AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

ANALYSIS OF DETERMINANTS OF ADOPTION OF ORGANIC FERTILIZER AND ITS EFFECT ON SMALLHOLDER FARMERS INCOME IN SHASHEMENE DISTRICT, ETHIOPIA

BIRU GELGO DUBE

A Thesis Submitted to the Graduate School in Partial Fulfilment for the Requirements of the Award of Master of Science Degree in Agricultural and Applied Economics of Egerton University

EGERTON UNIVERSITY

NOVEMBER, 2016

DECLARATION AND APPROVAL

DECLARATION

I hereby declare that this thesis is my original work and has not been presented in this or any other university for any award.

Signature_______________ Date____________________

Biru Gelgo Dube

KM17/13572/14

SUPERVISORS APPROVAL

This thesis has been submitted to graduate school with our approval as university supervisors.

Signature _______________ Date____________________

Prof. Patience M. Mshenga (PhD)

Associate Professor in the Department of Agricultural Economics and Agribusiness Management, Egerton University

Signature_____________ Date__________________

Prof. Lemma Zemedu (PhD)

Associate Professor of Agricultural Economics, Haramaya University, Ethiopia

COPYRIGHT

Biru Gelgo Dube © 2016

All rights reserved for this thesis. No part of this thesis may be reproduced, stored in any retrieval system or transmitted in any form, mechanical, photocopying, recording or otherwise without prior written permission from the author or Egerton University on behalf.

All rights reserved

DEDICATION

This work is dedicated to my parents, my brothers and sisters.

ACKNOWLEDGEMENT

First of all, I would like to thank almighty God for his endless protection. I would like to thank Egerton University for admitting me to undertake my studies. My best appreciation goes to German Academic Exchange service (DAAD) through African Economic Research Consortium (AERC) for financing my studies. I would like to thank my supervisors, professor Patience Mshenga and Professor Lemma Zemedu for their invaluable and critical comments, advice and guidance on this work from proposal development to final draft of the thesis. I would like to thank my brothers Defa, Genemo and Roba for their tireless financial and moral support. Thank you so much and I am always proud of you. I would like to extend my gratitude to my sisters and my parents for their love and care during my studies. My heartfelt appreciation goes to my close friends and relatives who stood next to me and encouraged me during my studies. Lastly, my thanks go to everyone whose name was not mentioned but contributed towards successful completion of this work in any way.

ABSTRACT

Ethiopia's agricultural sector accounts to 40 percent of national Gross Domestic Product. This shows that the sector is important in improving the livelihoods of the bulk of the population. Despite its importance, the agricultural sector in Ethiopia is characterized by low productivity. To improve this and overall economic growth, the Ethiopian government has focused on promotion of organic fertilizer use. However, adoption of organic fertilizer remains low in most parts of Ethiopia including Shashemene district. This study therefore aimed at identifying the major constraints of organic fertilizer adoption and its income effect with specific objectives being determining transaction costs associated with adoption of organic fertilizer, factors influencing adoption and use intensity and impact of organic fertilizer use on households' farm income. The study used primary data which was collected from 368 smallholder farmers. The analytical framework incorporated descriptive statistics, double hurdle model and propensity score matching. The results showed that the average transaction costs through bargaining, searching for information and transportation were 68.23 ETB, 53.33 ETB and 124.53 ETB respectively. Policing and enforcement costs were non-existent among the farmers. The household size, livestock number, extension contacts, access to information media and membership to farmer groups significantly influenced the decision to adopt organic fertilizer. The farm income, size of the cultivated plot, membership to farmer groups and application frequency of organic fertilizer significantly influenced the intensity of organic fertilizer use. Propensity score matching revealed that the adoption of organic fertilizer increased farmers per hectare farm income by between 2661 ETB and 2959 ETB. Thus, farmers should be encouraged to adopt organic fertilizer. This could be possible if the government and other stakeholders gave more attention to provision of better extension services and better access to information related to organic fertilizer adoption as well as making availability of this fertilizer to farmers easier.

TABLE OF CONTENTS

DECLARATION AND APPROVAL .... **i**

COPYRIGHT .... **ii**

DEDICATION .... **iii**

ACKNOWLEDGEMENT .... **iv**

ABSTRACT .... **v**

LIST OF TABLES .... **ix**

LIST OF FIGURES .... **x**

ACRONYMS AND ABBREVIATIONS .... **xi**

CHAPTER ONE **1**

INTRODUCTION **1**

1.1 Background to the Study 1

1.2 Statement of the Problem 3

1.3 Objectives of the Study 3

1.3.1 General Objective 3

1.3.2 Specific Objectives 3

1.4 Research Questions 4

1.5 Justification of the Study 4

1.6 Scope and Limitation of the Study 4

1.7 Definition of Terms 6

CHAPTER TWO **7**

LITERATURE REVIEW **7**

2.1 Importance of Agricultural Technology 7

2.2 Overview of Organic Fertilizer Use in Ethiopia 8

2.3 Role of Organic Fertilizer in Increasing Agricultural Production 8

2.4 Transaction Costs in Organic Fertilizer Adoption 9

2.5 Empirical Literature on Adoption of Organic Fertilizer 10

2.5.1 Farmers Perception on Adoption of Organic Fertilizer 13

2.6 Theoretical Framework 14
2.6.1 Utility Maximization Theory 14
2.6.2 Transaction Cost Theory 16
2.6.3 Solow Growth Model 16
2.7 Conceptual Framework 17
CHAPTER THREE 19
METHODOLOGY 19
3.1 Study Area 19
3.2 Research Design 21
3.3 Sampling Procedures and Sample Size 21
3.4 Methods of Data Collection 22
3.5 Data Analysis Techniques 22
3.5.1 Estimating and Characterizing Transaction Costs Associated with Organic Fertilizer Usage amongst Smallholder Farmers 22
3.5.2 Determining the Socio-Economic and Institutional Factors that Influence Adoption and Use Intensity of Organic Fertilizer 23
3.5.3 Detecting Multicollinearity, Outliers and Statistical Specification Problems 26
3.5.4 Determining the Effect of Organic Fertilizer Usage on Household's Income 27
3.5.5 Simulation-Based Sensitivity Analysis for Matching Estimators 30
3.6 Variables of the Model 31
CHAPTER FOUR 33
RESULTS AND DISCUSSION 33
4.1 Socio-Economic and Institutional Characteristics of Sampled Households 33
4.1.1 Results on Gender and Marital Status 33
4.1.2 Results on Age, Education, Household Size, Labour, Livestock Ownership, Farm Size, Income and Farming Experience 34

4.1.3 Results on Group membership, Access to credit, Extension visits, and Distance to the nearest market 40

4.2 Organic Fertilizer Adoption 43

4.3 Constraints to Adoption of Organic Fertilizer 44

4.4 Transaction Costs Associated with Organic Fertilizer Adoption 45

4.5 Econometric Analysis of Factors Influencing Adoption and Use Intensity of Organic Fertilizer 46

4.5.1 Results of Multicollinearity, Outliers and Statistical Specification Tests 46

4.5.2 Factors Affecting Adoption and Use Intensity of Organic Fertilizer 47

4.6 Results of Propensity Score Matching for Impact of Organic Fertilizer on Income 54

4.6.1 Choice of Matching Algorithms 55

4.6.2 Testing the Balancing Properties of Propensity Scores and Covariates 57

4.6.3 Impact of Organic Fertilizer Adoption on Households Farm Income 58

4.6.4 Results of Simulation Based Sensitivity Analysis 59

CHAPTER FIVE 61

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS 61

5.1. Summary 61

5.2. Conclusions 62

5.3. Policy Recommendations 62

5.4. Areas for Further Studies 63

REFERENCES 64

APPENDICES 70

LIST OF TABLES

Table 1: Definition and Prior Assumptions of the Variables Used in Empirical Analysis 32
Table 2: Results on Age, Education, Household size and Labour 36
Table 3: Results on Livestock Ownership, Farm Size, Income and Farming Experience 39
Table 4: Results on Farm Fertility 40
Table 5: Results on Group Membership, Access to Credit, Extension Visits, and Distance to the Nearest Market 42
Table 6: Results of the Households' Access to Information Media (radio and television) 43
Table 7: Constraints to Adoption of Organic Fertilizer 45
Table 8: Transactions Costs Related to Organic Fertilizer Adoption 46
Table 9: Results of Cragg's Double Hurdle Model (Probit Output) on Determinants of Decision of Adoption of Organic Fertilizer 50
Table 10: Results of Cragg's Double Hurdle Model (Truncated Output) on Factors Affecting Intensity of Organic Fertilizer Adoption 54
Table 11: Distribution of the Estimated Propensity Scores 55
Table 12: Results on Performance of Different Matching Algorithms 56
Table 13: Balancing Test of the Covariates Based on Kernel Matching Method 57
Table 14: Results of Chi-Square Test for Joint Significance of Variables 58
Table 15: Propensity Score Matching Results 59
Table 16: Simulation Based Sensitivity Analysis Results 60

LIST OF FIGURES

Figure 1: Factors influencing organic fertilizer adoption 18
Figure 2: Map of the study area 20
Figure 3: Distribution of households by gender and marital status 34
Figure 4: Rate of adoption of organic fertilizer 44
Figure 5: Matching distribution 55

ACRONYMS AND ABBREVIATIONS

DAP	Diammonium-Phosphate
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
IFDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Institute
ISD	Institute for Sustainable Development
Kg	Kilogram
KM	Kernel Matching
Km	Kilometre
mm	Millimetre
MoFED	Ministry of Finance and Economic Development
m^3	Cubic meter
NGOs	Non-governmental organizations
NNM	Nearest Neighbour Matching
NPC	National Planning Commission
OF	Organic fertilizer
PAs	Peasant Associations
PIF	Policy and Investment Framework
PSM	Propensity Score Matching
RM	Radius Matching
SM	Stratification Matching
SNNPR	Southern Nation Nationalities and Peoples Region
SWADO	Shashemene Woreda Agricultural Development Office
TLU	Tropical Livestock Units
USD	United States Dollar
^0c	Degree Celsius

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Ethiopia is one of the fastest growing economies in Africa. In the last decade, the Ethiopian economy registered a growth of 11 percent per annum on average in Gross Domestic Product (GDP) (Ministry of Finance and Economic Development (MoFED), 2014) compared to 3.8 percent for previous decade (World Bank, 2012). As such, it is rated as one of the fastest growing non-oil exporting economies in the world. This growth has been largely supported by relatively high growth in agriculture (MoFED, 2012). Therefore, the role of agriculture in the Ethiopian economy cannot be underscored.

In Ethiopia, about 86 percent of total export earnings is obtained from agriculture (MoFED, 2010). The sector makes a significant contribution to the national GDP and provides a basis for development of other sectors such as industry. More than 40 percent of the country's GDP is generated from agriculture. It is also the main source of income for 85 percent of people living in rural areas of the country consisting of more than 90 percent of the Ethiopian poor (IFPRI, 2010). Therefore, the sector is important in improving the livelihoods of the bulk of the population.

Despite its importance, the agricultural sector in Ethiopia is characterized by low productivity. This has resulted in increased poverty amongst most smallholder farmers. One of the major causes of low productivity is change in environmental conditions resulting from high population growth rate (International Food Policy Research Institute (IFPRI), 2010). The rapid population growth in rural and urban areas of Ethiopia has led to increased demand for energy and food. Many households use animal by-products such as manure for fuel while crop by-products are used both for fuel and animal fodder. The substitution of animal by-products and manure for fuel and animal fodder has led to low adoption of organic fertilizer by smallholder farmers. Rapid population growth has also resulted to increased demand for cultivable land leading to clearing of forests. This creates a serious problem on sustainability of the environment which has been associated with fluctuation of rainfall, exposing farm land to erosion and making agricultural production vulnerable to weather fluctuations as well as deterioration in soil fertility which cannot be restored easily. The deterioration in soil fertility is associated with inadequate recycling of soil nutrients leading to gradual depletion of soil organic matter (Scotti *et al*., 2015). This leads to a reduction in agricultural productivity and hence increasing poverty levels.

