculture, where the data are often heavily influenced by measurement errors and other stochastic factors such as weather condition and others (Coelli et al., 2005; Dey et al., 2005).

With regard to the determinants of technical efficiency, there are two approaches to analyze. Several efficiency measurement studies (Bravo-Ureta and Pinheiro, 1997; Nyemeck et al., 2003; Nkamleu, 2004) have first estimated stochastic frontiers to predict farm-level efficiencies and then regress these predicted efficiencies upon farm-specific variables in an attempt to explain variations in output between firms in an industry. This is usually referred as a two-stage procedure. However, several economists have criticized the two stage procedure (Battese et al. 1989; Reifschneider and Stevenson, 1991; Battese and Coelli, 1995) arguing that the socioeconomic variables should be incorporated directly into the estimation of production frontier model because such variables may have a direct influence on the production efficiency. To overcome inconsistencies in the assumptions regarding the independence of inefficiency effects Battese and Coelli (1995) and Coelli (1996) extended the stochastic production frontier model by suggesting that inefficiency effects (u_i) are expressed as an explicit function of a vector of farm specific variables and a random error. The Battese and Coelli (1995) model allows estimation of the farm specific efficiency scores and the factors explaining efficiency variations among farmers in a single stage estimation procedure. This study applies this model.

5.3.1 Stochastic frontier production function

The Stochastic frontier model was first proposed by Aigner et al. (1977) and Meeusen and van den Broeck (1977) independently to account for the presence of measurement errors and other noise in the data, which are beyond the control of firms. The model decomposes the error term into a two-sided random error that captures the random effects outside the control of the firm (the decision making unit) and the one-sided efficiency component.

The stochastic frontier production function model is given by:

$$Y_i = f(x_i; \beta) \exp(v_i - u_i) \qquad (5.1)$$

where Y is the quantity of output on the ith firm, x is a vector of inputs used, β is a vector of parameters, $f(x_i; \beta)$ is a suitable production function, v is a random error term assumed to be independently and identically distributed as $N(0, \sigma_u^2)$, independent of u, which represents technical inefficiency and is identically and independently distributed as truncated normal, with truncation at zero of the normal distribution (Battese and Coelli, 1995). The maximum likelihood estimation of Eq. (1) yields estimator for β and γ, where $\gamma = \frac{\sigma_u^2}{\sigma^2}$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$. The total variation of output from the frontier, which is attributed to technical inefficiency, is given by γ and has a value between zero and one.

Battese and Coelli (1995) proposed a model in which the technical inefficiency effects in a stochastic production frontier are a function of other explanatory variables. In their model, the technical inefficiency effects, u are obtained by truncation (at zero) of the normal distribution with mean, μ_i and variance σ_u^2 , such that:

$$\mu_i = z_i\delta \tag{5.2}$$

where z_i is a vector of farm-specific explanatory variables and δ is a vector of unknown coefficients of the farm-specific inefficiency variables.

5.3.2 Self-selection into agricultural extension program participation

When estimating a production frontier the underlying assumption is that all farmers in the sample have access to the same production technology. But this study includes a sub-sample of farmers participating in AE program who have information access and technical support from extension workers. To account for differences in AE participation separate production frontiers are estimated for each sub-sample of farmers by previous studies (Seyoum et al., 1998; Alene and Hassan, 2006). These sub-samples, however, are unlikely to represent unbiased representations of the population. If farmers choose to participate in the AE program based on their expected performance, the two sub-samples will systematically differ with respect to certain farm and household characteristics. As discussed in chapter 4, several factors determine the decision to participate in extension program in the study area. These are age, education, livestock ownership, adult equivalent, use of oxen power, membership in farmers' organizations and involvement in *kebele* administration among others. Details of how these factors determine extension participation is found in chapter 4, section 4.3.2.

While these factors may influence the farmer's propensity to participate in the program and they are also likely to influence the farmer's production performance. Consequently, if selection bias is ignored in the estimation of separate production frontiers, coefficient estimates will be biased

(Heckman, 1979). A common approach to address selection bias is the two-step Heckman procedure (e.g., Solis et al., 2007). However, this procedure is less suitable for nonlinear functions such as the stochastic frontier. We therefore use matching techniques similar to those of Mayen et al. (2010) and Rao et al. (2012) to compare the TE of AE participant farms with similar non-participant farms. We employed a matching model known as propensity score matching (Smith and Todd, 2005; Caliendo and Kopeinig, 2008). Details of the propensity score matching method has already been discussed in chapter 4 section 4.3.3.

As explained in section 4.3.3, the main assumption of PSM is selection on observables, also known as conditional independence or unconfoundedness assumption. Therefore, the specification of the propensity score is crucial because the logit model results depend on the unconfoundedness and overlap assumptions among others. Unconfoundedness assumption implies that adjusting for differences in observed covariates removes bias in comparisons between the two similar groups that only differs by AE participation. In other words, beyond the observed covariates, there are no unobserved characteristics that are associated both with the potential outcome and the treatment (Imbens and Wooldridge, 2009). Although unconfoundedness is formally untestable, there are ways to assess its plausibility. To address the unconfoundedness assumption different measures are taken by this study such as we included many covariates in our propensity score specification to minimize omitted variables bias following the suggestion in (Smith and Todd, 2005), then matching is implemented on the region of common support (Heckman et al., 1997). In addition, we employed a placebo regression (Imbens and Wooldridge, 2009) as a robustness check of the impact estimates to unobserved selection bias. This approach was used by Abebaw and Haile (2013); and Cunguara and Moder, (2011) to test unobserved bias. The overlap assumption implies that the conditional distributions of the covariates of AE participants overlap completely with non-participants (Dehejia and Wahba, 2002; Imbens and Wooldridge, 2009). There are two formal methods of testing the overlap assumption. The first is to plot the distribution of the propensity scores of AE participants and non-participants and visually assess whether the overlap assumption holds. The second method is to compute normalized differences between the two groups (Imbens and Woolridge, 2009).

5.4 Empirical models

In preliminary analysis, the trans-log stochastic production function was found to be an adequate representation of the data, given the specifications of the Cobb-Douglass stochastic frontier production function. The trans-log stochastic production functional form of equation (1) is given by:

$$\ln(Y_{ij}) = \beta_0 + \beta_{01}(ST_{ij}) + \beta_1 \ln(LD_{ij}) + \beta_2 ln(LR_{ij}) + \beta_3 ln(OX_{ij}) + \beta_4 ln(SC_{ij}) + \beta_5 ln(FT_{ij}) + \beta_{12} ln(LD_{ij}) \ln(LR_{ij}) + \beta_{13} \ln(LD_{ij}) \ln(OX_{ij}) + \beta_{14} \ln(LD_{ij}) \ln(SC_{ij}) + \beta_{15} \ln(LD_{ij}) \ln(FT_{ij}) + \beta_{23} \ln(LR_{ij}) \ln(OX_{ij}) + \beta_{24} \ln(LR_{ij}) \ln(SC_{ij}) + \beta_{25} \ln(LR_{ij}) \ln(FT_{ij}) + \beta_{34} \ln(OX_{ij}) \ln(SC_{ij}) + \beta_{35} \ln(OX_{ij}) \ln(FT_{ij}) + \beta_{45} \ln(SC_{ij}) \ln(FT_{ij}) + \beta_{11}\, 1/2 \left[ln(LD_{ij})\right]^2 + \beta_{22}\, 1/2 \left[ln(LR_{ij})\right]^2 + \beta_{33}\, 1/2 \left[\ln(OX_{ij})\right]^2 + \beta_{44}\, 1/2 \left[\ln(SC_{ij})\right]^2 + \beta_{55}\, 1/2 \left[\ln(FT_{ij})\right]^2 + V_{ij} - U_{ij} \tag{5.3}$$

where ln denotes natural logarithm and Y_{ij} denotes the quantity of teff yield of the ith farmer on the jth plot in kilograms per hectare; ST_{ij} is Soil type dummy (1 = fertile, 0 = otherwise), LD_{ij} is land planted for teff production in hectares; LR_{ij} is family and hired labor used for *teff* production in person day/ha; OX_{ij} is oxen labor used for *teff* production in oxen day/ha; SC_{ij} is the value of seed and agro-chemicals (pesticide, insecticide and herbicide) in Birr/ha and FT_{ij} is chemical fertilizer used for *teff* production in kg/ha. The quantity of fertilizer used on some plots was zero, so we used the approach in Sherlund et al. (2002) and equated the natural logarithm of zero to the logarithm of one-tenth of the smallest non-zero value in the sample (which turned out to be 1 kilogram of fertilizer used on the plot). β_0, β_i are unknown parameters to be estimated. V is the symmetric random variable associated with disturbances in production. U is a non-negative random variable associated with technical inefficiency and is obtained by truncation (at zero) of the normal distribution with mean μ_i and variance σ_u^2 , such that:

$$\mu_{ij} = \delta_0 + \delta_1 AGE_{ij} + \delta_2 ADEQ_{ij} + \delta_3 EDU_{ij} + \delta_4 TLU_{ij} + \delta_5 LD_{ij} + \delta_6 CRD_{ij} + \delta_7 AE_{ij} + \delta_8 COP_{ij} + \delta_9 SET_{ij} \tag{5.4}$$

where AGE is household head age in year; ADEQ is family size in adult equivalent scale; EDU is education status of the household head (1 = educated, 0 = otherwise); TLU is livestock ownership in Tropical Livestock Unit; LD is land planted for *teff* production in hectare; CRD is use of credit the previous year (1 = yes, 0 = no); AE represents agricultural extension program participation as dummy variable; COP is a dummy variable representing member ship in cooperatives and SET refers seed type (1= improved, 0=otherwise). $\delta_{ij}'s,$ are unknown parameters to be estimated.

It should be noted that the above model for technical inefficiencies in equation (5.4) can only be estimated if the technical inefficiency effects,U_i are stochastic and have particular distributional properties (Coelli and Battese, 1996). These conditions lead to conduct different hypothesis test using generalized likelihood- ratio statistic, λ, given by:

$$\lambda = -2[\ln\{L(H_0)\} - \ln\{L(H_1)\}] \qquad 5.5)$$

where L(H_0) and L(H_1) denote the values of likelihood function under the null (H_0) and alternative (H_1) hypotheses, respectively. Given the specifications of the stochastic production frontier model in equations (5.3) and (5.4), the technical efficiency index is defined as the ratio of observed output to the corresponding frontier output is given by:

$$TE_{ij} = \exp\left(-U_{ij}\right) \qquad (5.6)$$

The prediction of technical efficiency is based on its conditional expectations, given the model assumptions (Battese and Coelli, 1995). The parameters for the stochastic production function model in equation (5.3) and those for technical inefficiency model in equation (5.4) are estimated simultaneously using maximum-likelihood estimation of Frontier 4.1 program developed by Coelli (1994), which estimates the variance parameter of the likelihood function in terms of $\gamma = \frac{\sigma_u^2}{\sigma^2}$ and $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

Unlike Cobb Douglas stochastic frontier production function the coefficients of translog production function does not have straight forward interpretation. Following Battese and Broca (1997), the elasticity of output with respect to the kth inputs are computed as:

$$\frac{\partial lnY}{\partial lnX_k} = \beta_k + \beta_{kk}\overline{lnX_k} + \sum_{j=1\neq k}^{k} \beta_{kj}\,\overline{lnX_{kj}} - \theta\left(\frac{\partial\mu}{\partial X_k}\right), \tag{5.7}$$

where μ is defined by equation (5.4) and θ is defined by:

$$\theta = 1 - \frac{1}{\sigma}\left\{\frac{\phi\left(\frac{\mu}{\sigma}-\sigma\right)}{\Phi\left(\frac{\mu}{\sigma}-\sigma\right)} - \frac{\phi\left(\frac{\mu}{\sigma}\right)}{\Phi\left(\frac{\mu}{\sigma}\right)}\right\} \tag{5.8}$$

where ϕ and Φ represent the density and distribution functions of the standard normal random variable, respectively. The last term in equation (5.7) excluded for all variables except land as it also included in the inefficiency effects model. The elasticity of production with respect to land has two components: the first component referred to as elasticity of frontier output and the second referred to as elasticity of technical efficiency (Battese and Broca, 1997). The elasticities are evaluated at the means of the natural logarithms of the inputs.

To address selection bias in AE program participation the following logit model is estimated to obtain the propensity scores:

$$pr(AE\ participation = 1) = z_i\alpha + e_i \tag{5.9}$$

where z_i is a vector of farm and farmer characteristics (age, education, land size, livestock ownership, family size, oxen power, distance from extension center, involvement in kebele administration, member ship in cooperatives and location). α is a vector of parameters to be estimated. The propensity score of each farm is the estimated probability of being AE participant.

To address the overlap assumption the normalized difference (Imbens and Woolridge, 2009) is given by:

$$\Delta x = \frac{\bar{x}_1 - \bar{x}_0}{\sqrt{\sigma_1^2 + \sigma_0^2}} \tag{5.10}$$

Where $\overline{x_i}$ is the mean, and σ_i^2 is the sample variance.

5.5 Empirical results and discussions

5.5.1 Descriptive analysis of unmatched samples

Table 5.1: Descriptive statistics of variables included in the PSM analysis

Variables	Definition	Participants (N=364)		Non-participants (N=214)		P-value
		Mean	S.D	Mean	S.D	
Age	Age of the head in year	45.52	10.03	45.45	9.99	0.937
Education	Education of the head(1 = educated,0 = otherwise)	0.679	0.468	0.229	0.421	0.000
TLU	Livestock ownership in Tropical livestock Unit	8.822	3.59	4.45	2.18	0.000
Owned Land	Total cultivated owned land in ha	1.532	0.591	1.06	0.582	0.000
Family size	Family size in adult equivalent scale	3.212	1.041	2.566	0.956	0.000
Oxen day	Oxen labour used for teff production in oxen day/ha)	100.33	51.76	84.81	37.19	0.000
pdadist	Distance from Plot to extension center(walking minute)	38.173	21.97	40.789	24.09	0.183
Kebele adminstration	Involvement in kebele administration work	0.398	0.490	0.014	0.117	0.000
Cooperatives	Member in cooperatives(1 = yes, 0 = no)	0.953	0.211	0.588	0.493	0.000

Source: Own survey, 2012

As shown in Table 5.1 there is significant variation between AE participants and non-participants in all household and farm related characteristics except age and distance from extension center. Participants have higher mean value for education, livestock ownership, land size, family size, oxen labor, involvement in kebele administration and membership in cooperatives. These observable characteristics are used to estimate the propensity score of unmatched samples to obtain comparable groups for frontier analysis.

5.5.2 Propensity score matching results

The logit estimates of the AE participation are presented in Table 5.2. The logit model has a pseudo R^2 value of 0.52 and correctly predicts 76 percent of AE participation. Several variables are statistically significant and associated with AE participation. As expected education increases the probability of joining the extension program. This result is consistent with the notion that farmers with better human capital like education are among the early adopters (Gebreegziabher et al., 2011; Giovanopoulou et al., 2011). As hypothesized, wealth indicator variables except owned land size have significant effect on the probability of participation. One more tropical livestock unit increases the probability of participation in the extension program by about 26 percent. Family size in adult equivalent scale also increases the likelihood of participation. This is due to the labor intensive nature of Ethiopian agriculture. Hence, households who have large number of family size in adult equivalent scale have high likelihood of participation in the extension program.

Involvement in *kebele* administration has high coefficient value which affects the likelihood of participation. This implies that being affiliated with *kebele* administration, which is a non-farm related activity, increases significantly the likelihood of farmers to join the extension program. This is due to lack of clear boundary between the extension program and the political administration which often share common human and material resources. Hence, it is not surprising that being in a position to involve in *kebele* administration increases the probability of participation in government sponsored extension program. Membership in farmers' organization has also positive significance for the probability of participation in the extension program as expected and consistent with past findings (Benin et al., 2011; Abebaw and Haile, 2013).

In order to improve the robustness of the estimate the matches are restricted to AE participant and nonparticipant who have common support in the distribution of the propensity score. The non-parametric kernel method is used to allow matching of AE participants with the whole sample of non-participants, since the technique uses the whole sample of the comparison with common support to construct a weighted average match for each treated sample (Heckman et al., 1997 and 1998). That is, the entire sample of non-participants in the comparison group is used to construct a weighted average match to each participant in the treatment group.

Table 5.2: Results of logistic regression on AE participation (1/0)

Variables	Coef.	Std.err.
Age (ln)	-0.587	0.739
Education	1.651***	0.296
TLU (ln)	2.624***	0.388
Owned land	-0.313	0.299
Family size	0.309**	0.151
Oxen days (ln)	0.735	0.497
Plot distance from extension center	-0.154	0.145
Kebele administration	2.646***	0.685
Membership in Cooperatives	2.397***	0.465
Sitedummy_Enerata(cf:Kebi)	-0.140	0.379
Sitedummy_Wonka	-0.324	0.323
Constant	-3.058**	3.058
Observations	576	
Pseudo R^2	0.5219	
Model prediction rate: 76%		

Source: Own survey, 2012

5.5.3 Assessment on the overlap and unconfoundedness assumptions

To evaluate the overlap assumption we checked whether the balancing requirements of PSM are satisfied in our data. The balancing test in Table 5.3 indicates that the covariates of the two matched groups are well balanced in contrast to the unmatched samples presented in Table 5.1. All results of normalized differences between the two matched groups are small, suggesting that the overlap assumption is reasonable. Imbens and Wooldridge (2009) consider a normalized difference greater than 0.25 (in absolute value) to be substantial to detect any lack of overlap. Imbens and Wooldridge (2009) also argue that the assessment of the overlap assumption can be improved by graphical representation. As can be seen from Figure 5.1 the distribution of propensity scores of the two groups (participant and non-participant) are almost identical.

Table 5.3: Balancing test of matched samples

Variable	AE-participants (N=112)		Non-participants (N=56)		Normalized
	Mean	Standard deviation	Mean	Standard deviation	difference (Δx)
Age (ln)	3.795	0.283	3.767	0.221	0.03
Education	0.392	0.491	0.339	0.478	0.05
TLU (ln)	1.766	0.385	1.699	0.373	0.07
Owned land	1.323	0.585	1.258	0.598	0.05
Family size	3.006	1.106	2.914	1.145	0.06
Oxen days (ln)	3.164	0.319	3.119	0.271	0.05
Plot distance from extension center	37.55	17.71	38.73	22.38	0.18
Kebele administration	0.008	0.094	0.017	0.133	-0.20
Membership in cooperatives	0.928	0.259	0.857	0.353	0.09
Sitedummy_*Enerata(cf:Kebi)*	0.241	0.429	0.232	0.426	0.01
Sitedummy_*Wonka*	0.429	0.497	0.375	0.489	0.05

Source: Own survey, 2012

The graphical representation thus reinforces the results based on the normalized differences, suggesting that the overlap assumption is not a concern any more.

To evaluate the unconfoundedness assumption the placebo regression (Appendix Table A.2) were employed using age of spouse of the household head as a dependent variable including AE participation and similar variables used in the estimation of the propensity scores. The dependent variable is known a priori not to be caused by AE participation. According to Cunguara and Darnhofer (2011), the results from these placebo regressions are not necessarily the proof that the unconfoundedness assumption holds. But non-rejection of the null hypothesis that the coefficient on AE participation is zero suggests that there are no omitted variables correlated with AE participation. The result shows that AE participation does not have influence on the dependent variable, suggesting that there are no significant omitted variables. Therefore, the unconfoundedness assumption about selection on observables can be maintained and the causal interpretation of the results is plausible.

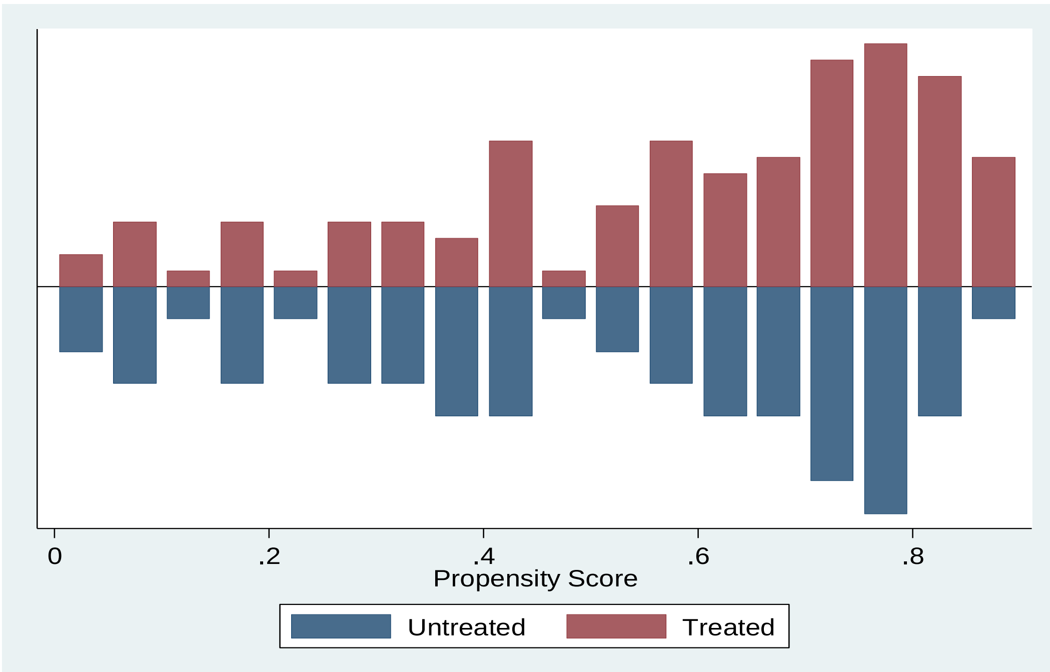

Figure 5.1: Propensity score distribution of matched samples

Table 5.4: Summary statistics of variables included in the efficiency analysis matched samples

Variables	Definition	Participants (N=112)		Non-participants (N=56)	
		Mean	S.D	Mean	S.D
Dependent variable: Yield	*teff* yield in kg/ha	1558.9	568	1285.6	358.0
Input variables:					
Soil type	1 = fertile, 0 = otherwise	0.25	0.434	0.23	0.426
Land	land planted to *teff* production in ha	0.299	0.166	0.333	0.159
Labour	labour used in person day/ha	125.6	69.86	106.4	33.37
Oxen day	oxen labour used in oxen day/ha	100.1	53.84	80.19	28.88
Seed and agro-chemicals	seed and agro-chemicals (pesticide and herbicide) cost in birr/ha	355.2	112.1	327.1	91.29
Fertilizer	chemical fertilizer used in kg/ha	140.0	93.95	85.51	43.44
Farm specific variables					
Age	Age of the head in year	46.24	12.68	45.27	10.51
Family size	Family size in adult equivalent scale	3.001	1.105	2.915	1.144
Education	Education of the head (1 = educated, 0 = otherwise)	0.392	0.491	0.339	0.478
TLU	Livestock ownership in Tropical livestock Unit	6.279	2.417	5.867	2.364
Plot size	Land planted to *teff* production in ha	0.299	0.165	0.333	0.159
Credit	Use of credit previous year (1 = yes, 0 = no)	0.232	0.426	0.196	0.399
AE participation	1 = participant 0 = non-participant	1	0	0	0
Cooperatives	Member in cooperatives(1 = yes, 0 = no)	0.928	0.259	0.857	0.353
Seed type	1 = improved seed, 0 = local seed	0.205	0.405	0.136	0.277

Source: Own survey, 2012

5.5.4 Parametric estimate of stochastic frontier production function

In our preliminary analysis we estimate two different models. In the first we assume that both participants and non-participants have the same production technology. The second assumption is both groups have different production technology. Using the model that allows for different technologies (estimating a frontier with the AE participation dummy and the interaction terms with all the inputs), we test the null hypothesis that all these coefficients are jointly equal to zero. The result from F-stat's P-value = 0.4153, indicates we cannot reject the null hypothesis that implies the two groups use same production technology. Hence the following frontier analysis result is based on same production technology assumption.

The maximum-likelihood estimates of the parameters of the translog stochastic frontier and inefficiency models based on PSM subsample are presented in Table 5.5. The functional specification is tested first. The choice of the empirical frontier production function was made based on the generalized likelihood ratio test (Coelli and Battese, 1996). The null hypothesis that the Cobb-Douglas model is appropriate representation of the data was strongly rejected (Table 5.6).

Table 5.5: Maximum likelihood estimates of the translog stochastic frontier and inefficiency model

Variables	Parameters	ML estimate	t-value	Elasticity of output	t-value
Stochastic frontier					
Constant	β_0	26.598	3.170***		
Soil type (dummy)	β_{01}	0.199	4.226***		
ln(Land)	β_1	-4.102	-2.025**	0.144	2.115**
ln(Labour)	β_2	-1.795	-0.628	0.236	1.99*
ln(Oxen day)	β_3	-2.101	-0.723	0.343	3.190***
ln(Seed and agro-chemicals)	β_4	-5.421	-2.366**	0.122	1.853*
ln (Fertilizer)	β_5	0.621	1.451	0.066	3.621***
ln(Land)x ln(Labour)	β_{12}	0.709	2.175**		

ln(Land)x ln(Oxen day)	β_{13}	-0.096	-0.297
ln(Land)x ln(Seed and agro-chemicals)	β_{14}	0.380	1.319
ln(Land)x ln (Fertilizer)	β_{15}	-0.101	-0.996
ln(Labour)x ln(Oxen day)	β_{23}	0.043	-0.076
ln(Labour)x ln(Seed and agro-chemicals)	β_{24}	0.222	0.488
ln(Labour)x ln (Fertilizer)	β_{25}	-0.127	-1.553
ln(Oxen day)x ln(Seed and agro-chemicals)	β_{34}	0.523	1.113
ln(Oxen day)x ln (Fertilizer)	β_{35}	-0.087	-0.917
ln(Seed and agro-chemicals)x ln (Fertilizer)	β_{45}	-0.004	-0.043
ln(Land)x ln(Land)	β_{11}	0.161	0.949
ln(Labour)x ln(Labour)	β_{22}	0.203	0.609
ln(Oxen day)x ln(Oxen day)	β_{33}	-0.056	-0.209
ln(Seed and agro-chemicals)x ln(Seed and agro-chemicals)	β_{44}	0.220	1.171
ln (Fertilizer)x ln (Fertilizer)	β_{55}	0.053	4.927***
Inefficiency model			
Constant	δ_0	0.464	2.299**
Age	δ_1	0.004	1.214
Family size	δ_2	0.032	1.097
Education	δ_3	-0.088	-1.018
TLU	δ_4	-0.039	-2.519**
Plot size	δ_5	-0.419	-1.081
Credit	δ_6	-0.242	-2.535**
AE participation	δ_8	-0.048	-0.708

Membership in cooperatives	δ_9	-0.011	-0.103
Seed type	δ_{10}	-0.239	-1.98*
Variance parameters			
Sigma-square	σ^2	0.063	4.266***
Gamma	γ	0.881	8.715***
Ln likelihood	27.896		

Source: Own computation

Therefore, the trans-log stochastic frontier and inefficiency model is more suitable to the farm survey data that adequately captures the production behavior of *teff* producer farmers in the study area. As expected, the frontier output elasticities (the percentage change in output divided by the percentage change of an input) of land, labor, oxen, seed and agrochemicals and fertilizer, are positive and significant. The dummy variable soil type has also positive and significant effect on *teff* production.

5.5.4.1. Factors influencing technical efficiency

The estimated coefficients of the explanatory variables in the model for technical inefficiency effects are of particular interest of this study and have important implications. The values for the parameters σ^2 and γ are reported at the end of Table 5.5. The parameter γ is statistically significant at the 1 percent level, with an estimated value of 0.88. These results indicate that inefficiency is highly significant among the studied farms. On top of that, the value of gamma (γ) indicates that there is 88 percent variation in output due to technical inefficiency. Furthermore, the null hypothesis $H_0: \gamma = 0$, tests whether the traditional average production function is appropriate as opposed to a frontier production function. As shown in Table 5.6, the test result revealed that the traditional response function is not an adequate representation of *teff* production in the study area, given the specifications of the translog stochastic frontier and inefficiency model. In other words, the result confirms that inefficiency exist and is indeed stochastic. The hypothesis that the explanatory variables in the model for the technical inefficiency effects have zero coefficients $H_0 = \delta_1 = \delta_2 == \delta_{10} = 0$ is rejected. This implies that joint estimation of the explanatory variables have a significant impact on technical efficiency.