Reducing poverty levels as well as improving food security necessitates creation of a better performing agricultural sector. This is thus the goal of the government and several development partners. In its first phase of five year (2010/11-2014/15) growth and transformation plan, the Ethiopian government had placed emphasis on agriculture and rural development specifically to reduce rural poverty and in general to improve overall economic growth (International Fertilizer Development Centre (IFDC), 2012). Based on the achievements, agriculture continued to be targeted in the second growth and transformation plan (2015/16 – 2019/20) giving priority to smallholder agriculture (National Planning Commission (NPC), 2015). These plans have been targeted ending poverty and making the country free from foreign aid by ensuring farmers reap maximum benefits from the agricultural sector (MoFED, 2015). To achieve this, the government has promoted different agricultural technologies in addition to scaling up the best practices of better performing farmers in overall sustainable improvement of agricultural productivity.

The major focus of the intervention was increasing land-labour ratio and adoption of new agricultural technologies by smallholder farmers. Such technologies include use of fertilizer as the main yield-augmenting technology. Due to this, the government and other development partners put more emphasis on fertilizer adoption to improve smallholder farmers' income in Ethiopia. It was also estimated that Ethiopia must essentially double use of fertilizer by 1.2 metric tons of fertilizer products to meet the Growth and Transformation Plan (GTP) target (IFDC, 2012). However, fertilizer adoption was initially limited to chemical fertilizer (Kassie *et al*., 2009) while less attention was given to organic fertilizer. Following the increased use of chemical fertilizer by smallholders, the soil had gradually deteriorated through loss of organic matter. It became compact, lifeless and less able to hold nutrients and water, resulting to low productivity.

Recently, the Ethiopian government and development partners have started promoting the use of organic fertilizer. The rate of adoption of organic fertilizer over the past was not known in Shashemene district. This is due to lack of well documented data over the past. The recent report (2013/14) however showed that about 42 percent of the farmers have adopted organic fertilizer in the district (SWADO, 2015). Nevertheless, the culture of recycling some potential sources of organic fertilizer such as animal manure and crop residuals has been poor in Shashemene district.

As such, this necessitated evaluation of factors contributing to low adoption of organic fertilizer and its effect on income in Shashemene district of Ethiopia.

1.2 Statement of the Problem

Farmers in rural areas of Ethiopia have been facing the challenge of declining agricultural productivity. One of the reasons for this is decrease in soil fertility. Since 1970s, the Ethiopian government has intervened in agricultural sector to overcome this problem through promotion of various agricultural technologies such as organic fertilizer. However, soil degradation has continued leading to decline in agricultural productivity. Further, despite the efforts made by the government and other development partners to enhance adoption of organic fertilizer in Shashemene district, the rate of adoption of this fertilizer remains low with only 42 percent of the households adopting organic fertilizer (SWADO, 2015). However, there is a dearth of information on the determinants of low adoption of this specific technology, the transaction costs involved as well as effect on household incomes. Thus, to fill this gap, this study was intended to evaluate the determinants of low adoption of organic fertilizer in Shashemene district. The impact of organic fertilizer use on households' farm income as well as the transaction costs involved in organic fertilizer adoption were evaluated.

1.3 Objectives of the Study

1.3.1 General Objective

To contribute to improved agricultural productivity through adoption of organic fertilizer in Shashemene district, West Arsi Zone, Oromia Regional State of Ethiopia.

1.3.2 Specific Objectives

i. To estimate transaction costs associated with organic fertilizer usage amongst smallholder farmers.

ii. To determine the socio-economic and institutional factors that influence adoption and use intensity of organic fertilizer.

iii. To determine the effect of organic fertilizer usage on smallholder farmers' farm income.

1.4 Research Questions

i. What is the level of transaction costs associated with organic fertilizer usage among smallholder farmers?

ii. What are the socioeconomic and institutional factors that influence adoption and use intensity of organic fertilizer?

iii. What is the effect of organic fertilizer usage on smallholder farmer's farm income?

1.5 Justification of the Study

Organic fertilizer is more affordable and sustainable compared to chemical fertilizer. Farmers can get this fertilizer at a lower cost and they can also prepare it locally on their farms as it requires less skill. It is more compatible with capabilities of smallholders with less skill and who lack capital to buy chemical fertilizer. Therefore, this study was focused on evaluating determinants of adoption of organic fertilizer in Shashemene district of Ethiopia. Evaluation of constraints related to adoption of organic fertilizer and income effect is relevant as it helps to provide empirical evidence to either confirm or deny the existing arguments in relation to the factors influencing adoption of organic fertilizer and its income effect. The study has also estimated transaction costs associated to adoption of organic fertilizer as adoption of any technology consists of its own cost implications for the adopters which needs to be addressed. The results of the study will help policy makers to come up with better ways of organic fertilizer adoption. Moreover, the study contributes toward improving agricultural productivity therefore improving farmers' farm income at household level and increasing income from agricultural sector at national level. The results of the study also provide insight toward further study on related areas.

1.6 Scope and Limitation of the Study

Agricultural productivity can be improved through employing different agricultural techniques such as conservation agriculture, adoption of improved variety of crops, fertilizer adoption and others. Although this study reviewed theoretical analysis related to some of these technologies, the main focus of analysis was adoption of organic fertilizer. This can be seen as the foremost limitation of this study. Absence of relevant data in the district agricultural office presented limitation to this study. To overcome this, primary data was collected from targeted stakeholders. Less availability of commercialized organic fertilizer in the study area also put limitation on the study. To counteract this, the study focused on the organic fertilizers which farmers can buy if available in the nearest market or prepare around their farms. Sever political instability that has taken place in early February, 2016 in most parts of Ethiopia including Shashemene district has also put limitation on this study. Several documents which could help the researcher were burnt during the time in some peasant associations.

The study has focused on smallholder farmers in Shashemene district while largescale commercial farmers were beyond the scope of this study. It is important to evaluate the farmers' willingness to accept this technology, it was however, beyond the scope of this study. The study, as its core objective was aimed at covering the determinants of adoption of organic fertilizer and its effect on income.

1.7 Definition of Terms

Adoption – is the choice of acquiring and using something. In this study "adoption of organic fertilizer" shows the stage or choice of using organic fertilizer.

Collective action – is an action taken by a group of people whose objective is to enhance resource use and achieve common goal.

Kebele – is the smallest unit of local government in Ethiopia. It comes after National, Regional, Zonal and woreda administration. It is also known as Peasant Association.

Organic fertilizer – is a plant food rich in carbonic content (Lavison, 2013) which is mainly prepared from animal matter, plant matter or minerals occurring in nature.

Opportunity cost – is the best value forgone because an alternative course of action has been chosen.

Productivity – is a measure of efficiency with which inputs are utilized in production. It is the ratio of agricultural outputs to agricultural inputs.

Smallholder – is farmers owning less than 5 hectares of land.

Technology – is a new or improved means of producing goods and services aimed at improving a given situation or changing status quo to a more desirable level.

Woreda – is the fourth administration level from the higher to the lower administration division in Ethiopia. It comes after National, Regional and Zonal administration. It is also known as *district*.

Teff – is a cereal crop grown in Ethiopia and used for preparing *enjera* (staple food in Ethiopia).

Transaction cost – is a cost resulted from the transfer of property right.

CHAPTER TWO

LITERATURE REVIEW

2.1 Importance of Agricultural Technology

Agricultural technology is a specific instrument designed to facilitate production in agricultural activity. It is an action designed to facilitate or improve pre-existing means of agricultural production. Therefore, agricultural technology is one of the resources in agricultural production (Chi and Yamada, 2002).

If the objective of the farming community is to increase agricultural production, it is clear that adoption of agricultural technology is the key instrument instead of simple expansion of agricultural land which might be hazardous to environmental conservation. In support of this, several studies have shown that sufficient agricultural technologies are available in developing countries to boost productivity. Although literature points out to the existence of sufficient agricultural technologies in Sub-Saharan Africa to increase food production, an appropriate policy environment coupled with an active technology transfer program has been lacking (Byerlee *et al*., 1994, as cited in Makokha *et al*., 2001). To improve this, several studies have been conducted suggesting the importance of agricultural technologies for better agricultural productivity.

Uaiene *et al*. (2009) stated that the issue of improving agricultural productivity can be addressed by adoption of better agricultural technologies. They argued that unless new technologies are adopted, increase in production will be slow posing rural poverty to remain widespread. Due to this, in most parts of Ethiopia, intensification of such technologies continues to be necessary to increase agricultural productivity. To ensure this sustainably, it was important to address core problems related to availability of agricultural technologies for farmers. This helps to ensure that smallholders have access to right technologies in the form that is appropriate to their local conditions accompanied with right information (IFDC, 2012).

However, in Ethiopia, farmers have little chance to adopt new agricultural technologies on their farms (Spielman *et al*., 2010). This is due to several constraints such as low human capital primarily low level of farmers' education. Most studies have evaluated the household heads' education level as the main determinant of technology adoption. However, even though household head is not educated, if the education level of any of family member is higher than that of the household head, this may affect their decision to adopt new technology. Thus, there is a need to evaluate technology adoption based on the highest level of education of any of the household's family member. In contrast, Endale (2011) stated that providing a platform for regular interaction of agricultural experts with farmers could enable farmers to adopt new technologies to boost their production. He explained that this is valuable as it helps in gaining insights and sharing experiences amongst farmers and experts.

2.2 Overview of Organic Fertilizer Use in Ethiopia

Organic fertilizer can be prepared from several sources such as crop residues, manure and municipality wastes among others. Animal manure and agricultural residues are the most common sources of organic fertilizer in Ethiopia. Other sources of organic fertilizer such as sewage sludge, slaughter house wastes and municipality solid waste (ISD, 2007) can also be processed to organic fertilizer. However, in Ethiopia, the number of plants available to process wastes found in cities and towns are limited. Due to this, the availability of organic fertilizer for farmers has been low in Ethiopia ("*Profile for Organic*…," n.d.). In addition to low availability of organic fertilizer, demand for organic fertilizer has been low in this country. However, few studies have evaluated adoption of organic fertilizer in Ethiopia (Terefe *et al*., 2014; Ketema, 2011) while most of them were biased toward adoption of chemical fertilizer (Yu and Nin-Pratt, 2014). Further, the trend or rate of adoption of organic fertilizer over the past years have not been well documented in this country.

2.3 Role of Organic Fertilizer in Increasing Agricultural Production

All agricultural crops require important nutrients in the soil for their growth. However, low productivity in Africa has been highly associated with low availability of nutrients for agricultural crops. Low soil nutrients associated with low application of fertilizer; particularly organic fertilizer has led to low productivity over the past decades. This has contributed to high food insecurity in most African countries including Ethiopia.

Ethiopian economy is highly dependent on agriculture. However, although the sector has been growing fast in this country, productivity remains low due to depletion of soil nutrients associated with low usage of organic fertilizer. The potential sources of organic fertilizer such as livestock dung and crop residuals in this country has not been appropriately used. Many smallholders remove a large proportion of crop residuals during the time of harvesting though these residues are an important source of nutrients. Due to this, the estimated annual national loss of nutrients was equivalent to the total amount of chemical fertilizer use in Ethiopia (PIF, 2010).