Since the dependent variable of the inefficiency model, Equation 5.4, is defined in terms of technical inefficiency, a farm-specific variable associated with the negative (positive) coefficient will have a positive (negative) impact on technical efficiency. The results of the study in Table 5.5 indicate that, livestock ownership (TLU), credit and seed type are significant factors and have positive impact on technical efficiency (negative impact on technical inefficiency), while age of the head, family size, education, plot size, AE participation and member ship in cooperatives do not have significant effect in reducing technical inefficiency.

The variable (TLU) has a positive and significant effect on technical efficiency in *teff* production. Livestock holding is a proxy for liquidity or access to cash. It is obvious that the crop husbandry is highly supplemented and complemented by the animal husbandry. It has systematic effect on efficiency i.e., the farmer who possesses more number of livestock will have more money to purchase agricultural inputs, and again used for draft power especially *teff* production in Ethiopia needs intensive draft power from land preparation to post harvest and timely transportation of the yield. The result is in agreement with Ahmed et al. (2002); Alene and Manyong (2006); Alemu et al. (2009) who found a positive and significant effect of livestock ownership on technical efficiency.

Credit has a significant inefficiency reducing effect on technical efficiency. This implies that access to credit in cash and/or in kind is likely to enhance the technical efficiency of *teff* producer farmers in the study area through the alleviation of capital constraints and thus enables farmers to make timely purchases of inputs that they cannot afford from their own resources. In the study area, credit is used for purchase of oxen and agricultural inputs. Our result is in agreement with Binam et al., (2004); Alene and Hassan (2008); Assefa (2011); who found the inefficiency reducing effect of credit on technical efficiency.

Use of improved seed has a significant inefficiency reducing effect. Farms with improved seed are more efficient than farms using local seeds. The popular teff variety in general in Ethiopia and particularly in the study area is called Quncho. According to Assefa et al., (2011) and Fufa et al., (2011) Quncho was developed from an intra-specific hybridization between two improved pure line selection varieties (DZ-01-974 and DZ-01-196). However, the role of improved *teff* seed is not overemphasized due to shortcomings in seed quality and timeliness of delivery that have been longstanding issues in Ethiopia (spileman, 2011). According to DSA (2006) poor cleaning, broken seed, low germination rates and the presence of mixed seeds have been reported in supplied seeds. This fact is also confirmed during our discussion with farmers and extension workers.

Although insignificant, the influence of AE participation which is the main point of this study on technical efficiency tends to be positive. The insignificant positive effect of AE participation on technical efficiency might be due to poor performance in the operation of extension systems and information delivery systems. Our field investigation and review of past researches (Abate, 2007; Kasa, 2008) show that the extension implementation in Ethiopia is constrained by a number of factors such as supply-push rather than demand-pull approach, poorly organized technology multiplication system, absence of institutional pluralism, low technology adoption rate, shortage of basic training for extension staff and mainly the tendency of many extension stakeholders dealing with the transmission of knowledge to conduct their assignment in a top-down manner. Often, the information conveyed is presented as a technological package comprising recommended practices. This is perceived as a less effective method for improving knowledge and skill. In this case, more participatory approaches are suggested to extend science-based knowledge and practices (Braun et al., 2002). The empirical evidence regarding the influence of the Ethiopian agricultural extension service on technical efficiency is mixed.

Table 5.6: Generalized Likelihood Ratio (LR) tests of hypotheses involving the parameters of the stochastic frontier and inefficiency model

Null hypothesis	LR statistics (λ)	Critical value (x^2)	Decision
$H_0: \beta_{kj} = 0$ (Cobb-Douglas)	53.64	24.99	Reject H_0
$H_0: \gamma = 0$(tradional production function)	40.79	2.71	Reject H_0
$H_0: \delta_1 = \delta_2 == \delta_{10} = 0$	31.09	18.31	Reject H_0

Source: Own computation

For instance, Seyoum et al. (1998) and Khairo and Battese (2005) found a positive significant effect of agricultural extension service on technical efficiency of maize producers. On the other hand other studies conducted in Ethiopia by Alene and Hassan (2008) and Alemu et al., (2009) reported that agricultural extension participation has no effect on technical efficiency, which is consistent with our result.

5.5.4.2 Technical efficiency distribution

Frequency distributions of the TE estimates are presented in Table 5.7. Estimated TE scores revealed that nearly 22 percent of the farms achieved efficiency from 81 to 90 percent, nearly 11 percent from 91 to 100 percent and the rest below these ranges with the mean efficiency of all the farms about 72 percent. This means that farms are performing on average 28 percent below their potential level. With little changes in the production process like better use and allocation of resources, efficient farm management practices and farming decisions, TE and hence the production level of the farms could be increased by around 28 percent.

Table 5.7: Technical efficiency distribution of AE participant and non-participant *teff* producer farms

Efficiency score	AE participants		Non-participants		All	
	Number	Percent	Number	Percent	Number	Percent
<50	8	7.14	5	8.93	13	7.74
51-60	17	15.18	9	16.08	26	15.48
61-70	28	25	11	19.64	39	23.21
71-80	20	17.86	14	25	34	20.23
81-90	24	21.43	13	23.21	37	22.02
91-100	15	13.39	5	8.93	20	11.91
Mean	72.29		71.44		72.00	
Minimum	33.09		35.01		33.09	
Maximum	95.98		95.87		95.98	

Source: Own computation

Since most of the farms are operating below the frontier level there is ample space for *teff* output growth through full improvements in TE.

On the other hand, the mean TE estimates for AE participant and non-participant *teff* producer farms are almost similar. AE participant farms have an average TE of 72.29 percent and the corresponding measure for non-participants is 71.44 percent. The participants and non-participants can gain, respectively, an average *teff* output growth of 27.71 percent and 28.56 percent through full improvements in TE. Most (25 percent) of AE participant farms have TE score between 61 to 70 percent whereas 25 percent of non-participant farms have TE ranging between 71 to 80 percent.

5.6 Conclusions

This chapter employed propensity score matching technique that accounts for endogenity of agricultural extension participation to estimate technical efficiency of two types of farmers, participants and non-participants of agricultural extension program in Gozamin district, north western highlands of Ethiopia. Since *teff* is the main staple food in Ethiopia, high productivity and efficiency in its production are crucial to food security in the country. However, *teff* production under improved technology encounters substantial inefficiencies.

The econometric results based on the stochastic production function indicate that the mean technical efficiency estimates for AE participant and non-participant *teff* producer farms are almost similar i.e., 72.29 percent and 71.44 percent respectively. Therefore, AE participation has had no positive significant influence on technical efficiency of *teff* producer farms. Moreover, both groups of farms have considerable overall technical inefficiencies suggesting the existence of immense potentials for enhancing production through improvements in efficiency with available technology and resources. An investigation of the influence of household and farm specific factors on efficiency revealed that livestock ownership (TLU), credit and improved seed are positively influence technical efficiency.

Despite the long history of government investment in the agricultural sector through extension service and promotion of new technology, smallholders' *teff* production remains technically inefficient. Therefore, based on the results of this study the following points are suggested to enhance *teff* production via improvement in efficiency. First there is a need for providing extension services with respect to technical skill and farm management capacity of the farmers. Besides demand driven livestock extension service are needed to enhance the complementary role of livestock production in minimizing liquidity constraints of farmers. Second greater access to credit service for farmers are needed to enhance their financial capacity which leads them to adopt improved technologies as well as practices that will ultimately increase their efficiency in farm production. Third, increasing the availability, quality and adoption of improved seed is required.

Chapter 6

Gender roles in agriculture and its implication for agricultural extension: a case study in North West Ethiopia

6.1 Introduction

Empowering poor and vulnerable household groups in a fundamental manner, as opposed to providing them with transitory support, has been increasingly sought as a way of ensuring their effective participation in the development process (Barrett et al., 2006). A critical aspect of promoting gender equality is the empowerment of women. Gender equality is an essential component for sustainable economic growth and poverty reduction (FAO, 2010). As a result several literatures have alerted development practitioners to give emphasis for gender-specific constraints faced by poor female farmers (Quisumbing and Pandolfelli, 2010; Ragasa et al., 2012; Kiptot and Franzel, 2012).

In many parts of the world and especially in developing countries females are the main farmers or producers who are actively involved in agriculture (FAO, 2009; Rahman et al., 2007). According to FAO (2011), females comprise, on average, 43 percent of the agricultural labor force in developing countries, ranging from 20 percent in Latin America to 50 percent in Eastern Asia and Sub-Saharan Africa. The same report argues that reducing gender inequalities in access to productive resources and services could produce an increase in yields on female's farms of between 20 percent and 30 percent, which could raise agricultural output in developing countries by 2.5 percent to 4 percent. Realizing these gains requires male and female farmers to have access to information and assistance. But despite of female farmers' role in agricultural production, their roles remain largely unrecognized and they have been virtually ignored by agricultural intervention programs (World Bank, 2010). Failure to recognize the different roles of males and females is costly because it results in misguided projects and programs, forgone agricultural output and incomes, and food and nutrition insecurity (FAO, 2010).

Globally, rural females, especially those from poor households, face a particular burden. This fact is also common phenomenon in Ethiopia. Even though gender division of labour in rural Ethiopia varies in terms of farming systems, cultural settings, location and the different wealth categories (Abera et al., 2006), female farmers perform up to 75 percent of farm labor, representing 70 percent of household food production in Ethiopia (USAID, 2013), contribute more than their male counterparts in crop production and management in Ambo district (Ogato et al., 2009).

However, in spite of the many farming activities they perform (EEA/EEPRI, 2006; Kassa, 2008), they are not fully perceived as farmers and agricultural decision makers. Traditionally, the farming systems research and extension approach has obscured the complexity of female's position in regard to household labor requirements (Frank, 1999). Furthermore, the community consider farming as inappropriate activity and physically demanding for females. When females do participate in extension activities they may not be provided equal recognition for their responsibilities and skills. This is because farmers and farming activities continue to be perceived as "male" by planners and agricultural service deliverers, thereby ignoring the important and increasing role females play in agriculture. Moreover, technology packages delivered by extension services sometimes reinforce stereotypic divisions of labor (Manfre et al., 2013). For instance Ethiopia's Women's Development and Change extension package provides advice related to horticultural production, raising of poultry and small ruminants on the basis of the assumption that female do not farm but garden (World Bank, 2010; Cohen and Lemma, 2011).

In contrast to the national policy and Ethiopian government ideology that strongly promote gender equality in all aspects of life, the top-down approach, the perception that "females are not farmers" and the focus on getting model farmers to adopt fixed-technology packages (World Bank, 2010) and serious selection bias during placement of program participants (Elias et al., 2013), the agricultural extension program tends to neglect poor farmers in general and females in particular (Ogato et al., 2009; Umeta, 2013). Although gender training and mainstreaming take place in some areas, women focused extension approaches are limited, and gender considerations are missing at all levels (Buchy and Basaznew, 2005). Furthermore, the development and dissemination of agricultural innovations rarely take gender-specific characteristics and requirements into account (Action Aid and CARE, 2012).

The PASDEP (Plan for Accelerated and Sustained Development to End Poverty) annual progress report 2007/8 states that PASDEP aims to reach all female headed households and 30 percent of married females in agricultural extension programs. However, according to the GTP document of the Ethiopian government, increasing extension service to female farmers in rural areas remains challenging.

As stated above many research studies had been designed to investigate the rural females' involvement in agriculture but there is still inadequate database on 'what kind of farm activities females do' in different regions of Ethiopia especially for female headed households. To integrate females in any agricultural development project's design and implementation as well as to understand how interventions can be best be targeted, it is essential to have a complete knowledge of 'what females do' in a specific location and cultural setting. Because extension service demands are location specific, flexible and often quick decisions and actions. Therefore, the purpose of this study is to analyze the gender division of labor in agricultural production in Amhara region, Gozamin district and to understand the level of female headed households' participation in the current agricultural extension program–PADETES.

6.2 Empirical methods

Data collected from 300 (225 male head and 75 female head farm households) are used for the analysis. The extent of gender role in agricultural activities were measured by using a three point continuum namely 'Always', 'Sometimes' and 'Not at all'. Descriptive statistics, t test and chi-square tests are used to understand the variation in gender division of labour in agriculture, female headed households' participation in agricultural extension program as well as their access to and use of resources. The rank orders of constraints that inhibit female headed households' access to extension service are identified through calculating score values of the constraints. The constraint list included nine items and among these, the constraints given by the respondents as first constraint has given nine points and the last constraint has one point. And then, by adding up all values, the score value of each constraint is identified and the constraint that got the highest score value is taken as the most important constraint.

6.3 Results and discussion

6.3.1 Demographic characteristics by gender of household head

Using simple mean comparison tests (Table 6.1), female heads differ significantly from their male headed counterparts across a number of dimensions. Female heads are on average less educated than male heads. The gender disparity in schooling is not limited to the education of the head but is also true for the household at large. Female headed households also tend to be smaller, family size and labour force in terms of adult equivalent scale. Household size is proportional to the amount of labor resources the household controls in a rural area because many farm operations (especially oxen ploughing) require intensive labor. Hence, with respect to labor endowments female headed households are at a disadvantaged position.

Table 6.1: Mean difference test of demographic characteristics, access to human, physical, capital and social resources by gender of household head

Resources	Mean		Std.dev		P-value
	Male	Female	Male	Female	
Age of head	45.3	46.7	10.8	7.54	NS
Education of head (1=literate)	0.51	0.18	0.50	0.39	***
Number of educated family members	3.89	2.11	1.76	0.97	***
Family size	5.97	4.09	1.81	1.41	***
Active family labour in adult equivalent	3.03	2.42	1.01	1.03	***
Land size in hectar	1.44	0.89	0.64	0.37	***
Livestock ownership in TLU	7.54	3.54	3.82	1.71	***
Credit (1= Yes)	0.15	0.01	0.27	0.11	***
Training (1= Yes)	0.80	0.32	0.40	0.46	***
Leadership position (1= Yes)	0.27	0.01	0.44	0.11	***
Membership in cooperatives	0.87	0.38	0.02	0.06	***

Notes: *** and NS represent statistical significance at 1 percent and non-significance respectively

Source: Own survey, 2012

Female headed households are also worse off compared to their male counterparts in terms of land and asset ownership. Male headed households own 1.4 hectares of land, on average, compared to 0.89 hectares for female headed households. Male headed households also have an average of 7.5 TLUs, which is significantly different from female headed households' holdings of 3.5 TLUs. In terms of capital and social resources, men heads, on average, have better access to credit, higher leadership position and member ship in cooperatives than female heads. All these indicate the disadvantaged position of female headed households' in terms of human, physical, capital and social resources.

6.3.2 Gender division of labor in crop and livestock production

As shown in Table 6.2 about 92 percent of male heads and about 82 percent of female heads, except for oxen ploughing for females, are engaged in crop production and related management activities. In the study area like male farmers who involved in all aspects of agricultural activities, majority of the rural female heads do manual ploughing, planting, weeding, harvesting, threshing, production transport, production storage and marketing. This fact is also observed by Ogato (2009), World Bank (2010) and USAID (2013) that state females are intimately involved in all aspects of agricultural production process. Unlike other activities their involvement in fertilizer and pesticide application is low. Mainly these two activities are undertaken by their sons' or relatives and/or they are not using inputs at all.

Regarding the gender division of labour in livestock production (Table 6.3), about 71 percent of female heads are engaged in livestock production and related management activities whereas male heads involvement is only 36 percent. Pen cleaning, dung processing, feeding, poultry production, forage preparation as well as milking and milk processing are among the main activities performed by females. Majority of males are mainly involved in pen construction, herding, livestock selling, feeding and forage preparation respectively.

Table 6.2: Gender role for crop production in the three rural villages (Kebele's) during the main agricultural season

Activities	Frequency of doing crop production activities					
	Always		Sometimes		Not at all	
	Male	Female	Male	Female	Male	Female
	Number (percent)	Number (percent)	Number (percent)	Number (percent)	Number (percent)	Number (percent)
Oxen ploughing	222 (98.7)	0 (0.0)	3 (1.33)	0 (0.0)	0 (0.0)	75 (100.0)
Manual ploughing	175 (77.8)	69 (92.0)	37 (16.4)	3 (4.0)	13 (5.8)	3 (4.0)
Planting	223 (99.1)	75 (100.0)	0 (0.0)	0 (0.0)	2 (0.9)	0 (0.0)
Weeding	222 (98.7)	74 (98.7)	0 (0.0)	0 (0.0)	3 (1.3)	1 (1.3)
Fertilizer application	150 (66.7)	25 (33.3)	72 (32.0)	25 (33.3)	3(1.3)	25 (33.3)
Pesticide application	102 (45.3)	20 (26.7)	52 (23.1)	5 (6.7)	71 (31.6)	50 (66.7)
Harvesting	223 (99.1)	74 (98.7)	1 (0.44)	0 (0.0)	1 (0.4)	1 (1.3)
Threshing	222 (98.7)	67 (89.3)	1 (0.44)	5 (6.7)	2 (0.89)	3 (4.0)
Production transport by cart	218 (96.9)	38 (50.7)	5 (2.22)	32 (42.7)	2 (0.89)	5 (6.7)
Manual production transport	140 (62.2)	72 (96.0)	39 (17.3)	0 (0.0)	46 (20.4)	3 (4.0)
Production storage	140 (62.2)	75 (100.0)	45 (20.0)	0 (0.0)	40 (17.9)	0 (0.0)
Production market	195 (86.7)	75 (100.0)	0 (0.0)	0 (0.0)	30(13.3)	0 (0.0)
Total	186 (82.7)	55 (73.9)	21 (9.4)	5.8 (7.7)	17.8 (7.9)	13.8(18.4)

Source- Survey data, 2012

Table 6.3: Gender role for livestock production in the three rural villages (Kebele's)

Activities	Frequency of doing livestock production activities					
	Always		Sometimes		Not at all	
	Male	Female	Male	Female	Male	Female
	Number (percent)	Number (percent)	Number (percent)	Number (percent)	Number (percent)	Number (percent)
Livestock pen construction	199 (88.4)	16 (21.3)	20 (8.9)	9 (12.0)	6 (2.7)	50 (66.7)
Livestock feeding	120 (53.3)	64 (85.3)	15 (6.7)	3 (4.0)	90 (40.0)	8 (10.7)
Pen cleaning	11 (4.9)	71 (94.7)	0 (0.0)	0 (0.0)	214 (95.1)	4 (5.3)
Dung processing	5 (2.2)	71 (94.7)	0 (0.0)	0 (0.0)	220 (97.8)	4 (5.3)
Milking and milk processing	23 (10.2)	44 (58.7)	12 (5.3)	19 (25.3)	190 (84.4)	12 (16.0)
Livestock selling	131 (58.2)	55 (73.3)	0 (0.0)	5 (6.7)	94 (41.8)	15 (20.0)
Herding	138 (61.3)	0 (0.0)	17 (7.6)	52 (69.3)	70 (31.1)	23 (30.7)
Forage preparation	70 (31.1)	48 (64.0)	23 (10.2)	0 (0.0)	132 (58.7)	27 (36.0)
Poultry production	12 (5.3)	49 (65.3)	0 (0.0)	20 (26.7)	213 (94.7)	6 (8.0)
Fattening	18 (8.0)	5 (6.7)	0 (0.0)	0 (0.0)	207 (92.0)	70 (93.3)
Total	72.7(32.3)	42.3(56.4)	8.7(3.9)	10.8(14.4)	143.6(63.8)	21.9(29.2)

Source: Survey data, 2012

6.3.3 Crop types grown by male and female headed households

Males are often viewed as being responsible for producing cash crops, while females are viewed responsible for producing subsistence crops for home consumption (Doss, 2002, World Bank, 2010). As a result technology packages delivered by extension services sometimes reinforce stereotypic divisions of labor (Manfre et al., 2013). However, the data presented in this study (Figure 6.1) revealed that substantial number of female farmers grow almost similar types of crops dominantly grown in the area such as *teff*, maize, wheat, barley, vegetables etc with their male counterparts and there are no crops that are grown exclusively by either male or female in the study area, implying that we cannot divide crops in to those grown by male and those grown by female at least in the study area.

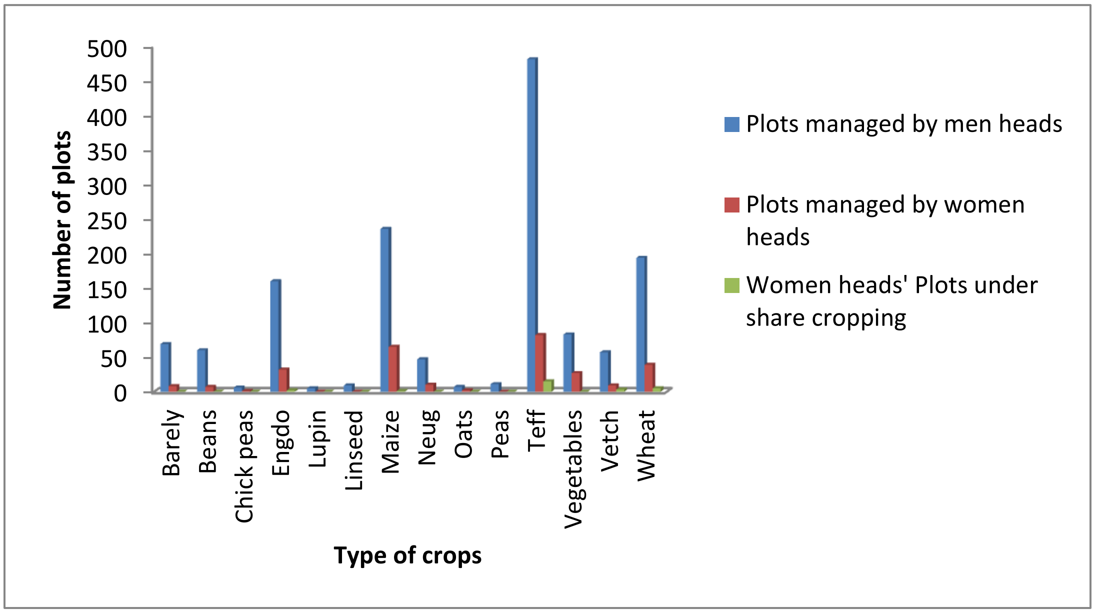

Figure 6.1: Crops grown by male and female head households

6.3.4 Gender-labor time budget analysis in domestic and farm activities

The time budget analysis (Table 6.4) indicates that females spent about 50 percent more time for domestic and farm activities compared to males. Gender differences become clearer when looking at female's workloads. Cooking and related activities (cleaning, child care, etc.), fire wood collection and fetching water are among the domestic activities they mainly perform. They also play significant role on farm work, poultry and livestock as well as vegetable gardening.

Table 6.4: Time budget analysis for gender division of labor (hrs/day) in the main agricultural season

Activities	Male heads	Female heads
Cooking & related works (cleaning, childcare…)	0.005	5.893
Fetching water	0.020	0.885
Fire wood collection	0.247	0.952
Vegetable gardening	0.384	0.798
Poultry and livestock related works	0.398	0.870
On farm work	9.116	5.840
Total	10.17	15.24

Source- Survey data, 2012

6.3.5 Gender dimension in agricultural extension services

As stated above female farmers are actively engaged in agricultural production and management activities. However, irrespective of their role, the extension service remains dominated by males. Male heads are more likely receive advice from development or extension agents than female heads. As shown in Table 6.5, from the total farm households (2077 [298 female heads plus 1779 male heads]) living in the three villages, only 15.8 percent of female headed farm households are users of the extension service whereas male headed farm households' extension service users account for the lion share (70.7 percent). The result is consistent with other studies that observed access to extension services is lower for females as compared with males (Kassa, 2008; World Bank, 2010; Ragasa, 2012; Birhane, 2013).

6.3.6 Constraints to access agricultural extension service for female headed households

In this section the first five most important constraints are discussed. During data pretesting one of the variable we used as a constraint was 'cultural (society) influence'. However most of the respondents clearly explained the influence is directly reflected by extension workers not by other members of the society. But it does not mean that there is no cultural influence at all as far as extension workers are part of the society rather we used the variable agricultural extension workers attitude because it is specifically related to our subject of study.

Table 6.5: Distribution of farmers according to their agricultural extension participation level in 2012

Participation level	Village 1(Enerata)		Village 2 (Wonka)		Village 3(Kebi)	
	Male	Female	Male	Female	Male	Female
Model farmers	146	1	75	1	42	0
Copy (follower) farmers	548	27	169	8	279	10
Traditional farmers	229	64	252	157	39	30
Total	923	92	496	166	360	40

Source- Extension workers documented report, 2012

As shown in Table 6.6, agricultural extension workers attitude towards female farmers ranked as first constraint to access agricultural extension service. Farmers who participated in our focus group discussion explained that most of the time extension workers are not motivated to work with female farmers due to the low recognition towards female's agricultural responsibility, skill and their limited productive assets. More importantly based on discussion with extension workers, they prefer to do with farmers who have better resource endowments that enable them to adopt the technology packages; just to skip the criteria used to evaluate the performance of extension workers i.e., the number of farmers adopting the technology packages in their mandate area. This fact is well observed by Kassa and Degnet (2004) and Lemma (2007) that quotas (the minimum number of farmers who should take up the technology packages) are imposed on extension agents. As a result, extension agents use whatever means available to persuade farmers who are able to adopt the packages to take part in PADETES and thereby meet their quotas. In addition, Tewedaj et al., (2009) stated that the incentives of extension agents are set in a way that they try to maximize farmers' adoption of standardized packages. This makes extension workers to function to meet the expectations of their supervisors, on whom their promotion and job security depended. All these intensify quantitative targeting of clients and preference of resource full farmers by extension workers. Even the strategy which has been designed to provide gender equitable extension service by recruiting female extension workers cannot handle the systematic discrimination of female farmers from extension services due to the quota system. Thus, the extension program needs to consider targeting mechanisms carefully because meeting quantitative targets may conflict with program objectives.

Table 6.6: Factors hindering female headed households' participation in agricultural extension service

Constraints	Score	Rank order
Attitude of extension workers	540	1st
Shortage of family labour	522	2nd
Lack of credit access	475	3rd
Low education level	396	4th
High price of agricultural inputs	335	5th
Shortage of draft power	276	6th
Small land size	200	7th
Workload	112	8th
Lack of awareness	63	9th

Source- Survey data, 2012

The second constraint faced by female headed households to access extension service is shortage of family labour. According to Bezabih and Holden (2007) female headed households are characterized by lack of assets (including draught power) as well as labor shortage in Ethiopia. More importantly, one of the characteristics of Ethiopian agriculture is its labour intensive nature which depends mainly on human labour and draft power. Botlhoko and Oladele (2013) observed that households who have large number of family size in adult equivalent scale have high likelihood of participation in the extension program. This fact is also discussed in Chapter 4 and 5 of this study.

Lack of access to credit is another constraint to get extension service. Credit arrangements alleviate capital constraints of farmers that enable them to timely purchase of agricultural inputs promoted by the extension service. Credit users in the study area were only 16 percent, of which female heads have only 1 percent access that is influenced by the nature of credit arrangements that reduces the attractiveness of input uptake. To be eligible, a farmer must have repaid all previous loans (Dercon, 2000) and the capacity to pay the loan is evaluated. Inconvenient payback time and lack of interest due to the tendency of farmers to avoid risk in instances of crop failure (Carlesson et al., 2005) are other factors for farmers' low use of credit. Moreover according to Davis et.al, (2010) in Ethiopia, farmers' access to agricultural credit (and financial services more broadly), remains inadequate, particularly female heads frequently lack credit, making it difficult for them to obtain inputs (Tewodaj et. al, 2009).

Education is a major factor enabling females to break down barriers to some cultural and social factors giving rise to the division of household labour. However, female's low education level hampers their participation in the extension program. As shown in Table 6.1 only 18 percent of female heads are literate. According to Gebreegziabher et al., (2011); Giovanopoulou et al., (2011), education increases the probability of joining the extension program with the notion that farmers with better human capital like education are among the early adopters.

High price of agricultural inputs is another important barrier to use extension service for female heads who often lack productive assets. This is not surprising given the fact that most of the modern inputs (especially fertilizers and agro-chemicals) prices have been increasing year after year. The remaining constraints are lack of draft power, small land size, work load and lack of awareness respectively.

6.4 Conclusions

This study clearly indicates the involvement of female farmers in agricultural production and management activities. Female heads play a key role in both crop and livestock production and management activities in the study area. However, their important agricultural role is often obscured as a result of their non-contribution in oxen ploughing which is mainly done and culturally given to men. Though, their absence in oxen ploughing could not be a justification for perceiving them as non-farmers and/or seen to be only helping, but they are excluded from extension programs. Indeed female headed households' lack of productive assets also creates bias towards their agricultural role and in turn denies their access to agricultural extension service. Thus, capturing the differences between males and females in terms of productive assets should be boldly underlined to design gender responsive services.