Kassa *et al.* (2014) showed that the adoption of organic fertilizer has positive impact on the agricultural productivity. They revealed that fertilizer adopters get better yield hence more farm income compared to their non-adopter counterparts. ISD (2007) showed that productivity can be increased by more than double if organic fertilizer is used compared to when chemical fertilizer is used while IFPRI (2010) revealed that productivity increases by 10-20 percent when organic fertilizer is used compared to when only chemical fertilizer is used thus increasing household income. This shows that the adoption of organic fertilizer is important for improving productivity thus contributing to increased farmers farm income. This has been possible through increasing yield with marginal increase in total cost (Cooke 1972, as cited in Lavison, 2013). The special characteristic and the very advantage of this fertilizer is that once it is applied, the farm can stay fertile for about four years and there is no need to apply it frequently therefore increasing productivity over several years. However, it was indicated that demand for organic fertilizer in Ethiopia has been low. This might be as a result of low understanding of its advantages (IFPRI, 2010).

2.4 Transaction Costs in Organic Fertilizer Adoption

It is important to estimate transaction costs (TC) related to technology adoption. Transaction costs include; search and information costs, bargaining and decision costs, and policing and enforcement costs which may be incurred between two or more parties (buyers and sellers and sometimes third body called mediator) (Coase, 1937). Search and information costs are costs incurred to determine that the required organic fertilizer is available at right time, place and price in a given market (Lavison, 2013). Bargaining costs are costs incurred between parties in case the buyer reaches the desirable agreement with the seller. Policing and enforcement costs are costs incurred in insuring that both parties stick to the terms agreed upon to facilitate the exchange (Lavison, 2013). Estimating these costs in relation to the technology being introduced in a given area is important because adoption of any technology has its own cost implication for the adopters (Lavison, 2013).

Smallholder farmers may incur higher transaction costs on marketing compared to large scale farmers because of low bargaining ability. Due to this, transaction cost can serve as a barrier to smallholder farmers to participate in input and product market (Coase, 1960 as cited in Lavison, 2013). Farmers may face several transaction costs while adopting organic fertilizer. These include cost of searching for the sources of organic fertilizer, bargaining costs, and others. In Ethiopia, particularly in Shashemene district, organic fertilizer lacks well-structured markets, that is, traders who make transaction formally, rather the exchange usually takes place within the village. This may also contribute to increased transaction costs of obtaining organic fertilizer.

According to Jagwe (2011), transaction cost vary among farmers based on factors such as remoteness of farmers from the point of exchange place. He further elaborated that factors such as household size and ownership of means of transportation are directly proportional to the transaction costs.

Transaction costs can be measured directly or indirectly from the costs of getting or using the technology. For example, finding the sources of organic fertilizer can be done through telephone calls, texts or internet therefore incurring costs which can be estimated directly. However, in the absence of these means of searching for information, a household may walk or get any other means of transportation and search for information. In this case, the value of the best alternative forgone can be measured indirectly which is commonly known as *opportunity cost*.

Reducing transaction costs related to adoption of organic fertilizer is important as it helps to encourage farmer's participation in adoption of this technology. However, despite the importance of analysis of transaction costs, several studies conducted on adoption of organic fertilizer have not assessed this cost (Akpan *et al.*, 2012; Terefe *et al.*, 2013; Martey *et al.*, 2013; Yu and Nin-Pratt, 2014).

2.5 Empirical Literature on Adoption of Organic Fertilizer

Adoption of a new technology may not be automatic. This is mainly due to the fact that a producer is rational and therefore prefers to see the benefit of a new technology before she/he adopts it. Farmers can see the performance of new technology by different ways. If the technology is new, they can see its performance on any of local development partners' demonstration area (Uaiene *et al*., 2009). However, if the technology is only new to some farmers while others have already adopted, new adopters may prefer to see its performance on neighbouring farmers' farm. In addition, once it is adopted, the technology must be properly used if agricultural productivity is to increase. Nevertheless, without close attention to the use and adoption of improved agricultural technologies, production growth is likely to slow. Therefore, in addition to adoption, monitoring as well as technical advice from agricultural experts is important for effectiveness of these technologies. This type of advice as well as assistance holds only if the technology is adopted. However, in most developing countries such as Ethiopia, adoption of agricultural technology such as organic fertilizer has been low.

Several factors have been identified as the main constraints of adoption of agricultural technologies by different scholars. These factors have been grouped into various categories by different researchers. Mwangi and Kariuki (2015) grouped these factors into technological factors, economic factors, institutional factors and household specific factors. They found that perception of farmers toward new technology adoption is a key to adoption. Their results also pointed out that the determinants of agricultural technology adoption do not always have the same effect on adoption rather the effect varies depending on the technology being introduced. For example, the effect of farm size on adoption of some technologies such as intensity of chemical fertilizer adoption can be positive and the same variable may have negative impact on some other technologies such as zero grazing technology.

Ajewole (2010) used personal characteristics of the farmers, resource use and production characteristics, institutional and technological attributes as groups of variables affecting adoption of agricultural technologies. He found that a household head who is younger with lower farming experience, higher education level, many extension visits, larger farm size and closer to the source of commercial organic fertilizer is more likely to adopt organic fertilizer compared to the households with opposite characteristics. However, Mwangi and Kariuki (2015) noted that there is no generally acceptable criteria to group these variables. This study has therefore grouped these variables as socioeconomic characteristics and institutional factors. Socioeconomic characteristics include age, gender, household size, education level, number of family who can provide labour, soil fertility, plot ownership, size of the plot, livestock holding, transaction costs and farm income. Institutional factors include access to credit, access to extension services, access to information media, membership in local farmers' associations, access to organic inputs and distance from the residence to the nearest market. These factors have been shown in different literature to have either negative, positive or no statistically significant impact on fertilizer adoption.

Endale (2011) in a study of use of DAP and Urea revealed that fertilizer adoption has high positive effect on production of some cereal crops such as *teff*, maize, wheat and barley. He also found that chemical fertilizers have insignificant effect on sorghum production due to specific characteristics of this crop whereby it usually grows in low rainfall area. This shows that technology adoption depends on the type of the crops under production as well as the climatic condition of the area. Thus, the type of crops grown and variation in weather conditions may affect the farmers' decision to adopt agricultural technology. For example, in some parts of Ethiopia, application of fertilizer on production of *teff* depends on the weather condition. Farmers in dry areas apply more fertilizer compared to farmers in high rainfall areas. Therefore, the compatibility of such technologies should be examined independently in different farming locations.

To characterize adoption of organic fertilizer, there is a need to look at factors affecting the adoption decision. Due to this, several researchers have tried to analyse determinants of the technology adoption. Uaiene *et al*. (2009) showed the relationship between households' membership to different local farmer associations and fertilizer adoption decision. They stated that better information dissemination through farmers' associations has positive impact on the decision to adopt new agricultural technologies. Better networked farmers may have better information about new technologies. Associations may also help to overcome credit markets failure. It helps farmers to get credit in terms of '*collective action.'* This is also crucial for smallholder farmers to reduce transaction costs related to cost of bargaining in buying organic fertilizer.

Endale (2011) showed that better access to credit, livestock ownership and having a large family size have positive impact on fertilizer adoption. Access to credit helps farmers to overcome financial problems existing between harvesting and land preparation. Uaiene *et al*. (2009) found that inadequate access to credit is one of the major challenges of technology adoption. Having a large number of livestock may act as collateral to accessing credit from local financial institutions. In the absence of finances, farmers may sell the livestock and buy fertilizer during planting season. In addition, having a large number of livestock provides dung which is a potential source of organic fertilizer. Thus, any farmer who does not own livestock may not easily adopt organic fertilizer.

A study conducted by Ketema and Bauer (2011) on fertilizer consumption, stated that a farmer with a large family is likely to adopt manure than chemical fertilizer. This is because such a farmer can get enough labour for both manure preparation and planting. Thus, a household with many members is more likely to demand more manure compared to a small household. Chemical fertilizer is relatively more capital intensive. Availability of enough capital increases the demand for chemical fertilizer. Therefore, availability of credit services coupled with small households may shift demand for organic fertilizer to chemical fertilizer.

In some parts of Ethiopia, women, in farming activities are treated differently from men. Culturally, some jobs are only for men while others are reserved for women. The finding of Ketema and Bauer (2011) on the study about fertilizer consumption in East and West Hararghe Zone of Ethiopia revealed that manure application is considered as women's job. Therefore, a household with more women is more likely to adopt organic fertilizer than that with less women.

Birungi (2007) showed that an increase in distance of the plot from the farm site decreases manure application as it requires more labour and cost to transport the organic fertilizer from the village to the farmstead. However, increase in plot size increases likelihood of manure application. Ketema and Bauer (2011) also found that land size is positively related to manure application. As land size increases, it encourages investment through improving cost related to its application, therefore, the advantage of economies of scale is achieved. However, as the farm size becomes smaller, steeper and more fertile less manure is applied.

Most of the above literature concluded that there is a trade-off between chemical and organic fertilizer. However, generally, organic fertilizer adoption is low in Ethiopia; particularly, in Shashemene district. Thus, there is a need to look for policy options which target at enabling farmers to increase adoption of organic fertilizer.

2.5.1 Farmers Perception on Adoption of Organic Fertilizer

Perception is an important condition for technology adoption. According to Van de Ban and Hawkin (1988) cited by Chi and Yamada (2002), perception is the process by which we receive information or stimuli from our environment and transform it into psychological awareness. According to Mwangi and Kariuki (2015) and Akpan *et al.* (2012), farmers' perception about the performance of agricultural technologies significantly influences the decision to adopt them. Farmers may perceive that the performance of the technology being introduced is better than the earlier technologies. However, though they have positive perception about the specific technology, they may not adopt it because of lack of know how to use the technology, financial shortage or other constraints. Thus, positive perception is not a guarantee for a farmer to adopt a given technology.

The results of a study conducted by Diagne and Zeller (2001) in Malawi on adoption of agricultural technology showed that a farmer with low plot fertility has positive perception toward adoption of farm technology. This might be due to farmers' expectation of better returns from adoption of this technology. However, in Ethiopia, specifically in Shashemene *woreda*, though the plots of some farmers are not fertile they have never adopted organic fertilizer.

2.6 Theoretical Framework

This study used three theories to evaluate determinants of adoption of organic fertilizer and its effect on income. This includes utility maximization theory, transaction cost theory and Solow growth model framework.

2.6.1 Utility Maximization Theory

Different models have been used by different researchers to build up on theories of adoption of new agricultural technologies. Most of these models are built on the theory of rational expectation. It is assumed that a firm's expectation is always rational (maximum profit). However, for smallholder farmers, the reason for technology adoption is not necessarily profit maximization (Njane, 2007). They could have some primary objectives such as maintenance of social status, fulfilling minimum subsistence requirements and others. To achieve the objectives, which can be represented by maximum utility, a farmer need to adopt new technologies. On the other hand, according to Mendola (2007), farmers' decision making of technology adoption is guided by risk and uncertainties. Generally, based on the expectation, farmers decide either to adopt or not adopt new technologies.