In general, the results of the study clearly revealed the existence of gender-biased extension system in the study area irrespective of female's role in agriculture and ignoring female's important roles in agricultural production limits their contribution for agricultural development. Therefore, in order to improve rural livelihoods and to reduce the gender gap in agricultural extension service, it is essential to promote female farmers' participation in agricultural extension activities by providing gender-responsive training to extension workers, improving the criteria used for performance evaluation of agricultural extension workers to minimize the effect of quantitative targeting of clients that may conflict with program objectives, developing policies and programs that strengthen female's physical access to resources, and introducing time-saving infrastructures. All these measures not only increase female's ability to adopt improved technologies or engage in more remunerative livelihood strategies, but also contribute to female's empowerment in the household and the community at large. In general bringing the rural female folk in to the main stream of the community life and making them active participants in the rural life reformation process needs serious considerations.

Chapter 7

Summary, overall conclusions and implications of the study

7.1 Summary of main results

As part of the agriculture development led industrialization strategy, the Ethiopian government introduced the National Extension Intervention Program, i.e., the Participatory Demonstration, Training and Extension System in 1995 to improve smallholders' farm production and productivity through better access to technological packages that combined fertilizers, improved seeds and better management practices.

The success of agricultural extension service in Ethiopia is often measured in terms of the number of farmers taking part or full of the packages and/or physical inputs such as improved seed, chemical fertilizer, herbicides and pesticides. Few empirical evidences reported that participation in agriculture extension program has led to improvements in agricultural productivity and efficiency, while other evidences asserted that the Ethiopian extension program has non-significant effect on productivity as well as technical efficiency. All these studies however, did not address the problem of selection-bias that comes due to self-selection of farmers into the program and endogenous program placement. In the actual situation extension program participants are not selected randomly, as it is often the case with non-experimental data and this leads to a biased result. The resulting estimates will either overestimate or underestimate. This study for the first time attempted to analyze the effect of agricultural extension program-PADETES on smallholders' farm productivity, efficiency and female farmers' empowerment in North West Ethiopia through addressing selection biases that occur during program placement.

Even though the overall effect of extension program participation cannot be known for certain because of the lack of reasonably accurate baseline data for comparison, this study employs a bench mark OLS, treatment effect model, propensity score matching methods and translog stochastic frontier production function to mitigate some of the challenges in the estimation of effect of agricultural extension participation on farm productivity and efficiency.

This study used cross-sectional data obtained from farm households who participated and non-participated in PADETES in Gozamin district, North West Ethiopia. Gozamin district was selected purposively to fulfill the following criteria; where crop production is widely practiced, where extension program have been implemented for relatively longer period of time, the availability of different agro-ecologies and its representativeness to the Ethiopian highlands. Three hundred farm households consisting of a comparable group of participants and non-participants were surveyed during 2011/12 main agricultural season. To understand how farmers are using the technologies promoted by the extension program intensive plot level data were collected. Data collection was done using structured questionnaire which was pre-tested through a pilot survey.

The different model estimations indicate the positive effect of extension participation on farm productivity. Different factors had positively influence farm productivity. These are age, plot size, soil quality, slope of the plot, use of improved seed, amount of chemical fertilizer, application of compost, ploughing frequency, intensity of labour and oxen power. However, in spite of its positive effect, our finding clearly shows the existence of selection bias which tends to target relatively wealthier farm households and those affiliated to *kebele* administration, which is not directly related to farm productivity. The participation could have increased farm productivity by up to 20 percent had it not been to the serious selection bias observed during program placement. Furthermore, the program has been constrained by insufficient, non-diversified and/or poor quality farm inputs, such as improved seeds, weak research-extension linkage and services like credit and training to implement technologies promoted by the program. As a result, the observed overall farm productivity is less by about half than the target set by the extension program.

Despite the long history of government investment in the agricultural sector through extension service and promotion of new technology, smallholders' are found technically inefficient as evidenced with *teff* production. The econometric results based on the stochastic production function indicate that the mean technical efficiency estimates for agricultural extension participant and non-participant *teff* producers' are almost similar i.e., 72.29 percent and 71.44 percent respectively. This implied that participants and non-participants can achieve, respectively, an average of about 27.71 percent and 28.56 percent growth in *teff* production through full technical efficiency improvements. This indicated that, participation in agricultural extension program has had no positive significant influence on technical efficiency of *teff* producer farms.

Moreover, both groups of farms have considerable overall technical inefficiencies suggesting the existence of immense potentials for enhancing production through improvements in efficiency with available technology and resources. Livestock ownership (TLU), credit and improved seed are found to positively influence technical efficiency of *teff* producer farmers, while age of the head, family size, education, plot size, AE participation and membership in cooperatives did not have significant effect in reducing technical inefficiency.

The results from the gender division of labour in agricultural production revealed that female heads spent about 50 percent more time for domestic and farm activities compared to male heads. Female heads play a key role in both crop and livestock production and management activities in the study area. About 92 percent of male heads and about 82 percent of female heads, except for oxen ploughing for female, are engaged in crop production activities. In addition, about 71 percent of female are engaged in livestock production and related management activities whereas male's involvement is only 36 percent. Our result also indicated that substantial number of female farmers grows almost similar types of crops dominantly grown in the area such as *teff*, maize, wheat, barley, vegetables etc with their male counterparts and there are no crops that are grown exclusively by. However, in spite of female's significant role in crop and livestock production, only 15.8 percent of females are users of the agricultural extension service whereas males account for the lion share (70.7 percent). This clearly revealed that the program failed to target female farmers in the study area. The quota system imposed on extension workers that led them to target resource-rich farmers combined with female's poor access to resources are the most important factors that led to the denial of female's client-ship in extension services. This calls for serious consideration and actions by all bodies concerned.

7.2 Conclusions and policy implications

The above findings show that the agricultural extension program failed to bring the desired level of change by the measures of crop productivity, technical efficiency and women's empowerment. It may be difficult to draw definite policy recommendations based on these results as this study was based on limited macro level and cross sectional data covering only one production year. Nevertheless, the results could still be very informative for re-designing agricultural development strategies aimed at raising farm productivity, farm efficiency and empowering female farmers through agricultural extension service. The results could help to design appropriate strategies on the implementation of the agricultural extension program on the ground to make the service accessible for all farmers without any partiality. It could also give insight for policy planners on how the real implementation of the program is mismatched with the objectives of the program on paper. Therefore, based on the results obtained some important implications and recommendations can be drawn as follows:

(1) In order to improve the benefits to be gained in terms of farm productivity through agricultural extension program, the extension program should be accessible for all without any entry barriers and this requires maintaining a clear boundary between the program and the local politics which is lacking at the moment. The program should not be used to gain political/power control; instead the role of extension service in enhancing agricultural production growth should get serious attention. In addition, despite the emphasis in raising agricultural productivity through improved technologies, there is serious shortage of improved and diversified crop technologies. Therefore, generation and adaptation of improved, diversified and quality agricultural inputs remain critically important, for this establishing and strengthening research-extension linkage is very crucial. Moreover, to strengthen the capacity of resource poor farmers in implementing extension advices, the local government should create the necessary asset portfolio among the poor.

(2) The substantial technical inefficiency observed in *teff* production implies the availability of ample opportunities to raise *teff* production with available technology and resources. Hence, given farmer's resource constraints to modernize their agricultural practices and increase farm production in a sustainable manner, agricultural development strategies should consider feasible strategies that would raise the efficiency of farm production. In addition, policies and strategies that improve technical skill and farm management capacity of farmers, access to demand driven livestock extension service, credit and availability of quality and diversified improved seed could help to raise the efficiency of *teff* production.

(3) Despite the Ethiopian government's strong advocacy for promoting gender equality in all sphere of life, this study indicated the existence of male farmers dominated extension service. To reduce the gender gap in agricultural extension service, it is essential to promote female farmers' participation in agricultural extension activities by providing gender-responsive training to

extension workers in particular and the community at large. Improving the criteria used for performance evaluation of agricultural extension workers and targeting mechanisms need attention to minimize the effect of quantitative targeting that may conflict with program objectives. Rather it is essential to make female's participation in training and skill development be part of the extension workers evaluation criteria until the gender gap becomes insignificant. In addition, capturing the differences between male and female in terms of productive assets should be boldly underlined to design gender responsive services. Further, developing policies and programs that strengthen female's physical access to resources, and introducing time-saving infrastructures remains critical.

In general to achieve full potential impact of agricultural extension and to get the expected outcome in terms of farm productivity, efficient utilization of available technologies and resources as well as to maintain the reliability and responsiveness of the extension program, this study argue that refinements in the extension approach should be explored. Such refinements would need to disentangle the system away from politics, top-down, supply-driven, package approaches for limited crops, to more dynamic, responsive, impartial and competitive service provision. However, without such changes, the agricultural extension system in Ethiopia will become extraneous to the needs of smallholders production system.

7.3 Research prospects

Attribution and estimating the counterfactual are the challenges that emanate from the nature of impact evaluation itself. Thus, in order to control these challenges and to get more representative figure about the impact of the extension program on farm productivity, efficiency and women farmer's empowerment at national level, conducting similar studies further dealing with wider sample size and area coverage remain important. Moreover, establishing time series data that considers how other aspects of the national extension program such as natural resource conservation practices, role of farmer training centers and other collaborative institutions affect impact of extension program in terms of intermediate and final outcomes remain important.

References

Abate, H. (2007). Review of extension systems applied in Ethiopia with special emphasis to the participatory demonstration and training extension system. Food and Agriculture Organization of the United Nations, (unpublished), Addis Ababa, Ethiopia.

Abate, T., Shiferaw, B., Gebeyehu, S., Amsalu, B., Negash, K., Assefa, et al. (2011). A systems and partnership approach to agricultural research for development: Lessons from Ethiopia. In Outlook on Agriculture Journal, 40(3): 213–220. http://dx.doi.org/10.5367/oa.2011.0048

Abebaw, D. and Haile, M.G. (2013). The impact of cooperatives on agricultural technology adoption: Empirical evidence from Ethiopia. Food policy, 38: 82-91. http://dx.doi.org/10.1016/j.foodpol.2012.10.003

Abera, G., Gudeta, H., Belissa, M., Shale, G., Degefe, A. and kassa, B. (2006). Gender Based Roles and Resource Use Right in Potato Production and Marketing System: The Case of Some Districts in Oromia, Ethiopia. A Research Report, Addis Ababa.

Action Aid and CARE (2012). What works for women: Proven approaches for empowering women smallholders and achieving food security. Retrieved from http://www.actionaidusa.org/publications/.

ATA (Agricultural Transformation Agency) (2012). www.ata.gov.et/programs/value-chain-programs/**tef.**

Ahmed, M. M., Gebremedhin, B., Benin, S. and Ehui, S. (2002). Measurement and source of technical efficiency of land tenure contracts in Ethiopia. Environmental and Development Economics, 7: 507-528.

Aigner, D.J., Lovell, C.K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. Journal of Econometrics, 6 (1): 21–37.

Alemu, B. A., Nuppenau, E. A. and Boland, H. (2009). Technical efficiency of farming systems across agro-ecological zones in Ethiopia: An application of stochastic frontier analysis. Agricultural Journal, 4 (4): 202-207.

Alemu, D. and Tripp, R. (2010). Seed system potential in Ethiopia: Constraints and opportunities for enhancing production, IFPRI Working Paper, Washington DC. http://www.ifpri.org/sites/default/files/publications

Alene, A. D. (2003). Improved production technology and efficiency of smallholder farmers in Ethiopia: Extended parametric and non-parametric approaches to production efficiency analysis, PhD dissertation.

Alene, A. D. and Hassan, R. M. (2008). Efficiency of food production under old and new technology: The case of farmers within and outside the extension package program in Ethiopia. The Journal of Developing Areas, 41(2): 233-249.

Alene, A. D. and Hassen, R. M. (2006). The efficiency of traditional and hybrid maize production in Eastern Ethiopia: An extended efficiency decomposition approach. Journal of African Economies, 15(1): 91-116.

Alene, A. D. and Manyong, V. M. (2006). Farmer to farmer technology diffusion and yield variation among adopters: the case of improved cowpea in northern Nigeria. Agricultural Economics, 35: 203-211.

Alene, A. D. and Zeller, M. (2005). Technology adoption and farmers efficiency in multiple crops production in eastern Ethiopia: A comparison of parametric and non-parametric distance functions. Agricultural Economics Review, 6(1):5-17

Alene, A. D. and Manyong, V. M. (2007). The effects of education on agricultural productivity under traditional and improved technology in Northern Nigeria: An Endogenous Switching Regression Analysis. Empirical Economics, 32:141-159.

Alvarez, A. and Arias, C. (2004). Technical efficiency and farm size: A conditional analysis. Agricultural Economics 30(3), 241–250. http://dx.doi.org/10.1016/j.agecon.2003.04.001

Anderson J. R. (2007). Agricultural advisory services: a background paper for “innovating through science and technology”. Background paper for the World Development Report 2008.

Anderson, J. R. and Feder, G. (2003). Rural extension services: World Bank Policy Research Working Paper, 2976, World Bank, Washington D.C.

Anderson, J. R. and Feder, G. (2007). Hand book of agricultural economics, agricultural extension (pp. 2343-2372). In R. Evenson, & P. Pingali (Eds.). Agriculture and Rural Development Department, World Bank, Washington, DC.

Angrist, J. D. and Imbens, G. W. (1995). Two-stage least squares estimates of average causal effects in models with variable treatment intensity. Journal of the American Statistical Association, 90(430), 431-442.

Anriquez, G. and Stamoulis, K. (2007). Rural development and poverty reduction: Is agriculture still the key? ESA Working Paper No.7-02, Rome Italy.

Asfaw, S., Shiferaw, B., Simtowe, F. and Lipper, L. (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. Food policy, 37: 283-295. http://dx.doi.org/10.1016/j.foodpol.2012.02.013

Assefa, K., Aliye, S., Belay, G., Metaferia, G., Tefera H. and Sorrells, M. E. (2011). Quncho: the first popular tef variety in Ethiopia. International Journal of Agricultural Sustainability, 25-34.

Assefa, K., Yu, J. K., Zeid, M., Belay, G., Tefera, H. and Sorrells, M. E., (2010). Breeding tef [Eragrostis tef (Zucc.) Trotter]: conventional and molecular approaches (review). Plant Breeding. http://dx.doi.org/j.1439–0523.2010.01782.x.

Assefa, S. (2011). Analysis of technical efficiency of crop producing smallholder farmers in Tigray, Ethiopia. Munich Personal RePEc Archive.

Atilaw, A. and L. Korbu (2011). Recent development in seed systems of Ethiopia. In: Alemu, D., S. Kiyoshi and A. Kirub (eds). Improving Farmers' Access to Seed. Empowering Farmers' Innovation. Series No. 1: 13-30.

Ayalew, D. and Deininger, K. 2012. Causes and implications of credit rationing in rural Ethiopia. The importance of spatial variation. Policy Research Working Paper, 6096, the World Bank e-Library.

Ayele,G., Bekele, M. and Zekeria, S. (2006). Productivity and Efficiency of Agricultural Extension Package in Ethiopia. The Ethiopian Development Research Institute Research Report 5, Addis Ababa, Ethiopia.

Bachewe, F (2009). The state of subsistence agriculture in Ethiopia: sources of output growth and agricultural inefficiency. PhD. dissertation submitted to the faculty of the graduate school of the University of Minnesota.

Barham J. and Chitemi C. (2008). Collective action initiatives to improve marketing performance: Lessons from farmer groups in Tanzania. Collective Action for Property Rights (Capri) Working Paper No. 74.

Barrett, C., Reardon, T. and Webb, P. (2001). Non-farm income diversification and household livelihood strategies in rural Africa: Concepts, dynamics, and policy implications. Food Policy, 26(4), 315–331. http://dx.doi.org/10.1016/S0306-9192(01)00014-8

Battese, G. and Broca, S. (1997). Functional forms of stochastic frontier production functions and models for technical inefficiency effects: a comparative study for wheat farmers in Pakistan. J. Prod. Anal., 8: 395–414.

Battese, G. E. Coelli, T. J., and Colby, T. C. (1989). Estimation of frontier production functions and the efficiencies of Indian farms using panel data from ICRISAT's village level studies. J Quant Econ., 5:327–348

Battese. G. E. and Coelli, T. J. (1995). A model of technical inefficiency effects in a stochastic frontier production function for panel data. Empir. Econ., 20: 325–332

Benin, S. (2006). Policies and programs affecting land management practices, input use, and productivity in the highlands of Amhara Region, Ethiopia. In J. Pender, F. Place, & S. Ehui (Eds.), strategies for sustainable land management in the East African Highlands. Washington, DC: IFPRI.

Benin, S., Nkonya, E., Okecho, G., Randriamamonjy, J., Kato, E., Lubade, G., & Kyotalimye, M. (2011).). Returns to spending on agricultural extension: The case of the National Agricultural Advisory Services (NAADA) Program of Uganda. Agricultural economics, 42: 249-267. http://dx.doi.org/10.1111/j.1574-0862.2010.00512

Berhane G. (2013). Gender differences in access to extension services and agricultural productivity. Journal of Agricultural Education and Extension, 19, 5, 437-468**.**

Beshir H., Emana, B., Kassa, B., & Haji, J. (2012). Determinants of chemical fertilizer technology adoption in North Eastern Highlands of Ethiopia: The double hurdle approach. Journal of Research in Economics and International Finance, 2, 39-49.

Binam, J. N., Tonye, J., Wandji, N., Nyambi, G. and Akoa, M. (2004). Factors affecting the technical efficiency among smallholder farmers in the slash and burn agriculture zone of Cameroon. Food Policy, 29: 531-545.

Birhanu, K. (2012). The political economy of agricultural extension in Ethiopia: Economic growth and political control: working paper, 042 future agriculture.

Birhanu, K. (2014). The political economy of agricultural extension in Ethiopia: Economic growth and political control. 21th KUASS (Kyoto University African Studies Seminar).

Birner, R., Davis, K., Pender, J., Nkonya, E., Anandajayasekeram, P., Ekboir, J., Mbabu, A., Spielman, D. J. Horna, D., and Benin, S. (2009). "From Best Practice to Best Fit: A framework for designing and analysing agricultural advisory services worldwide". Journal of Agricultural Extension and Education, 15(4): 341-355

Bishaw, Z., Sahlu, Y. and Simane B. (2008). The status of the Ethiopian seed industry. In Farmers, seeds and varieties: Supporting informal seed supply in Ethiopia. Ed. M. H. Thijssen, Z. Bishaw, A. Beshir, and W.S. de Boef. Wageningen.

Bonger, T., Ayele, G. and Kumsa. T. (2004). Agricultural extension, adoption and diffusion in Ethiopia. Ethiopian Development Research Institute (EDRI) Research report 1. Addis Ababa.

Braun, A., Thiele, G. and Fernandez, M. (2002). Farmer field schools and local agricultural research committee: complementary platforms for integrated decision-making in sustainable agriculture. ODI, Agricultural Research and Extension, Network Paper 105.

Bravo-Ureta, B. E. and Pinheiro, A. E. (1997). Technical, economic and allocative efficiency in peasant farming: evidence from the Dominican Republic. The Developing Economics, xxxv (1): 48–67.

Caliendo, M. and Kopeinig, S. (2008). Some practical guidance for the implementation of propensity score matching. Journal of Economic Surveys, 22: 31–72. http://dx.doi.org/10.1111/j.1467-6419.2007.00527

Carlesson, F., Kohlin, G., Mekonnen, A. and Yusuf, M. (2005). Are agricultural extension packages what Ethiopian farmers want? A stated preference analyses, working paper No. 172, Department of Economics, Goteborg University.

Charatsary C., Papadaki-Klaudianou, A. and Michailidis, A. (2011). Farmers as consumers of agricultural education services: willingness to pay and spend time. Journal of agricultural education and extension, 3:253-266.

Christoplos, I. (2010). Mobilizing the Potential of Rural and Agricultural Extension. Neuchatel Group.

CIA (Central Intelligence Agency) (2014). The world fact book. https://www.cia.gov/library/publications/the-world-factbook/geos/et.html

CIA (Central Intelligence Agency) (2012). The world fact book.

http://www.immigration-usa.com/world_fact_book_2012/ethiopia/ethiopia_people.html

Coelli, T. J. (1994). A guide to FRONTIER version 4.1: A computer program for stochastic frontier production and cost function estimation. Mimeo, Department of Econometrics, University of New England, Armidale, Australia.

Coelli, T. J. and Battese, G. E. (1996). Identification of factors which influence the technical efficiency of Indian farmers. Aust J Agric Econ., 40(2): 103–128.

Coelli, T. J., Prasada Rao, D. S., O'Donnell, C. J. and Battese, G. E. (2005). An introduction to efficiency and productivity analysis, 2nd .ed. New York: Springer Science.

Coelli, T. J. (1996). A guide to Frontier Version 4.1: A computer Program for Frontier Production Function Estimation. CEPA Working Paper 96/07, Department of Econometrics, University of New England, Armidale.

Cohen, M. J. and Lemma, M. (2011). Agricultural extension services and gender equality: An institutional analysis of four districts in Ethiopia, IFPRI Discussion Paper, 01094.

Coughenour, C. M. and Swanson, L. E. (1988). Rewards, values and satisfactions with farm work. Rural Sociology, 53 (4): 442–459.

CSA (Central Statistical Agency) (2008). Statistical abstract 2008, Central Statistical Agency, Addis Ababa, Ethiopia.

CSA. (2011). Agriculture in Figures: Key findings of the 2008/09-2010/11 agricultural sample surveys for all sectors and seasons, Country Summary.

Cunguara, B. and Darnhofer, I. (2011). Assessing the impact of improved agricultural technologies on household income in rural Mozambique. Food Policy, 36: 378-390.

Cunguara, B. and Moder, K. (2011). Is agricultural extension helping the poor? Evidence from rural Mozambique. Journal of African Economies, 0: 1-34. http://dx.doi.org/10.1093/jae/ejr015

Davis, K., Swanson, B., Amudavi, D., Ayalew, D., Flohrs , A., Riese, J., Lamb, C. and Zerfu, E. (2010). In-depth assessment of the public agricultural extension system of Ethiopia and recommendations for improvement. IFPRI, Discussion Paper 01041.

Dehejia, R. and Wahba, S. (2002). Propensity score matching methods for non-experimental causal studies. The Review of Economics and Statistics, 84 (1): 151–161.

Dercon, S. (2000). *Growth and poverty in Ethiopia in the 1990s*: An economic perspective. Centre for the study of African Economies, Oxford University.

Dercon, S. and Christiaensen, L. (2007). *Consumption risk, technology adoption and poverty traps: Evidence from Ethiopia*. World Bank Policy Research Working Paper 4527, Washington, DC: World Bank.

Dey, M. M., Paraguas, F. J., Sricantuk, N., Xinhua, Y., Bhatta, R. and Dung, L.T.C. (2005). Technical efficiency of fresh water pond polyculture production in selected Asian countries: estimation and implication. Aquac Econ Manag., 9(1&2): 39–63.

Diao, X. and P. Hazell. (2004). Exploring market opportunities for African smallholders. 2020 Africa Conference Brief No. 6. Washington D.C., USA.

Dong F., Lu, J. and Featherstone, A. M. (2010). *Effects of credit constraints on productivity and rural household income in China Working Paper 10-WP 516*.

Doss, C. R. (2002). Men's crops? Women's crops? The gender patterns of cropping in Ghana. World development, 30, 11, 1987-2000.

Doss, C. R. and Morris, M. L. (2001). How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Agricultural Economics, 25: 27–39. http://dx.doi.org/10.1111/j.1574-0862.2001.tb00233.x

DSA (Development Studies Associates) (2006). Study on improving the efficiency of input markets. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

DSA (Development Studies Associates). (2006). *Study on improving the efficiency of input markets*. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

EEA/EEPRI (2006). Evaluation of the Ethiopian agricultural extension with particular emphasis on the Participatory Demonstration and Training Extension System (PADETES). First edition, Addis Ababa, Ethiopia.

Falco, S., Bezabih, M. and Yesuf, M. (2010). Seeds for livelihood: Crop biodiversity and food production in Ethiopia. Ecological Economics 69 (2010) 1695–1702

FAO (2009). Gender in Agriculture: Sourcebook, http://www.genderinag.org/content/gender-agriculture-sourcebook.

FAO (2010). Gender dimensions of agricultural and rural employment: Differentiated pathways out of poverty Status, trends and gaps Published by the Food and Agricultural Organization of the United Nations, the International Fund for Agricultural Development and the International Labour Office Rome, 2010.

FAO (2013). FAO-Food Security Indicators. http://faostat3.fao.org/home/index.html#DOWNLOAD

FAO (2011). The state of food and agriculture 2010-2011. Rome: Food and Agriculture Organization of the United Nations.

FAO (2010). Ethiopia country brief. Retrieved from www.fao.org/countries/55528/en/eth/

FAO 1995. Improving the relevance and effectiveness of agricultural extension activities for women farmers - An André Mayer research study.

Farrell, M. J. (1957). The measurement of production efficiency. Journal of Royal Statistical Society, 120: 253–282.

Feder, G., Murgai, R. and Quizon, J. B. (2004). The acquisition and diffusion of knowledge: The case of pest management training in farmer field schools, Indonesia. Journal of Agricultural Economics, *55*(2), 221-243.

Feleke, S. and Zegeye, T. (2006). Adoption of improved maize varieties in southern Ethiopia: factors and strategy options. Food Policy, 31(5), 442-457. http://dx.doi.org/10.1016/j.foodpol.2005.12.003

Frank, E. (1999). Gender, agricultural development and food security in Amhara, Ethiopia: The contested identity of women farmers in Ethiopia .USAID/Ethiopia.

Fufa, B., Behute, B., Simons, R. and Berhe. T. (2011). Strengthening the teff value chain in Ethiopia. Mimeo, Agricultural Transformation Agency (ATA), Addis Ababa.

Gebregziabher, G. and Holden, S. (2011). Does irrigation enhance and food deficits discourage fertilizer adoption in a risky environment: Evidence from Tigray, Ethiopia. J. Dev. Agric. Econ., 30(10), 514–528.

Gebregziabher, K., Mathijs, E., Maertens, M., Deckers, J. and Bauer, H. (2011). Extension participation, household income and income diversification: A system equations approach. Retrieved from www.csae.ox.ac.uk/conferences/2011-EDiA/.../437

Gebremedhin, B., Hoekstra, D. and Tegegne A. (2006). Commercialization of Ethiopian agriculture: Extension service from input supplier to knowledge broker and facilitator. IPMS Working Paper No. 1,36. International Livestock Research Institute

Gebremedhin, B., Jalata, M. and Hoekstra, D. (2009). Smallholders, institutional services, and commercial transformation in Ethiopia. Journal of Agricultural Economics, *40*, 773-787. http://dx.doi.org/10.1111/j.1574-0862.2009.00414

Gebre-Selassie, A. and Bekele, T. (2011). A review of Ethiopian agriculture: Roles, policy and small-scale farming systems. Country analysis: Ethiopia and D.R. Congo. Global growing case book.

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.

Gebre-Selassie S. (2003). Summary report on recent economic and agricultural policy. Paper prepared for the roles of agriculture international conference 20-22 October, 2003 – Rome, Italy.

Genius M. G., Pantzios, C. J. and Tzouvelekas, V. (2006). Information acquisition and adoption of organic farming practices. *Journal of* Agricultural and Resource Economics, 31(1), 93-113.

Giovanopoulou, E., Nastis, S. A. and Papanagiotou, E. (2011). Modeling farmer participation in agri-environmental nitrate pollution reducing schemes. Ecological economics, 70, 2175-2180.

Gozamin *Woreda* Finance and Economic Development sector Office Document. (2010). Allocation of budget from 2003 to 2010, East Gojam zone, Amhara Regional State.

Grepperud, S. (1996). Population pressure and land degradation: The case of Ethiopia. Journal of Environmental Economics and Management, 30 (1): 18–33. http://dx.doi.org/10.1006/jeem.1996.0002

GulUnal, F. (2008). *Small is beautiful: Evidence of an inverse relationship between farm size and yield in Turkey*. Working Paper No. 551. The Levy Economics Institute.

Heckman, J.and Navarro-Lozano, S. (2004). Using matching, instrumental variables, and control functions to estimate economic choice models. The Review of Economics and Statistics, 86(1), 30–57.