Let U_{i1} and U_{i0} represent a firm's utility derived from two choices, in this case; adoption of organic fertilizer and not adopting organic fertilizer respectively. The assumption is that a firm derives maximum utility as much as possible from his/her efforts which depends on expected utility to be obtained from either adopting or not adopting the new technology. Farmer *i* is likely to adopt a new technology (organic fertilizer) if the expected utility of adoption (U_{i1}) is larger than the expected utility of not adopting (U_{i0}). Therefore, farmer *i* adopts organic fertilizer when expected utility to be derived from adoption of organic fertilizer is larger than expected utility to be derived from not adopting organic fertilizer subject to some exogenous variables such as level of income, experience, information and other constraints.

That is, if $U_{i1} > U_{i0}$, then

$$U_i = U_{i1} - U_{i0} > 0 \quad (1)$$

However, utility is unobservable. A binary random variable Y_i (taking the value of one if the technology is adopted and zero otherwise) can only be observed. This variable for which its real value is not observable is also called latent variable. Based on the theory of utility maximization, a rational firm adopts a given new technology if *U (1, x) > U (0, x).* Where, *1* represent the state with new technology and *0* represent the state with old technology, and *x* representing vector of additional attributes that may influence decision to adopt. Mathematically:

$$U_{i1} = w'\beta_{i1} + Z_{i1}^{'}\gamma_{i1} + \varepsilon_{i1} \text{.........} (2)$$

and

$$U_{i0} = w'\beta_{i0} + Z_{i0}^{'}\gamma_{i0} + \varepsilon_{i0} \text{.........} (3)$$

In both equations (equation 2 and 3), the observable (measurable) vector of characteristics of the household is denoted by *w'*. The vectors $Z_{i0}^{'}$ and $Z_{i1}^{'}$ denote attributes of the two choices that might be choice specific. The random terms, ε_{i0} and ε_{i1} represents the stochastic elements that are not known by the observer, but known only by individuals.

Based on the outcomes of equations (2) and (3) individual preferences are ranked. Therefore, if $y = 1$ denoting the individual choice of alternative 1, from $y = 1$ we can conclude that $U_{i1} > U_{i0}$.

Since the outcome is driven by the random elements in the utility function, we have:

$$U_i = w'(\beta_{i1} - \beta_{i0}) + Z'(\gamma_{i1} - \gamma_{i0}) + (\varepsilon_{i1} - \varepsilon_{i0}) = w'\beta_i + Z'\gamma_i + \varepsilon_i = \delta x + \varepsilon \text{.........} (4)$$

$$\varepsilon_{i1} - \varepsilon_{i0} = \varepsilon_i$$

Assuming the error terms (ε_{i1}, ε_{i0} and ε_i) in equation (4) are independent and normally distributed, following probit specification, probabilities of choice can be estimated. After probit estimation, the above equation will have the following form:

$$P(y = 1 \mid x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \text{..........} + \beta_n x_n + \varepsilon \text{.........} (5)$$

Where β represents estimated parameters and *x* represents factors influencing adoption of organic fertilizer such as age, gender of household head, level of schooling, and other institutional and socio-economic variables and ε represents error term.

This theory was used to analyse determinants of adoption of organic fertilizer in Shashemene district, Ethiopia. Therefore, it was assumed that farmers adopt organic fertilizer when they expect higher productivity from adoption of organic fertilizer than other types of fertilizer.

2.6.2 Transaction Cost Theory

Transaction cost presents costs to the parties involved in transaction (Coase, 1937). The theory of transaction cost states that difficulties in economic exchange between sellers and buyers arise because of three exchange related problems, namely; opportunism, bounded rationality and asymmetric information. Incorporating this cost into agricultural model is also possible (Lavison, 2013). The theory of transaction cost suggests that costs associated with market sometimes favour hierarchies. This could be due to adverse selection which occurs when sellers value the good more than its actual value. Adverse selection makes the buyer (who is not sure of the value of the good) to be unwilling to pay more than the expected value of the good. On the other hand, in the presence of contracts, it can be difficult for the buyers to control the behaviour of the sellers or vice versa known as moral hazard. Moral hazard occurs when one party (buyer or seller) is careless because he/she is already in the contract. This can make smallholder farmers not to participate in the market as their paying capacity is low. For example, smallholder farmers may get organic fertilizer easily if there is no barrier in terms of transaction costs which can be high in the presence of moral hazard and adverse selection. This theory was used in this study to evaluate transaction costs related to adoption of organic fertilizer.

2.6.3 Solow Growth Model

Solow growth model is a model of capital accumulation in production economy which is strictly interested in output (real income). The model was developed by Solow in 1956 and has been applied to the study of growth problems. It assumes that all people work all the time and therefore no labour/leisure choice. Producers save a fixed portion of income and own the firms thus collecting their income, rent and profit in the form of output. The theory assumes that output (Q) is a function of labour (L) and capital (K):

$$Q = f(K, L) \quad \text{.......... (6)}$$

This model uses a production function of the Cobb-Douglas type presented as follows:

$$Q = AK^a L^b \quad \text{.......... (7)}$$

Where; Q, A, K and L are output, multifactor productivity, capital and labour respectively. a and b are less than one, indicating diminishing returns to a single factor and a + b = 1, indicating constant returns to scale. According to Solow (1956), an increase in output takes place due to an increase in multifactor productivity as well as an increase in capital per worker. It was therefore in this case assumed that, increase in use of organic fertilizer increases farm output hence income. The model states that output grows throughout. However, since production exhibits diminishing returns, at some point, the change in output slows down.

2.7 Conceptual Framework

Although portfolios of agricultural technologies (for instance, fertilizer adoption) are available to farmers, their adoption has been constrained by several factors overtime. In Shashemene district of Ethiopia, fertilizer adoption was among the highly promoted agricultural technologies to improve farm productivity. This promotion included both organic and inorganic fertilizer. However, adoption of organic fertilizer remains low up to early 2016 compared to chemical fertilizer due to some exogenous factors determining acceptance of this technology. These factors were classified into socio-economic factors and institutional factors. Socio economic factors include household related variables such as household characteristics, ownership, and transaction costs while institutional factors include access to the market, information and credit.

It was hypothesized that several factors influence organic fertilizer adoption. A younger household with less experience, more formal education level and higher number of working family member is likely to adopt organic fertilizer. Thus, the more the level of education, number of working family members and farming experience of household, the higher the likelihood of adopting organic fertilizer. Female headed households are likely to adopt organic fertilizer compared to male headed. Land and livestock ownership have positive effect on adoption of organic fertilizer. If a household owns livestock, he would have better sources of organic fertilizer such as animal manure. This increases likelihood of adopting organic fertilizer. Better access to information has positive effect on farmers' decision of adoption of organic fertilizer. Farmers can get information from local farmers associations, extension services and information media. Thus, improvement in access to information could increase farmers' propensity of organic fertilizer adoption. Availability of organic fertilizer at a lower cost for farmers increases likelihood of adopting organic fertilizer. Thus, the lower the transaction costs related to organic fertilizer adoption, the higher the likelihood of adopting organic fertilizer. Adoption of organic fertilizer improves soil fertility therefore increasing farm income. Generally, these variables and their relationship is presented diagrammatically as given in Figure 1.

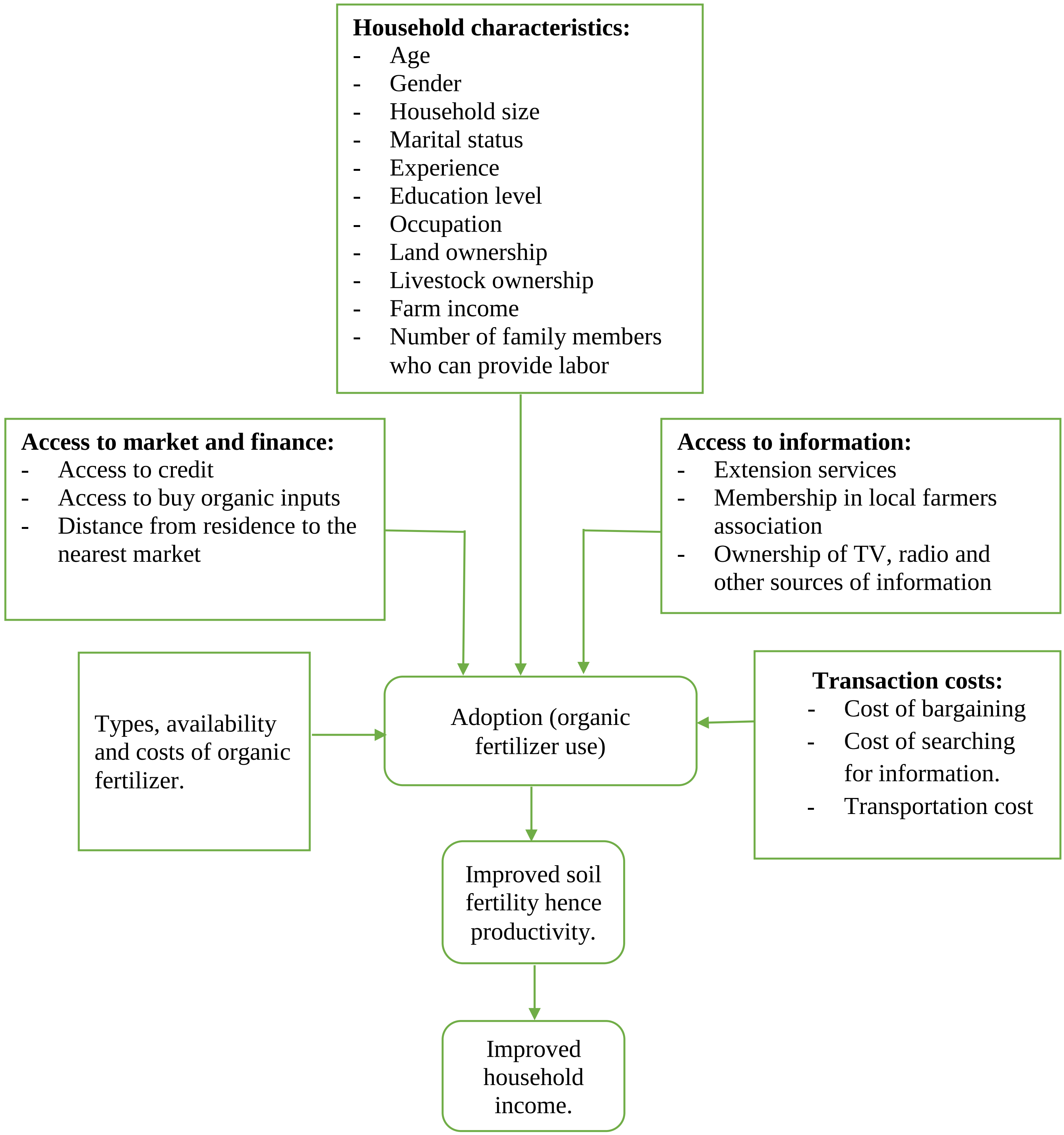

Figure 1: Factors influencing organic fertilizer adoption

CHAPTER THREE

METHODOLOGY

3.1 Study Area

This study was carried out in Shashemene district of Ethiopia. Shashemene is situated on $7^0$05' to $7^0$19'north and $38^0$23' to $38^0$41' east. It is found in West Arsi zone of Oromia regional state and located 250 km south of Addis Ababa; the capital of Ethiopia and 25 km north of Hawassa; the regional capital of SNNPR. This district is bordered on the south by SNNPR state, on the north by Arsi Nagelle district, on the east by Kore district, on the south east by Kofele district and on the west by Shalla district. Its climate is characterized as temperate with annual temperature ranging from 12^0c to 27^0c. It is 1,685 m to 2,722 m above sea level with a total area of 467.18 km square. More than 87 percent of this land is cultivable. The district has a population of 42,942, of which more than 85 percent depend on agriculture for their livelihood and majority of them are smallholders owning a plot of less than 5 hectares. The agro climatic conditions of the district are favourable for agriculture with two rainy seasons. It has an annual rain fall ranging from 700 mm to 950 mm. The major agricultural crops grown in the district include wheat, maize, *teff*, beans, potato and vegetables amongst others (SWADO, 2015). Although agriculture has been the main activity in the district, agricultural productivity remains low.

Shashemene district is rich in livestock. It has more than 524,771 heads of livestock comprising 41 percent of cattle, 19 percent of goats, 11 percent of sheep, and others. This shows that the district has ample resources for preparing organic fertilizer especially from animal dung which could enable the districts' smallholder farmers to overcome the problem of low crop productivity. The high potential for organic fertilizer production with low adoption rate (42 percent of adopters) made the district to be chosen for the study. Moreover, the report of the district agricultural development office showed that fertilizer to land ratio in the district was 70 kg per hectare whereas the recommended level was 100 kg per hectare. This was another reason which has made this area to be chosen for the study to identify constraints of organic fertilizer adoption. Generally, Shashemene district is shown below on the map depicted in Figure 2.

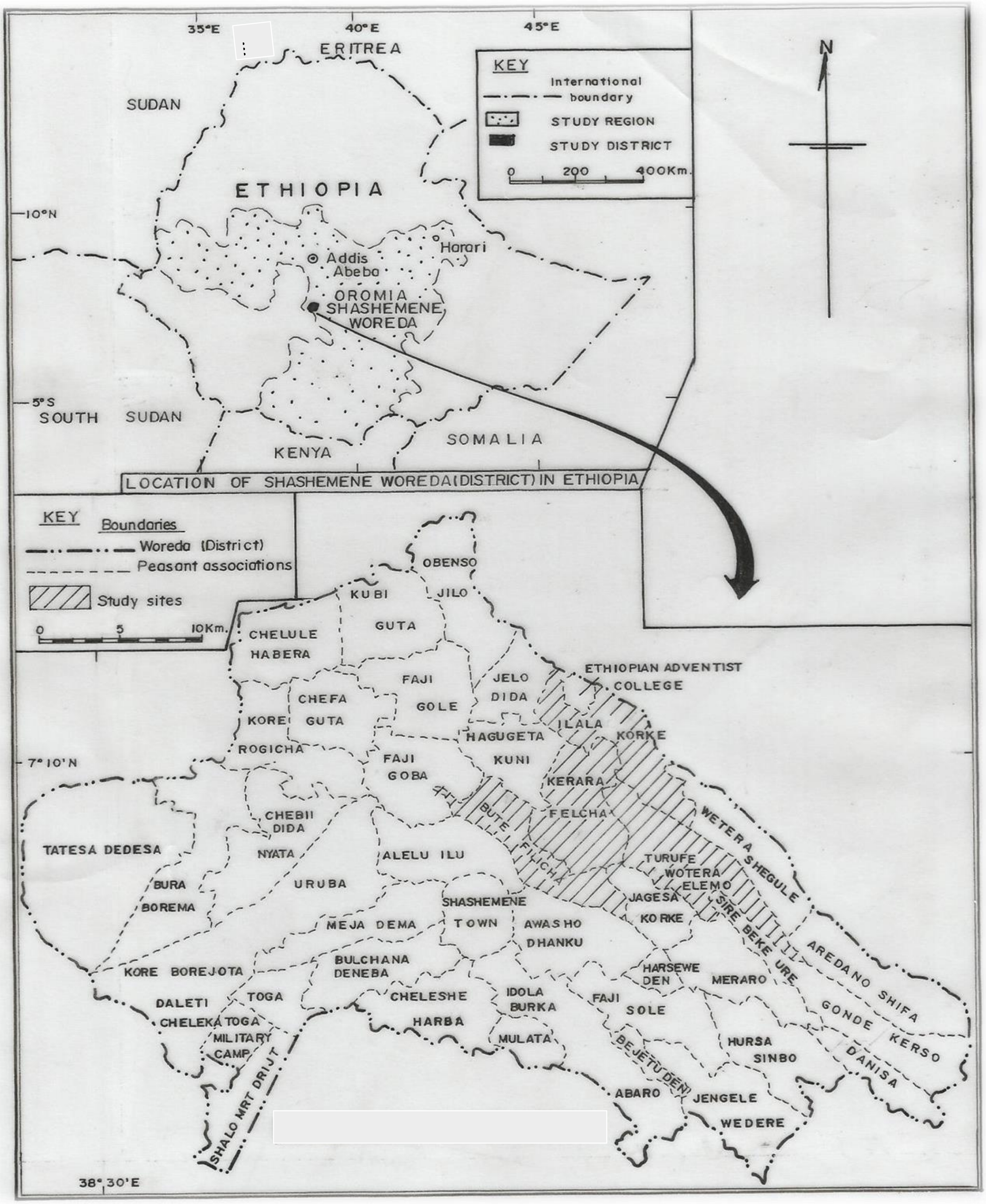

Figure 2: Map of the study area

Source: SWADO, 2015

3.2 Research Design

Primary data was collected using a household survey design. This was preferred because it allows collection of primary data where the population is large. The study used descriptive survey design and the design was preferred because it allows analysis of both quantitative and qualitative data. Descriptive survey also helps to describe characteristics of targeted individuals or groups.

3.3 Sampling Procedures and Sample Size

This study targeted smallholder farmers in Shashemene district of Ethiopia. Two stage sampling technique was used to identify respondents for the study. In the first stage, purposive sampling of *kebeles* was done selecting Ilala korke, Wotera turufe elemo, Butte filicha and Kerara filicha. These *kebeles* experience relatively higher intensity of organic fertilizer adopters and favour similar agro-climate condition. In the second stage, systematic sampling was used to choose a sample for adopters of organic fertilizer from the selected *kebeles*. The technique was employed after the lists of adopters which was believed to be homogenous and random were obtained from the respective *kebeles* office. Systematic sampling can be applied only if the given sampling unit is logically homogeneous and random (*Systematic Sampling*, n.d.). This implies that there should be no reflection of certain pattern in the list of population over the chosen sampling interval. For example, if the list coincides with the periodicity over certain characteristics being measured, then selection of respondents using systematic sampling may result in biased choose of representatives. In current study area, the lists of non-adopters had reflected certain pattern of similarity in terms of their location. Moreover, the list was stored as it was obtained from the small administration units called *zone* and the researcher was not certain about their complete homogeneity. Due this, the study employed simple random sampling to draw respondents for non-adopters. Accordingly, the table of random number was used to draw appropriate number of respondents.

As suggested by Yamane (1967), since the population number (number of targeted population) is known in the study area, the following formula can best provide the required sample size for this study.

$$n = \frac{N}{1 + N(e^2)} \quad \ldots\ldots (8)$$

Where; n is sample size, *N* is the population size (total number of the households in four *kebeles*), *e* is allowable margin of error (level of precision) ranging from 0.05 to 0.1. Margin of error shows the percentage at which the opinion or behaviour of the sample deviates from the total population. The smaller the margin of error the more the sample is representative to the population at a given confidence level. Therefore, for this study, allowing the smallest possible margin of error (e = 0.05), the total sample size became:

$$n = \frac{4368}{1 + 4368 * (0.05)^2}$$

n =366.443, showing that a total sample of 367 was required for this study.

Based on the estimated proportion of the adopters and non-adopters of organic fertilizer, whereby adopters in the district were about 42 percent and non-adopters were about 58 percent of the population, proportionally 155 households (42 percent of the sample) and 213 households (58 percent of the sample) were selected from the lists of adopters and non-adopters respectively.

3.4 Methods of Data Collection

A structured questionnaire was used for this study as the data collection instrument. The questionnaire was administered to the respondents after the permit was obtained from the district agricultural development office. The permit was mainly used to get list of farmers from respective PAs. The questionnaire was translated to local language (*Afaan Oromoo*) and then pretested on 25 households to determine the validity and reliability of the instrument. Pre-test interview was done by the researcher while the final data collection was done primarily by the researcher assisted by trained development agents working in the respective peasant associations. It was administered personally to all respondents.

To support the data collected from the field, secondary data, which was collected from different published or non-published research journals and reports of woreda agricultural development office were used.

3.5 Data Analysis Techniques

3.5.1 Estimating and Characterizing Transaction Costs Associated with Organic Fertilizer Usage amongst Smallholder Farmers

Transaction cost measures all costs incurred by farmers' when using organic fertilizer. It is the sum of the costs for searching information, bargaining, and enforcements. Like any other costs, transaction cost is divided into variable and fixed cost. Thus, to arrive at a total transaction cost, it is important to consider both variable transaction cost and fixed transaction cost elements. These costs can also be determined directly or through the opportunity cost. Lavison (2013) used transaction cost formula given in equation (9) to estimate transaction costs associated with adoption of organic fertilizer in vegetable production in Ghana. The formula was introduced by Coase (1937). It has been used to estimate aggregate transaction costs incurred by the households' in using a given technology. Transaction costs also differ from one household to the other household or from one technology to another technology. Following Coase (1937), this study employed the following formula to estimate transaction costs associated with organic fertilizer use among smallholder farmers in Shashemene *woreda*. Accordingly:

$$T_i = \sum_{i=1}^{n} C_{ij} \quad \text{......} \quad (9)$$

$$\mathbf{C}_{\boldsymbol{i}} = C_{info} + C_{opcost} + C_{barg} + C_{oth} \quad \text{......} \quad (10)$$

Where; T_i is the i^{th} farmer total transaction cost and C_{ij} is the transaction costs faced by i^{th} farmer from j^{th} source. C_i is the i^{th} farmer transaction cost from C_{info}, C_{opcost}, C_{barg}, and C_{oth} representing cost of searching for information about organic fertilizer, opportunity cost of searching for sources of organic fertilizer, bargaining costs and other transaction costs related to organic fertilizer adoption respectively estimated in Ethiopian Birr.

Moreover, descriptive statistics which involves mean was used to characterize smallholder farmer's based on transaction costs related to organic fertilizer adoption.

3.5.2 Determining the Socio-Economic and Institutional Factors that Influence Adoption and Use Intensity of Organic Fertilizer

The double hurdle (DH) model was employed to analyse factors that influence adoption and use intensity of organic fertilizer. The model was chosen because it has an advantage over the other models such as Linear Probability Models in that, it reveals both the probability of willingness to adopt and intensity of adoption (Terefe *et al.*, 2013). The DH model controls the reciprocal relationship (dual endogeneity) between the two factors; adoption decision and use intensity (Ketema, 2011). It is also ideal as it can resolve the problem of heteroscedasticity (Asante *et al*., 2011). Thus, several studies used this model to estimate technology adoption and use intensity (Yu and Nin-Pratt, 2014; Martey *et al.*, 2013; Terefe *et al.*, 2013; Akpan *et al.*, 2012). The model was introduced by Cragg (1971) and assumes that a household head makes two independent and sequential decisions regarding adoption and use intensity of the technology. Assuming these two independent decisions, the first stage of the model deals with the adoption decision equation which can be expressed as:

$$d_i{*} = \alpha_1 X_i + u_i \quad \text{……………………………………………………….……....…. (11)}$$

Where; $d_i\,*$ is unobservable choice of adoption decision and also known as latent variable, X_i is a vector of explanatory variables hypothesized to affect decision to adopt organic fertilizer, and u_i is normally distributed error term with zero mean and constant variance. Then, the observed organic fertilizer adoption decision is:

$$D_i = \begin{cases} 1 & if \quad d_i{*} > 0 \\ 0 & if \quad d_i{*} \leq 0 \end{cases} \quad \text{……..…………………….……………………..……..…. (12)}$$

Where; $d_i\,*$ is unobservable choice of the technology by the i^{th} household, and D_i represents observable i^{th} household decision to participate in technology adoption; 1 if a respondent reports organic fertilizer use and 0 otherwise.