Heckman, J.and Robb, R. (1985). Alternative methods for evaluating the impact of interventions: An overview. Journal of Econometrics, 30(1), 239–267.

Heckman, J., Ichimura H., Smith J. and Todd P. (1997). Matching as econometric evaluation estimator: Evidence from evaluating a job-training program. Review of Economic Studies, 64: 605–654. http://dx.doi.org/10.1111/1467-937X.00044

Heckman, J., Ichimura H., Smith J. and Todd P. (1998). Characterizing selection bias using experimental data. Econometrica, 66: 1017–1098.

Hegde, N. G. (2005). Traditional extension methods in modern agriculture. Indian farming special issue on World food day. Pp.45-47

Henseler, J., Ringle, C. M. and Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. Advances in International Marketing, 20: 277–319.

Hu, R., Yang, Z., Kelly, P. and Huang, J. (2009). Agricultural extension system reform and agent time allocation in China. China Economic Review 20: 303–315.

IFDC (International Fertilizer Development Center) (2012). Ethiopia fertilizer assessment

Imbens, G. and Wooldridge, J. (2009) .Recent developments in the econometrics of program evaluation. Journal of Economic Literature, 47 (1): 5–86. http://dx.doi.org/10.1257/jel.47.1.5

IRIN (Integrated Regional Information Networks). (2012). Humanitarian news and analysis Ethiopia: http://www.irinnews.org/report/96154/ethiopia

Jones, L. E., Diekmann, F. and Batte, M. T. (2010). Staying in touch through extension: An analysis of farmers' use of alternative extension information products. Journal of agricultural and applied economics, 42(2): 229-246

Jones, R., Goheen, A., Dhuyvetter, K., Kastens, T. and AmanorBoadu, V. (2007). Using distance Education in extension programming. *Journal of agricultural and applied economics*, 39(2):265-274

Kassa, B. (2003). Agricultural extension in Ethiopia: The case of participatory demonstration and training extension system. Journal of Social Development in Africa, 18(1), 49–83.

Kassa, B. and Abebaw, D. (2004). Challenges facing agricultural extension agents: A case study from South-Western Ethiopia. African Development Review, 16 (1): 139–168. http://dx.doi.org/10.1111/j.1467-8268.2004.00087

Kassa, H. (2008). Agricultural extension in Ethiopia: Historical evolution, relevant policies and challenges, in Taye Assefa (ed.), Digest of Ethiopia's national policies, strategies and programs: Addis Ababa: Eclipse Printers.

Kassie, M., Zikhali, P., Manjur, K. and Edward, E. (2009). Adoption of sustainable agriculture practices: Evidence from a semi-arid region of Ethiopia. Natural Resources Forum, 39: 189–98. http://dx.doi.org/10.1111/j.1477-8947.2009.01224

Khairo, S. A., Battese, G. E. (2005). A study of technical inefficiencies of maize farmers within and outside the new agricultural extension program in the Harari region of Ethiopia. South African Journal of Agricultural Extension, 34(1): 136-150.

Kiptot, E. and Franzel, S. (2012). Gender and agroforestry in Africa: a review of women's Participation. Agro-forestry System, 84, 35–58

Lefort, R. (2010). Powers – *Mengist* – and peasants in rural Ethiopia: The post-2005 interlude. Journal of Modern African Studies, 48(3), 435-460. http://dx.doi.org/10.1017/S0022278X10000297

Lemma, M. (2007). The agricultural knowledge system in Tigray, Ethiopia: Recent history and actual effectiveness. Weikersheim, Germany: Margraff Publishers.

Lemma, T., Sehai, E. and Hoekstra, D. (2011). Status and capacity of Farmer Training Centers (FTCs) in the Improving Productivity and Market Success (IPMS) Pilot Learning Woredas (PLWs). Retrieved from http://cgspace.cgiar.org/handle/10568/16899

Lundvall, K. and Battese, G. E. (2000). Farm size, age, and efficiency: Evidence from Kenyan manufacturing farms. Journal of Development Studies, 36(3), 146–163.

Magingxa, L. and A. Kamara (2003). Institutional perspectives of enhancing smallholder market access in South Africa, paper presented at the 41st annual conference of the Agricultural Economic Association of South Africa held in Pretoria.

Manfre, C., Deborah R., Andrea A., Gale S., Kathleen C., Mercy A. and MEAS Project (2013). Reducing the gender gap in agricultural extension and advisory services: How to find the Best Fit for men and women farmers. MEAS discussion paper series on Good Practices and Best Fit approaches in extension and advisory service provision, USAID.

Mayen, C. D., Balagtas, J.V. and Alexander, C. E. (2010). Technology adoption and technical efficiency: Organic and conventional dairy farms in the United States. Amer. J.Agr. Econ., 1–15.

Meeusen, W. and van den Broeck, J. (1977). Efficiency estimation from Cobb-Douglas production functions with composed error. International Economic Review, 18: 435–444.

Mendola, M. (2007). Agricultural technology adoption and poverty reduction: A propensity score matching analysis for rural Bangladesh. Food Policy, 32, 372-393. http://dx.doi.org/10.1016/j.foodpol.2006.07.003

Mitik, L. and Engida, E. (2013). Public investment in irrigation and training for an agriculture led-development: A CGE Approach for Ethiopia, working paper 2013-02, PEP project.

MoFED (Ministry of Finance and Economic Development) (2002) Ethiopia: Sustainable Development and Poverty Reduction Program, Federal Democratic Republic of Ethiopia (FDRE), Addis Ababa, Ethiopia.

MoFED (2003). Rural development policy and strategies, government of the federal democratic republic of Ethiopia. Ministry of Finance and Economic Development Economic Policy and Planning Department Addis Ababa.

MoFED (2007). Ethiopia: Building on Progress: A Plan for Accelerated and Sustained Development to End Poverty (PASDEP). Addis Ababa: MOFED.

MoFED (2010). Growth and Transformation Plan: 2010/11-2014/15. Volume I: Main Text. Addis Ababa: Ministry of Finance and Economic Development (MoFED). Available at:http://www.mofed.gov.et/index.php?option=com_content&view=article&id=14&Itemid=94MoFED (2012) "Ethiopia's progress towards eradicating poverty: An interim report on poverty analysis study (2010/11)", Addis Ababa.

MoFED (2012). Ethiopia's Progress towards Eradicating Poverty: An Interim Report on Poverty Analysis Study (2010/11), Addis Ababa, Ethiopia.

Mulat, D. (1999). The challenge of increasing food production in Ethiopia. In Alemayehu, G. and Berhanu, N. (eds) The Ethiopian economy: Performance and evaluation. Proceedings of the eighth annual conference on the Ethiopian economy, Nazareth.

Nega, F., Mathijs, E., Deckers, J., Haile, M., Nyssen, J. and Tollens, E. (2010). Rural poverty dynamics and impact of intervention programs up on chronic and transitory poverty in Northern Ethiopia. African Development Review, 22, 92–114. http://dx.doi.org/10.1111/j.1467-8268.2009.00229

Nkamleu, G. B. (2004). Productivity growth, technical progress and efficiency change in African agriculture. African Development Review, 16 (1): 203–222.

Nyemeck, B. J., Sylla, K., Diarra, I. and Nyambi, G. (2003). Factors affecting technical efficiency among coffee farmers in Coˆte doIvoire: an evidence of Centre West region. African Development Review, 15 (1): 66–76.

Ogato, G. S., Boon, E. K. and Subramani, J. (2009). Improving access to productive resources and agricultural services through gender empowerment: A case study of three rural communities in Ambo district, Ethiopia. Journal of Human Ecology, 27, 2, 85-100.

Pender, J. and Gebremedhin, B. (2007). Determinants of agricultural and land management practices and impacts on crop production and household income in the highlands of Tigray, Ethiopia. Journal of African Economies, 17(3), 395–450. http://dx.doi.org/10.1093/jae/ejm028

PIF (2010). Ethiopia's agricultural sector Policy and Investment Framework (PIF) 2010-2020. MoRAD final report.

Quisumbing, A. R. and Pandolfelli, L. (2010). Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. World Development, 38, 4, 581-592.

Ragasa, C., Berhane, G. Tadesse, F. and Seyoum, T. A. (2012). Gender differences in access to extension services and agricultural productivity. Working paper, 49, IFIPRI.

Rahman, S. A. and Ibrahim, H. (2007). Socio-economic study of gender role in farm production in Nasarawa State of Nigeria. Asia-Pasfic Journal of Rural Development, 1, 57-66.

Rao, E. J.O, Brummer, B. and Qaim, M. (2012). Farmer participation in supermarket channels, production technology, and efficiency: the case of vegetables in Kenya. Amer. J. Agr. Econ., 94(4): 891–912.

Reifschneider, D. and Stevenson, R. (1991). Systematic departures from the frontier: a framework for the analysis of firm inefficiency. Int. Econ. Rev., 32: 715–723.

Ridaura, S. L., Masera, O. and Astier, M. (2002). Evaluating the sustainability of complex socio-environmental systems— the MESMIS framework. Ecological Indicators, 2 (2): 135–148.

Rosenbaum, P. and Rubin, D. (1985). Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. American Statistician, 39, 33–38. http://dx.doi.org/10.2307/2683903

Rosenbaum, P. and Rubin, D. (1983). The central role of the propensity score in observational studies for causal effect. Biometrika, 70(1), 41-55. http://dx.doi.org/10.1093/biomet/70.1.41

Rubin, D. B. (1977). Assignment to treatment group on the basis of a covariate. Journal of Educational Statistics, *2*, 1–26. http://dx.doi.org/10.3102/10769986002001001

Salami, A., Kamara, A. B. and Brixiova, Z. (2010). Smallholder agriculture in East Africa: Trends, constraints and opportunities, Working Papers Series No 105 African Development Bank, Tunis, Tunisia

Seyoum, E. T., Battese, G. E. and Fleming, E. M. (1998). Technical efficiency and productivity of maize producers in eastern Ethiopia: a study of farmers within and outside the Sasakawa-Global 2000 project. Agricultural Economics, 341-348.

Sharma, K. R., Leung, P. and Zaleskib, H. M. (1999). Technical, allocative, and economic efficiencies in swine production in Hawaii: A comparison of parametric and nonparametric approaches. Agricultural Economics, 20(1), 23–35. http://dx.doi.org/10.1016/S0169-5150(98)00072-3

Sherlund, S. M., Barrett, C. B. and Adesina, A. A. (2002). Smallholder technical efficiency controlling for environmental production conditions. Journal of Development Economics, 69(1): 85-101.

Smith, J. and Todd, P. (2005). Does matching overcome Lalonde’s critique of non-experimental estimators? Journal of Econometrics, 125, 305–353. http://dx.doi.org/10.1016/j.jeconom.2004.04.011

Solis, D., Bravo-Ureta, B. E. and Quiroga, R. E. (2007). Soil conservation and technical efficiency among hillside farmers in Central America: A switching regression model. Australian Journal of Agricultural and Resource Economics, 51(4): 491–510.

Spielman D. J. (2008). Encouraging economic growth in Ethiopia: Perspectives on agricultural input markets. Agricultural extension and advisory services, and agricultural education and training. Briefing note prepared for DIFID.

Spielman D. J., 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. http://dx.doi.org/10.1016/j.foodpol.2009.12.002

Spielman, D. J., Davis, K., Negash, M. and Ayele, G. (2011). Rural innovation systems and networks: findings from a study of Ethiopian smallholders. Agriculture and human values, 28:195–212

Spielman, D. J., Kelemework, D. and Alemu, D. (2011). Seed, fertilizer, and agricultural extension in Ethiopia. Ethiopia Strategy Support Program II (ESSP II) Working Paper No 20. International Food Policy Research Institute.

Staatz, J., and Dembele, N. (2007). Agriculture for development in sub-Saharan Africa. Background paper for the World Development Report 2008.

Tewodaj, M., Cohen, M. J. Birner, R., Lemma, M., Randriamamonjy, J. Tadesse, F. and Paulos, Z. (2009). Agricultural extension in Ethiopia through a gender and governance lens. IFPRI: Washington D.C.

Thangata, P. and Mequaninte, T. (2011). The impact of agricultural extension services on farm household efficiency in Ethiopia.

The Federal Democratic Republic of Ethiopia .Growth and Transformation Plan (GTP) 2010/11-2014/15 Draft Ministry of Finance and Economic Development (MoFED) September 2010 AA.

Thirtle, C., Beyers, L., Ismael, Y. and Piesse, J. (2003). Can GM technologies help the poor? The impact of Bt cotton in Makhathini Flats, KwaZulu-Natal. World Development, 31(4), 717–732.

Tiwari, K. R., Sitaula, B. K., Nyborg, I. L. P. and Paudel, G. S. (2008). Determinants of farmers adoption of improved soil conservation technology in a middle mountain watershed of Central Nepal. Environmental Management, 42, 210-222

Umeta, G. (2013). Analysis of female headed households' participation in agricultural extension package program in East Showa Zone, Ethiopia. American Journal of Research Communication, 1, 8, 227-245.

UNDP. (2013). Human Development Report, New York: UNDP.

UNESCO Institute for Education (2005). Foundations of Adult Education in Africa. Cape Town/South Africa: UNESCO Institute for Education.

USAID (2013). Empowering women through agricultural development in Ethiopia.

USDA (United States Department of Agriculture) (2013). Resources, policies, and agricultural productivity in Sub-Saharan Africa. Economic Research Report Number 145

Wiggins, S. (2009). Can the smallholder model deliver poverty reduction and food security for a rapidly growing population in Africa? Paper for the Expert Meeting on How to feed the World in 2050, Rome.

Wooldridge, J. M. (2010). Econometric analysis of cross section and panel data. volume 1 of MIT Press Books.

World Bank, (2006). *Ethiopia: Policies for pro-poor agricultural growth*. Washington, DC: World Bank.

World Bank (2007). Ethiopia: Accelerating equitable growth. Country economic memorandum, Part I: overview, report no 36662-ET. Washington, D.C.

World Bank (2008). The growth report: Strategies for sustained growth and inclusive development, Washington D.C., Commission on Growth and Development, World Bank.

World Bank, (2010). Agriculture and rural development series: Gender and governance in rural Service: Insight from India, Ghana, and Ethiopia. World Bank, Washington, D.C.

World Development Report (WDR). (2008). Agriculture for development. The World Bank, Washington, DC

World Health Organization. (2000). *Client satisfaction evaluation*. Work book 6.