The second stage deals with the outcome equation which uses a truncated model. The equation helps to determine the extent of optimum use intensity of organic fertilizer. Most households in Shashemene district use some sources of organic fertilizer such as manure without measuring its amount. Due to this, it was difficult to know the exact amount of organic fertilizer used by farmers on their farms. However, households who use compost use m^3 (cubic meter) measurement when preparing and *quintal (*a unit of weight equal to 100 kg) when transporting it to their farms. Thus, the application level of compost on their farms is better known by farmers compared to other organic fertilizers such as manure. Therefore, in this stage, only respondents who reported positive use of compost which is greater than or equal to the optimum use intensity of compost in the study area were included. The evidence from the districts' agricultural development office also showed that 42 percent of the farmers in the district were compost users. On the basis of that, using the compost as a proxy to evaluate intensity of organic fertilizer adoption, the optimum organic fertilizer use was determined as the average level of compost usage per hectare in the study area. This was arrived at by dividing total sum of per hectare use of this fertilizer to total number of respondents who reported positive use of organic fertilizer. A dependent variable that has a zero value for a significant fraction of the observation requires a truncated regression model (referred to as a modified Tobit model in this case) because standard OLS results in a biased and inconsistent parameter estimates (Greene, 2002). The bias arises from the fact that if one considers only the observable observation and omits the others, there is no guarantee that the expected value of the error term will be zero (Terefe *et al*., 2013). The truncated model which closely resembles the Tobit model was used to deal with the use intensity of organic fertilizer (outcome) equation which can be presented as follows:

Let, $Y_i{*} = \alpha_1 X_i + u_i$ ……………………………………………………………… (13)

and

$$Y_i = \begin{cases} Y_i{*} \ \ if \ \ \ D_i = 1 \text{ and } Y_i{*} \geq \mu \\ 0 \ \ \ if \ \ D_i \leq 0 \ and \ Y_i{*} < \mu \end{cases} \qquad \text{……………………………………………… (14)}$$

Where; Y_i represents observed use intensity of compost by the household *i*, $Y_i{*}$ is the level of compost being used by the household *i*, μ representing threshold; minimum compost use intensity considered as optimum in the study area, and D_i as explained earlier. Then, the following empirical models were specified to evaluate factors affecting adoption decision and use intensity of organic fertilizer using double hurdle model:

1st hurdle: Adoption decision model (Probit output);

$$\begin{aligned} Adop = {} & \beta_0 + \beta_1 Age + \beta_2 Gend + \beta_3 Hsize + \beta_4 Educ + \beta_5 Incom + \beta_6 Exp + \\ & \beta_7 Powner + \beta_8 Sfertility + \beta_9 Lstock + \beta_{10} Cred + \beta_{11} Exten + \beta_{12} Aces \\ & + \beta_{13} Memb + \beta_{14} Dist + \beta_{15} Mar + \beta_{16} Wfam + \beta_{17} Feduc + \varepsilon \text{.............................(15)} \end{aligned}$$

2nd hurdle: Outcome equation model (Truncated output);

$$\begin{aligned} Y_i = {} & \beta_0 + \beta_1 Age + \beta_2 Gend + \beta_3 Hsize + \beta_4 Educ + \beta_5 Incom + \beta_6 Exp + \\ & \beta_7 Powner + \beta_8 Sfertility + \beta_9 Lstock + \beta_{10} Cred + \beta_{11} Exten + \beta_{12} Aces \\ & + \beta_{13} Memb + \beta_{14} Dist + \beta_{15} Mar + \beta_{16} Wfam + \beta_{17} Feduc + \beta_{18} FreqAppl + \varepsilon \text{...........(16)} \end{aligned}$$

Where, the variables on equation (15) and (16) represented as; *Adop* is organic fertilizer adoption taking values of 1 for adopters and 0 for non-adopters, Y_i is quantity of compost being used by the respondents in the study area, *Age* is age of the household, *Gend* is gender of household head, *Hsize* is size of the family, *Educ* is education level of household, *Incom* is household heads' farm income, *Exp* is farming experience of household, *Powner* is plot owner, *Sfert* is soil fertility, *Lstock* is livestock ownership, *Cred* is access to credit, *Exten* is extension contacts, *Aces* is access to TV, radio and other social media, *Memb* is membership in local farmers associations, *Dist* is distance from the residence to the nearest market in kilometres, *Mar* is marital status of household head, *Wfam* is number of family member with at least the age of 18 years, *Feduc* is Higher education level of any of family member, *FreqAppl* is frequency of application, β_0 is constant, β_1 to β_{18} is coefficients of respective explanatory variables and ε is error term.

3.5.3 Detecting Multicollinearity, Outliers and Statistical Specification Problems

There are different types of statistical problems which should be checked during analysis before executing the final model. Multicollinearity is one of the most common problem. Thus, in this study, all the hypothesized explanatory variables were checked for the existence of such a problem. Multicollinearity arises due to the existence of linear relationship between explanatory variables. The problem may cause the estimated regression coefficients to have wrong signs, smaller *t*-ratios for many variables and high R^2 in the regression. It may also cause variances and standard errors to be high with a wide confidence intervals making the estimation accuracy of the impact of each variable low (Gujarati, 2004; Greene, 2002).

Different methods have been suggested by several scholars on the ways of detecting multicollinearity among explanatory variables. Variance-inflating factor (VIF) technique is among these methods. The technique shows how variance of an estimator is inflated by the presence of multicollinearity (Gujarati, 2004). VIF can be computed mathematically as follows:

$$VIF = \frac{1}{1 - R^2} \quad \text{………………………………………………………} \quad (17)$$

Where; R^2 is coefficient of determination among explanatory variables and *VIF* is variance inflating factor. The larger the value of *VIF*, the more the degree of collinearity among explanatory variables (Gujarati, 2004). This study has also employed *VIF* method to check for the existence of multicollinearity. If the *VIF* of a variable exceeds 10, which could happen if a multiple R^2 exceeds 0.9, that variable is said to be highly collinear (Gujarati, 2004).

Similarly, contingency coefficient (CC) method was also used in this study to measure the degree of association among discrete explanatory variables (Healy, 1984). CC can be computed mathematically as follows:

$$CC = \sqrt{\frac{x^2}{n + x^2}} \quad \text{………………………………………………………} \quad (18)$$

Where; CC is contingency coefficient, x^2 is chi-square value and n is sample size.

According to Healy (1984), a discrete/dummy variable is said to be collinear with another variable if the value of contingency coefficient (CC) is greater than 0.75. Availability of heteroscedasticity was also tested using White's test while existence of omitted variables was tested using Ramsey regression specification-error test for omitted variables (ovtest). Moreover, availability of outliers was checked using graphs involving box plots.

3.5.4 Determining the Effect of Organic Fertilizer Usage on Household's Income

Farmers choose either to adopt or not to adopt a given technology based on expectations, objectives, and observable and unobservable characteristics. This is referred to as self-selection (Chala and Tilahun, 2014). Thus, simple comparison of the adopters with non-adopters tends to overestimate the impact of improved agricultural technology on farmers income. To overcome this problem, propensity score matching (PSM) has been used as the best procedure. In impact analysis, specially, when the dimensions of the covariates are many, individual matching on the basis of observed covariates may not be feasible. Thus, instead of matching along covariates, matching along the propensity scores may provide better results. Hence, recently, several studies have used this procedure to evaluate the impact of agricultural technologies on the households' income (Acheampong and Owusu, 2014; Chala and Tilahun, 2014; Awotide *et al.*, 2012; Nguezet *et al*., 2011).

PSM has an advantage of reducing dimensionality of matching to a single dimension (Chala and Tilahun, 2014). It is the best possible procedure to evaluate the individual probability of receiving the treatment given the observed covariates (Rubin and Rosenbaum, 1983). It determines the average treatment effect on the treated farmers (organic fertilizer adopters). That is, the causal effect of adoption of organic fertilizer on farmers per hectare farm income (average income from wheat, maize, *teff*, and beans). This is done in the final stage while PSM estimates propensity scores and checks for balancing conditions in the first step. The scores can be estimated for treatment variables using probit model (Mendola, 2007). This study was thus employed the probit model to predict the propensity scores using all socio-economic and institutional variables included in the analysis of objective two excluding farm income. The effectiveness of PSM depends on two assumptions. These are assumption of conditional independence and assumption of common support.

Assumption of Conditional Independence (ACI): This assumption states that the selection into the adoption group is solely based on the observable characteristics. Given the values of some observable covariates, the assumption implies that the value of the outcome variable is independent of the treatment state. This means the household's farm income should be independent of adoption assignment. Therefore, the organic fertilizer adopter's outcome and the non-adopter's outcome is independent of the treatment status.

$$Y_0,\ Y_1 \perp A\ |Z \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (19)$$

$$E\ (Y_1\ |P,\ A_i = 1) = E\ (Y_0\ |P,\ A_i = 0) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (20)$$

Where, P is i^{th} farmer propensity of organic fertilizer adoption, Y_1 is outcome (farm income) of i^{th} farmer when organic fertilizer is adopted, Y_0 is outcome of i^{th} farmer when organic fertilizer is not adopted, E is expectation operator, and A is the state where i^{th} farmer adopts or not adopt organic fertilizer; 1 for a farmer who has adopted organic fertilizer and 0 otherwise.

Equation (20) shows that adopters could have the same average farm income as non-adopters if they would have not participated in adoption of organic fertilizer controlling all pre-program observable household characteristics that are correlated with the program participation and the outcome variable (Adelman *et al*., 2008). Thus, the non-adopters outcome can be used as an unbiased estimator of the counterfactual outcome for the adopters.

Common Support Assumption (CSA): This assumption states that the average treatment effect for the treated (ATT) is only defined within the region of common support. It also assumes that no explanatory variable predicts the treatment perfectly.

$$0 < p\ (A = 1\ |Z) < 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (21)$$

If the above two assumptions are satisfied, then conditional to estimates of propensity scores (p), the observed outcome (average farm income) of organic fertilizer adopters can be substituted for the missing average farm income of non-adopters.

Given that the propensity scores are balanced and the above assumptions are satisfied, according to Rosenbaum and Rubin (1983) the parameter of interest which is ATT can be estimated as:

$$ATT = E(y_1 - y_0 / A = 1)$$

$$= E(y_1 / A = 1) - E(y_0 / A = 1) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22)$$

Where, y_1 is outcome (farm income) of i^{th} farmers when organic fertilizer is adopted, y_0 is outcome of i^{th} farmers when organic fertilizer is not adopted, E is expectation operator, and A is the state where i^{th} farmer adopts or not adopt organic fertilizer; 1 for a farmer who has adopted organic fertilizer and 0 otherwise.

In impact evaluation, the interest is not on $E(y_0 / A=0)$, but on $E(y_0 / A=1)$. Therefore, PSM uses estimated propensity scores to match the observed mean farm income of the non-adopters who are most similar in observed characteristics with adopters. That is, it uses $E(y_0 / A=0)$ to estimate the counterfactual $E(y_0 / A=1)$. Therefore:

$$ATT = E(y_1 - y_0 / A=1)$$
$$= E[E(y_1 - y_0 / A=1, p(z))]$$
$$= E[E(y_1 / A=1, p(z) - E(y_0 / A=1, p(z) / A=1)]$$
$$= E[E(y_1 / A=1, p(z) - E(y_0 / A=0, p(z) / A=0)] \quad \text{……………..………..… (23)}$$

Where; *ATT*, *E*, y_1, y_0, p and *A* are defined as earlier.

A number of proposed methods are available to deal with matching similar adopters and non-adopters. Nearest neighbour matching method (NNM), radius matching method (RM), stratification matching method (SM) and kernel based matching method (KM) are the most commonly used matching methods based on similarity of propensity scores among the observations.

The NNM method matches each of the treated individual with the control individual that has the closest propensity score. It estimates the average treatment effect for the treated, the controls or the sample as whole or their standard errors (Abadie *et al.*, 2004). In this method, more than one comparison units can also be used for matching. Using more comparison unit allows a trade-off between reduced variance and increased bias. Using more information for construction of counterfactuals reduces variance and using poorer match increases bias. In the KM method, all adopters are matched with a weighted average of all non-adopters using the given weights. The weight depends on the distance between controls and treatments. It is inversely proportional to the distance between the propensity scores of adopters and non-adopters group. The closest control units are given more weights. However, sometimes, the distance between treatments and controls are substantial. To handle this, radius (calliper) matching method might be the best. RM method is a variation of NNM method which tries to avoid problem of bad matches through using tolerance of maximum distance allowed (Grilli and Rampichini, 2011). However, it is difficult to know in advance which tolerance level is reasonable. The other method of matching propensity scores is stratification matching method. This method classifies the common support in to different intervals and calculates mean difference of outcomes (the impact of the technology) within each interval.

The choice of a specific matching algorithm depends on the data in question, and in particular on the degree of overlap between the treatment and comparison groups in terms of the propensity score (Berhe, 2014). It is also stated that consideration of several matching algorithm in tandem is advantageous as it allows measuring robustness of the impact estimates (Becker and Ichino, 2002). Thus, this study used nearest neighbourhood matching, radius matching, stratification matching and kernel based matching methods to match and compare the average per hectare farm income between samples of adopters and non-adopters of organic fertilizer.

3.5.5 Simulation-Based Sensitivity Analysis for Matching Estimators

The propensity score measures individual probability of receiving the treatment subject to the observed covariates (z). That is:

$$p(z) = P(D = 1|z) \quad (24)$$

Independence of the potential outcome Y_0 on the treatment assignment subject to z shows that Y_0 is independent of the treatment assignment subject to p(z). Therefore, the propensity score can be used as a univariate summary of all observable variables. If p(z) is known, the average treatment effect on treated (ATT) can be consistently estimated as:

$$ATT = E(Y_1 - Y_0 | D = 1) = E_{(p(z)|D=1)}\left[E(Y_1|p(z), D = 1) - E(Y_0|p(z), D = 0\right] \quad (25)$$

Where; *ATT*, *E*, Y_0, Y_1, D, z and *p* are defined as earlier. Practically, p(z) is unknown and has to be estimated through probabilistic model such as probit or logit. All the pre-treatment observable variables that influence both selection into the treatment and the outcome should be included in the model when estimating propensity scores. To make sure that within each cell of the propensity score the treated and control units have the same distribution of observable covariates, higher-order or interaction terms should be included in the specification of the model. Including these terms is important only if the terms can serve in satisfying the estimated propensity scores.

One of the central assumptions of the sensitivity analysis is that treatment assignment is not unconfounded given the set of covariates *z*. This implies that the Common Support Assumption (CSA) no longer holds. It is also assumed that the CIA holds given *z* and an unobserved binary variable (U). Where;

U: $Y_0 \perp\!\!\!\perp D |$ (z, U)

As long as U is existing and unobserved, the outcome of the controls; E (Y_0 |D = 0) cannot be credibly used to estimate the counterfactual outcome of the treated; E (Y_1 |D = 1). This means:

$$E(Y_0 | D = 1, z) \neq E(Y_0 | D = 0, z) \quad (26)$$

Conversely, if U is known together with the observable covariates (z), then it would have been possible to estimate ATT using the outcome of controls. This is because:

$$E(Y_0 | D = 1, z, U) = E(Y_0 | D = 0, z, U) \quad (27)$$

Considering the following equation with binary potential outcomes,

$$Y = D * Y_1 + (1 - D) * Y_0$$

The distribution of the binary confounding factor U is fully characterized by the choice of four parameters:

$$p_{ij} = p(u = 1 | D = i, Y = j) = p(u = 1 | D = i, Y = j, z) \quad (28)$$

In order to make the simulation of the potential confounder feasible, two simplifying assumptions are made. These are the assumption of binary U and conditional independence of U with respect to z. It was also indicated that the simulation assumptions pointed out here have no impact on the results of the sensitivity analysis (Ichino, Mealli and Nannicini, 2007). Using a given set of values of the sensitivity parameters, the matching estimation is repeated many times and a simulated estimate of the ATT is retrieved as an average of the ATTs over the distribution of U. Then, the simulated U is treated as any other observed covariate and included in the set of matching variables to estimate the propensity score and compute ATT according to the chosen matching algorithms.

3.6 Variables of the Model

The dependent variable for the first hurdle of the second objective was participation in organic fertilizer adoption. The variable was dummy and represented by 1 for the households who have adopted organic fertilizer and 0 otherwise. In the second hurdle, the dependent variable was intensity of organic fertilizer adoption and it was continuous. All the explanatory variables hypothesized to have impact on adoption of organic fertilizer including dependent variables were summarized in the Table 1.

Table 1: Definition and Prior Assumptions of the Variables Used in Empirical Analysis

Variable	Description	Hypothesis
OF	Organic fertilizer adoption; 1 = if adopted, 0 = otherwise	
Intensity	Intensity of organic fertilizer use in quintal	
Age	Age of household head in years.	-
Gend	Gender of household head; 1 = male, 0 = female	+/-
Educ	Household head education level in years.	+
Feduc	Highest education level in the family; years of schooling.	+
Mstatus	Marital status of household head; 1 = married, 2 = widowed, 3 = divorced, 4 = single.	+
Wfam	Number of labourers; family members within the age of at least 18 years.	+
Hsize	Household size; total number of family members.	+
Exp	Length of time household head practiced farming in years.	-
Incom	Household head's per hectare farm income in ETB	+
Powner	Households' farm size in hectare.	+
Sfertility	Perception about the soil fertility; 1 = less fertile, 2 = medium, 3 = fertile.	
Lstock	Ownership of livestock measured as tropical livestock units (TLU).	+
Dist	Distance from the residence to the nearest market in kilometres.	-
FreqAppl	Frequency of organic fertilizer application; 1 = every season, 2 = per two season, 3 = per three season, 4 = above three season.	-
Cred	Amount of credit in Ethiopian Birr.	
Exten	Access to Extension services; number of extension meeting during previous agricultural season.	+
Memb	Number of organizations a household is a member in.	+
Tc	Transaction costs associated with organic fertilizer adoption in ETB.	-
Aces	Access to information media such as radio and television; 1 = have access, 0 = no access.	+

Note, TLU is a unit that represents an animal of 250 kg live weight. Following Runge-metzger (1988), the unit was 1.0 for cattle, 0.1 for sheep and goat, and 0.04 for chicken.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-Economic and Institutional Characteristics of Sampled Households

4.1.1 Results on Gender and Marital Status

The results presented in Figure 3 show that about 11.4 percent of the households were female headed while about 88.6 percent were male headed. Among the adopters of organic fertilizer, about 12 percent of the households were female headed against 88 percent of the male headed households. On the other hand, amongst the non-adopters of organic fertilizer, about 11 percent of the households were female headed while the remaining 89 percent were male headed. The results showed that the proportion of male headed households were higher both among the adopters and non-adopters of organic fertilizer compared to that for female headed households. Among the adopters of organic fertilizer, the higher proportion of male headed households could be due to better exposure that the male headed households have to different technologies and trainings delivered by extension agents. According to IFPRI (2012), male heads are more likely to attend community meetings and visit demonstration plots or research centres compared to female heads. This could possibly make male headed households to be more adopters of organic fertilizer.

The results on the marital status indicated that overall 95.1 percent of the household heads were married, 1.1 percent were single, 1.9 percent were widowed and 1.9 percent were divorced. Amongst the organic fertilizer adopters, 96.1 percent of the household heads were married while the proportion was about 94.3 percent among the non-adopters of organic fertilizer. The proportion of married household heads was higher among the adopters compared to the non-adopters implying that respondents who are the heads as a result of being married are more likely to adopt organic fertilizer. This could be due to the heavy concern that the married households have to improve output at minimal possible cost over the limited and competing resources (Bonabana-Wabbi, 2002). Martey *et al.* (2013) noted that marriage increases farmer's concern for household welfare thus increasing farmer's participation in agricultural technology adoption. Further, among the widowed household heads, 46.2 percent were adopters against 53.8 percent of non-adopters while all the divorcee and single household heads were found to be non-adopters of organic fertilizer.

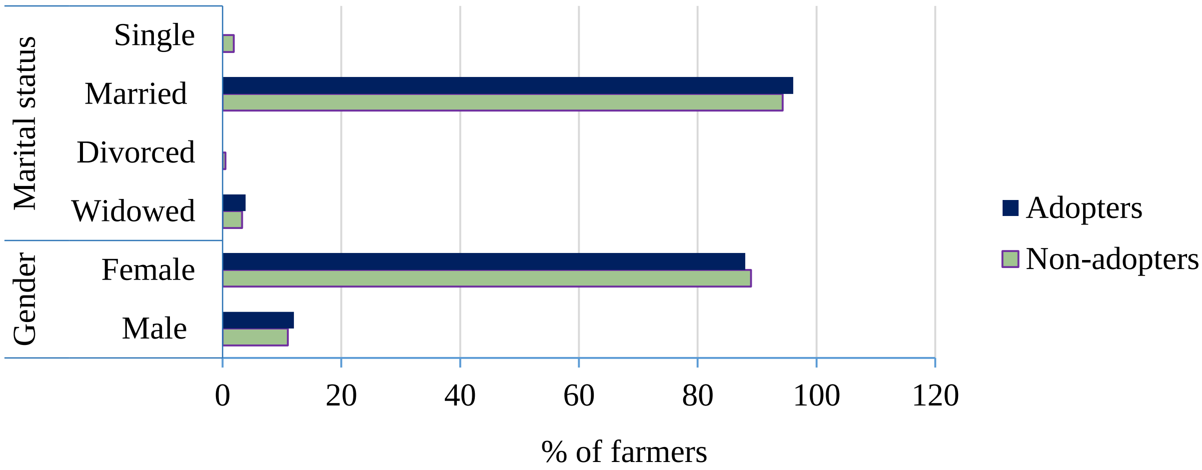

Figure 3: Distribution of households by gender and marital status

4.1.2 Results on Age, Education, Household Size, Labour, Livestock Ownership, Farm Size, Income and Farming Experience

The results of continuous socio-economic variables are given in Table 2 and 3. Results on age show that the average age for the sampled farmers was 44.11 years (Table 2). The average age of organic fertilizer adopters and non-adopters were found to be 44 and 44.2 years respectively. These results show that majority of the households were at productive stages of their lives in terms of the capacity to work. Although the difference was quite low, on average, adopters were younger than non-adopters. Ajewole (2010) argued that younger household heads are more likely to adopt organic fertilizer on their farms in Nigeria. This might be due to the fact that younger farmers are typically less risk-averse and are more willing to try new technologies (Mwangi and Kariuki, 2015). Older households are less dynamic and innovative in terms of the technology adoption (Enete and Igbokwe, 2009).