Yilmaz, S. and Venugopal, V. (2008). Local government discretion and accountability in Ethiopia. International Studies Program Working Paper 08-38, Atlanta: Georgia State University.

Yu, B., Nin-Pratt, A., Funes, J. and Gemessa, S. A. (2011). Cereal production and technology adoption in Ethiopia. IFPRI Discussion Paper 01131

Zerfu, D. and Larsony, D. F. (2011). Incomplete markets and fertilizer use: Evidence from Ethiopia.

Appendix

Table A.1: Placebo regression result

Dependent variable: age of head’s spouse	Coefficient	Standard error	P-value
Agricultural extension participation	0.554	0.653	0.397
Age of HH(ln)	36.37	1.443	0.001
Education of HH	-0.17	0.517	0.742
Owned livestock(ln)	0.394	0.805	0.625
Owned land	0.311	0.502	0.537
Adult equivalent	0.122	0.258	0.637
Oxen days (ln)	0.012	0.474	0.979
Plot distance from extension center(ln)	-0.473	0.416	0.256
Kebele administration	-0.161	1.832	0.930
Membership in farmers’ organizations	-1.418	1.752	0.419
Sitedummy_Enerata(cf:Kebi)	1.789	0.676	0.008
Sitedummy_Wonka	1.602	0.606	0.009
Constant	-99.52	5.21	0.003
Number of observations	366		
F(12, 353)	142.87		
Prob> F	0.000		
R squared	0.81		

Table A.2: Placebo regression result

Dependent variable: age of head’s spouse	Coefficient	Standard error	P-value
Agricultural extension participation	1.077	0.863	0.214
Age of HH(ln)	36.37	1.443	0.001
Education of HH	1.451	0.935	0.123
Owned livestock(ln)	0.394	0.805	0.625
Owned land	-0.546	0.945	0.564
Adult equivalent	-0.403	0.470	0.393
Oxen days (ln)	0.012	0.474	0.979
Plot distance from extension center(ln)	-0.473	0.416	0.256
Kebele administration	-0.161	1.832	0.930
Membership in cooperatives	-1.418	1.752	0.419
Sitedummy_Enerata(cf:Kebi)	1.789	0.676	0.008
Sitedummy_Wonka	1.602	0.606	0.009
constant	-99.52	5.21	0.003
Number of observations	168		
F(10, 156)	142.87		
Prob > F	0.000		
R squared	0.76		

Thesis Summary

Ethiopia's economy is heavily reliant on the agriculture sector. The sector is yet characterized by low productivity, dominated by smallholders who are subsistence, small-scale and resource poor. To improve the performance of the sector the Government of Ethiopia (GoE) launched various policies and strategies including the National Extension Intervention Program (NEIP) strategy, known as the Participatory Demonstration, Training and Extension System (PADETES) in 1995. PADETES aims at improving income and supply of food via agricultural production and productivity, increasing industrial and export crops, ensuring rehabilitation and conservation of natural resources, and empowering farmers, especially female farmers in agricultural development. However, there has been little attention and rigorous analysis on the impact of agricultural extension interventions. The few impact studies available showed mixed results and mainly the success of the program was literally judged by the number of farmers taking part or full of the packages and/or farm inputs.

The objectives of this study were to analyze the effect of agricultural extension program-PADETES on smallholders' farm productivity, efficiency and women farmers' empowerment in North West Ethiopia. This study used cross-sectional data obtained from three case study rural villages consisting of 300 farm house holds, comprising extension program participant and no-participant, including 1112 plot level data for the productivity analysis and 576 plots for efficiency analysis. Even though the overall effect of agricultural extension program cannot be known for certain because of the lack of reasonably accurate baseline data for comparison, this study employed a bench mark ordinary least square method, Heckman treatment effect model and propensity score matching methods to control unobserved variability and potential endogeniety.

The different model estimations indicate the positive effect of agricultural extension on farm productivity. However, the positive effect in productivity is marginal (6%). Different factors had positively influence farm productivity, such as age, plot size, soil quality, slope of the plot, use of improved seed, amount of chemical fertilizer, and application of compost, ploughing frequency, intensity of labour and oxen power. Although the result indicated a positive effect of agricultural extension on farm productivity, the study found existence of selection bias which tends to target relatively wealthier farm households and those affiliated to *kebele* administration which is a nonagricultural activity. The participation could have increased farm productivity by up to 20 percent had it not been to the serious selection bias observed during program placement.

On the other hand, the econometric results based on the stochastic frontier production function indicated that substantial inefficiency is observed in extension participant's production. The participants and non-participants can, respectively, increase *teff* production by an average of about 27.71 percent and 28.56 percent through full technical efficiency improvements. This implied that, participation in agricultural extension program has had no positive significant influence on the technical efficiency of *teff* production. Moreover, both groups of farms have considerable overall technical inefficiencies suggesting the existence of immense potentials for enhancing production through improvements in efficiency with available technology and resources. This study provided evidence of the positive role of livestock ownership, credit and improved seed (though not overemphasized due to shortcomings in seed quality and timeliness of delivery) in enhancing efficiency of *teff* production.

The results from the gender division of labour in agricultural production revealed that female heads spent about 50 percent more time for domestic and farm activities compared to male heads. Female heads play a key role in both crop and livestock production and management activities in the study area. However, in spite of women's significant role in crop and livestock production, only 15.8 percent of female heads are users of the extension service whereas male heads account for the lion share (70.7 percent). Despite of the Ethiopian government advocacy that strongly promotes gender equality in all sphere of life, this study indicated the existence of male dominated extension service. The quota system imposed on extension workers that led them to target resource-rich farmers combined with women's poor access to resources are the most important factors for the denial of women's client-ship in extension services.

The results of this study provide a valuable policy insight in which improving access to diversified technology choices, quality agricultural inputs and well-defined advisory service are critically necessary for extension participants on top of expanding the program to less resourceful farmers by avoiding any entry barriers in the future. For the generation and adaptation of improved, diversified and quality agricultural inputs establishing and strengthening the research-extension linkage is very crucial. In addition, policies and strategies that improve technical skill and farm management capacity of farmers, access to demand driven livestock extension service, credit and availability of quality improved seed could help to raise the technical efficiency of smallholder farmers. To reduce the gender gap in agricultural extension service, it is essential to promote female farmers' participation in agricultural extension activities by providing gender-responsive training to extension workers in particular and the community at large. Further, improving the criteria used for performance evaluation of agricultural extension workers and targeting mechanisms need attention to minimize the effect of quantitative targeting that may conflict with program objectives. In addition, capturing the differences between male and female in terms of productive assets should be boldly underlined to design gender responsive services.

Furthermore, to get the expected outcome in terms of farm productivity, efficient utilization of available technologies and resources as well as to maintain the reliability and responsiveness of the extension program, refinements in the extension approach should be explored. Such refinements would need to disentangle the system away from politics, top-down, supply-driven package approaches to limited crops, to more dynamic, responsive, impartial and competitive service provision. However, without such changes, the agricultural extension system in Ethiopia will become extraneous to the needs of smallholders production systems.

Thesis Summary in Japanese

摘　要

エチオピア経済は、農業部門に重度に依存している。しかし、農業部門は、低生産性で特徴づけられ、小規模かつ資源の乏しい生存目的の小農が優勢である。そこで、農業部門の成果を改善するため、エチオピア政府は、1995 年に参加型実証・訓練・普及システム（PADATES）として知られる国家普及活動プログラム戦略を含むさまざまな政策や戦略を立ち上げた。PADATES は、農業生産の増大や生産性向上を通じた所得や食料供給の改善、工芸作物や輸出作物の増大、自然資源の回復・保全、農業者、特に女性農業者に対する能力付与を図ることを目的としている。しかしながら、農業普及活動がもたらすインパクトに対しては、ほとんど関心が払われてこなかったほか、それに関する念入りな分析も行われてこなかった。そのインパクトに関するわずかな研究も、雑多な結論を示しているとともに、普及プログラムの成果は、主にプログラム・パッケージや農業投入物の全体または一部を利用した農業者数によって検討されてきた。

本研究の目的は、小農の土地生産性、効率性、女性農業者に対する能力付与に対して農業普及プログラム（PADATES）がもたらした効果を、エチオピア北西部を対象として分析することである。本研究では、普及プログラム参加者と非参加者で構成される 300 戸の農家世帯を含んだ３ヵ所の農村集落から得られた横断面データ（生産性分析のための 1,112 圃場のデータと効率性分析のための 576 圃場データも含む）を使用した。比較対象となる正確な基準データがないため、農業普及プログラムの全体効果は把握できないが、本研究では通常の最小二乗法（重回帰分析）のほか、非観測変数や潜在的な内生性を制御するために、Heckman の Treatment effect モデル、傾向スコアマッチング法（Propensity score matching method）やトランス・ログ型生産関数モデルを採用した。

さまざまなモデルによる評価は、土地生産性に対する農業普及活動のプラス効果を示している。しかし、土地生産性に対するプラス効果は、限界的（ぎりぎり）なものであった（6％）。なお、年齢、圃場サイズ、土壌の質、圃場傾斜度、改良種子の使用、化学肥料投入量、堆肥施用、耕耘頻度、労働集約度、畜力（雄牛）利用、等のさまざまな要因が、土地生産性に対してプラスの効果を与えていた。ただし、この結果は、土地生産性に対する農業普及活動のプラス効果を示しているものの、相対的に裕福な農家や地区（kebele）行政当局の関係者が農業普及活動の対象となっている傾向があり、普及プログラム参加者の選択には偏りが存在することが明らかになった。かりに、普及プログラムの実施において深刻な参加者選択の偏りがなければ、プログラム参加者は 20％まで土地生産性を増加させることが可能であったと考えられる。

他方、フロンティア生産関数に基づいた計量経済学的計測結果からは、普及プログラム参加者の生産活動には実質的な非効率性が観測されることが明らかになった。普及プログラムの参加者と非参加者は、テフ生産量を平均でそれぞれ 27.71％、28.56％ほど高めることが可能であ

る。このことは、農業普及プログラムへの参加は、テフ生産の技術効率性に対して統計的に有意なプラスの効果をもたらしていなかったことを表している。さらに、両方の農業者グループ（普及プログラム参加者と非参加者）は、全体的にかなり技術非効率性を抱えており、そのことは、利用可能な技術や資源の利用により効率性を改善することを通じて、生産性を高める測り知れない潜在力が存在することを示している。また、本研究では、家畜所有、信用サービス、改良種子（品質や配給の適時性の問題により過大に強調することはできないが・・・）がテフ生産の効率性を高めるうえで積極的な役割を備えていることの証拠を提示した。

他方、農業生産における労働のジェンダー領域に関わる分析からは、女性世帯主は男性世帯主と比較して、家事や農業活動において約 50％多い時間を費やしていることが明らかになった。対象地域においては、女性世帯主は作物生産、家畜生産や経営活動で重要な役割を果たしている。しかし、作物・家畜生産に対する女性の重要な役割にも拘わらず、男性世帯主は 70.7％が普及サービスの利用者であったのに対して、女性世帯主はわずか 15.8％だけが普及サービスの利用者であった。生活のすべての側面で性間の平等性を強力に促進するエチオピア政府の唱導にもかかわらず、本研究は男性優位の普及サービスの存在を示した。また、女性の資源に対する貧弱なアクセスと結びついて、資源を豊富に有する農業者を対象とするように普及員を仕向けさせるように普及員に課された割り当て制度は、普及サービスにおいて女性を顧客とする精神を否定する最も重要な要因である。

将来的に農業普及サービスへの参入障壁を排除することによって、あまり資源を持たない農業者に普及プログラムを拡張するという極みから考えると、本研究の結果は、多様で良質な農業投入物に対するアクセス改善と明確に規定された助言サービスが普及活動の参加者にとってきわめて重要である、という価値ある政策的眼識を提供するものである。改良された多様で良質な農業投入物の産出と改変にとって、研究と普及の間の連携の確立と強化は非常に重要なものである。くわえて、農業者の技術スキルや経営管理能力、需要主導型の畜産普及サービスに対するアクセス、信用サービス、品質改良種子の利用可能性を改善する政策や戦略は、小規模農業者の技術効率性を高めるのに役立つであろう。農業普及サービスの性間ギャップを減少させるため、特に普及員に対して、またコミュニティ全体に対して、性に対応した訓練を提供することにより、農業普及活動への女性参加を促進することは非常に重要なことである。さらに、農業普及員の成果評価に使用される基準や普及サービス対象者を定める仕組みの改善は、普及プログラムの目的と衝突するかも知れない量的目標の最小化に対する注意を必要とする。くわえて、生産用資産の観点から男性と女性の間に存在する格差の捕獲が、性に対応したサービスをデザインするうえで大いに強調されるべきである。

結論として、普及プログラムの信頼性や対応性を維持することと同様、土地生産性や利用可能な技術・資源の有効利用の観点から期待される成果を獲得するために、普及システムの洗練化が探求されるべきである。そのような洗練化は、政治活動、トップダウン、供給主導やパッケージ的接近から普及システムを解き放す必要があるだろう。しかしながら、そのような変革がなければ、エチオピアの農業普及システムは、小農生産システムが求めるニーズとは無関係のものとなってしまう。

List of Publications

Asres Elias, Makoto Nohmi, Kumi Yasunobu & Akira Ishida (2013). Effect of Agricultural Extension Program on Smallholders' Farm Productivity: Evidence from Three Peasant Associations in the Highlands of Ethiopia. Journal of Agricultural Science; Vol. 5, No. 8; 163-181 (DOI:10.5539/jas.v5n8p163)

This article covers chapter 4.

Asres Elias, Makoto Nohmi, Kumi Yasunobu, Akira Ishida and Arega.D. Alene (2014). THE EFFECT OF AGRICULTURAL EXTENSION SERVICE ON THE TECHNICAL EFFICIENCY OF TEFF (*ERAGROSTISTEF*) PRODUCERS IN ETHIOPIA. American Journal of Applied Sciences 11 (2): 223-239 (DOI:10.3844/ajassp.2014.223.239)

This article covers chapter 5.

Asres Elias, Makoto Nohmi, Kumi Yasunobu & Akira Ishida (2015). Does Gender Division of Labour Matters for the Differences in Access to Agricultural Extension Services? A Case Study in North West Ethiopia. Journal of Agricultural Science; Vol. 7, No. 1; 138-147 (DOI:10.5539/jas.v7n1p138)

This article covers chapter 6.