Education is the potential source of knowledge which enables one to understand instructions, access and comprehend information about the new technology (Okuthe *et al.*, 2013). In this study, education level was measured as the number of years of schooling starting from zero or no education to university graduate. The average years of formal schooling for the sampled farmers was 5.99 years (Table 2). Among the organic fertilizer adopters, the average years of formal schooling was 6.35 while among the non-adopters, it was about 5.74. This shows that more educated farmers were adopters in the study area which might be the result of better education. Education could likely allows farmers to make efficient decision, and be the early adopters who can take the advantage of the new technology (Orinda, 2013). Further, about 12.3 percent of the adopters and 8 percent of the non-adopter household heads were found to be illiterate (Appendix 2).

The overall highest level of any of family member's education among the respondents was 10.33 years (Table 2). In comparison, it was about 10.7 years among the adopters of organic fertilizer and 10.1 years among the non-adopters of organic fertilizer. This implies that the average highest level of education among the adopters was higher compared to that of non-adopters revealing that relatively adopters' family have achieved higher education. This is due to the fact that the most educated family member with better capacity to interpret different information have a tendency to influence household's decision to adopt organic fertilizer. Kassie *et al.* (2009) noted that adoption of organic fertilizer, for instance, composting is knowledge intensive requiring more formal education. It is therefore reasonable to conclude that higher education of any of family members could intensify adoption of organic fertilizer among the farmers.

In relation to family size, the overall average household size among the respondents was found to be 7.13 (Table 2). Among the adopters of organic fertilizer, the average household size was about 7.26 whereas it was about 7.02 amongst the non-adopters. On average, the household size was higher among the adopters compared to non-adopters. The fact that organic fertilizer is labour intensive compared to the other types of fertilizer supports the results. Larger family size may enable one to provide additional labour needed in use of the organic fertilizer (Ajewole, 2010). Furthermore, about 98.4 percent of the households have had family size ranging from 2 to 14 while the remaining 1.6 percent had a family size of only 1 (Appendix 2).

A family member was presented as being able to provide labour if he or she is at least within an age of 18 years. This is because the age at which one is allowed to work in most places is 18 years and above. The results indicated that the overall average family member who can provide labour among the sampled households was 3.09 (Table 2). The average family member who provide labour was about 3.27 among the adopters of organic fertilizer and 2.95 among the non-adopters showing that adopters were having larger average family member who provide labour for farm activities. This further indicated better capacity of adopters in terms of labour supply for their farm activities which might have helped them to adopt labour intensive organic fertilizer. The finding was concurrent with Ajewole (2010). He claimed that ability of the household members to provide additional labour could increase possibility of organic fertilizer use.

Table 2: Results on Age, Education, Household Size and Labour (*N*=368)

Characteristics	Adopters		Non-adopters		Overall mean	Test statistics
	Mean	SD	Mean	SD		*t* – value
Age (years)	43.99	11.00	44.20	11.88	44.11	-0.17
Household head education (years)	6.35	3.84	5.74	3.39	5.99	1.61
Highest education in the family (years)	10.65	2.90	10.10	3.01	10.33	1.75*
Household size (family number)	7.26	3.01	7.02	3.36	7.13	0.71
Labour (number)	3.27	2.76	2.95	2.70	3.09	1.11

Note, *** and * indicate significance at 1% and 10% probability level respectively while SD denotes standard deviation.

The number of livestock owned was presented in terms of the tropical livestock unit (TLU) giving different weights for different types of livestock's. According to Runge-metzger (1988), TLU is a unit that represents an animal of 250 kg live weight where, 1 is assigned for cattle, 0.1 for sheep and goat, and 0.04 for chicken. The manure from animals such as donkeys, horses and mules are not used as sources of organic fertilizer in the study area. During composting, farmers totally exclude the manure of such animals because these manures cannot be easily decomposed as those obtained from the cattle's, sheep, goats and chicken. Due to this, excluding donkeys, horses and mules, other livestock's such as cattle's, sheep, goats and chicken were used as the potential sources of organic fertilizer in the study area. Accordingly, the survey results indicated that the overall average livestock holding among the farmers was about 5.31 units (Table 3). The average livestock holding was about 7.8 among the adopters and 3.5 among the non-adopters. The fact that the livestock has the potential resources (animal manure) for organic fertilizer preparation could make the number of livestock units to be quite important for adoption of organic fertilizer (Tefera *et al*., 2013). Due to this, the larger average livestock holding shown among the adopters possibly had intensified organic fertilizer adoption compared to low livestock holding farmers. The difference was significant at 1 percent probability level showing the importance of livestock in adoption of organic fertilizer. Further, the results show that about 3.8 percent of the adopters and 36.2 percent of the non-adopters of organic fertilizer did not own any livestock (Appendix 2).

In relation to farm size, the average farm size among the sampled households was 0.94 hectares (Table 3). On average, the organic fertilizer adopters own about 1 hectare of farm land while the non-adopters own about 0.86 hectare of the farm land. The current study had predicted that farmers with relatively larger farm size are likely to adopt organic fertilizer. This could be primarily due to lower marginal costs associated with adoption of labour intensive technology on the larger area of the farm land. The results indicated that the households with larger farm land were adopters of organic fertilizer possibly due to lower marginal costs. The mean difference of the farm size between the adopters of organic fertilizer and the non-adopters of organic fertilizer was significant at 1 percent probability level. Martey *et al.* (2013) argued that an increase in cultivation plot is associated with financial constraints for smallholder farmers in Ghana thus reducing adoption of chemical fertilizer. Lower use of chemical fertilizer could possibly result in more use of organic fertilizer in Ethiopia. Ketema (2011) claimed that manure use is negatively correlated with application of chemical fertilizer in Tirgai region of Ethiopia as these two types of fertilizers are substitute for each other. Moreover, majority of the households (64.4 percent) own less than or equal to 0.75 hectares of the farm land. About 7.1 percent of the adopters of organic fertilizer own 2 to 3 hectares of the farm land while the corresponding proportionate for non-adopters was 2.4 percent showing that adopters own larger farm land than non-adopters (Appendix 2).

The average farm income among the respondents was found to be 12975.58 ETB per annum (Table 3). Amongst the respondents who have adopted organic fertilizer, the average farm income was about 14497.55 ETB while the non-adopters of organic fertilizer had an average farm income of 11868.04 ETB. The higher average farm income among the adopters may justify that adopters of organic fertilizer are more dependent on agricultural activities. Dependency of farmers on agricultural activities makes them to be more concerned about yield increasing technologies such as organic fertilizer. On the other hand, according to Makokha *et al.* (2001), a household whose income depends on farm activities does not have enough capital to use chemical fertilizer in Kenya thus they opt to use manure to compensate outflow of nutrients. Moreover, the difference of the average farm incomes among the adopters and the non-adopters of organic fertilizer was found to be significant at 1 percent probability level.

Regarding the experience, the average farming experience of the respondents was 23.93 years while that for the adopters and non-adopters of organic fertilizer was found to be 24 years and 23.9 years respectively (Table 3). According to Obisesan (2014), more years of farming experience help farmers to evaluate the advantage of agricultural technology and be the early adopters of new technology. More experienced farmers seem to have better information and knowledge accumulated over time. Years of experience for majority of the organic fertilizer adopters were distributed between 21 and 30 while for majority of the non-adopters of organic fertilizer, it was distributed between 11 and 20 (Appendix 2). This implies that relatively most adopters of organic fertilizer had more years of farming experience. Akpan *et al.* (2012) claimed that farming experience improves farmer's behaviour of coping up with problems of soil infertility and reduces likelihood of chemical fertilizer adoption while in support of this, Ketema (2011) noted that lower use of chemical fertilizer could possibly result in more use of organic fertilizer. Moreover, the maximum farming experience reported among the respondents was 50 years while 1 year was the minimum farming experience.

Table 3: Results on Livestock Ownership, Farm size, Income and Farming Experience (*N*=368)

Characteristics	Adopters		Non-adopters		Overall mean	Test statistics
	Mean	SD	Mean	SD		*t* – value
Livestock ownership (TLU)	7.81	5.15	3.48	4.36	5.31	8.71***
Farm size (hectares)	1.06	0.53	0.86	0.40	0.94	4.06***
Farm income	14497.55	7491.62	11868.04	6979.41	12975.58	3.46***
Experience (years)	23.97	10.57	23.89	11.16	23.93	0.07

Note, *** and * indicate significance at 1% and 10% probability level respectively while SD denotes standard deviation.

In this study, farm fertility represents the household's perception about the fertility of their farm. The results presented in Table 4 show that about 23.9 percent of the adopters believed that their farms were not fertile. In comparison, the corresponding figure for non-adopters was about 22.1 percent. Relatively, a higher proportion of households who perceived that their plots are not fertile were found to be adopters of organic fertilizer. Low farm fertility has been reported to be a major constraint to agricultural production by an increasing number of farmers in Ethiopia (Makokha *et al.*, 2001). This shows that low fertility of the farm could be one of the reasons for adoption of organic fertilizer. Kpadonou *et al.* (2015) noted that the problem of soil fertility (decrease in farm fertility) is associated with greater likelihood of organic fertilizer use in the Sahel region. The survey results of this study further revealed that about 72.9 and 3.2 percent of the adopter households perceived that their farms were medium and fertile respectively. On the other hand, about 74.6 percent and 3.3 percent of the non-adopters were believed that their farms were medium and fertile respectively.

Table 4: Results on Farm Fertility (*N*=368)

Characteristics	Adopters		Non-adopters		Test statistics
	Freq.	%	Freq.	%	χ^2 - value
Farm fertility					
Not fertile	37	23.9	47	22.1	
Medium	113	72.9	159	74.6	0.17
Fertile	5	3.2	7	3.3	

4.1.3 Results on Group membership, Access to credit, Extension visits, and Distance to the nearest market

The results of the continuous institutional characteristics are presented in Table 5. The results show that overall 41 percent of the sampled respondents were members of farmers based associations while the remaining nearly 59 percent were not. The results further show that about 57.4 percent of the adopters were members of at least one farmer based organization whereas the percentage of non-adopter who belonged to at least one farmer group was 29.1 percent (Appendix 2). Compared to non-adopters, most members of the farmers based organizations were adopters. Farmer based organizations are the potential sources of information. Unlike that of information media such as television and radio, the information obtained through membership in a given farmer group involves two way discussion which can be easily understood by the farmers. Due to this, availability of such organizations may increase frequency of discussion among the member farmers therefore enhancing communication for development (Berhe, 2014). Households belonging to farmers group such as associations and cooperatives can easily access fertilizer technology (Martey *et al.*, 2013). As such, existence of farmers based organizations could possibly increase the adoption rate of organic fertilizer. The mean difference of membership in different farmers based organizations between the adopters and the non-adopters of organic fertilizer was significant at 1 percent probability level. This implies that the membership in such organizations could enhance adoption of organic fertilizer. The results further indicated that the average number of farmer organizations the respondents belonged to was less than 1 for both adopters and non-adopters of organic fertilizer.

Credit is an important source of finance in agricultural technology adoption. The major sources of credit in Shashemene district include: Oromia credit and saving share-company (OCSSCO/*WLQO)* and farmers based associations such as *Idir*. It was found that about 18.2 percent of the sampled respondents had accessed and used credit while about 82.8 percent of them did not access credit due to different reasons such as high interest rate. The results of credit access and use among the respondents was low. This may be related to the enforcements that financial institutions have been putting on farmers to payback the debt even if the crop failed such as in the year 2007 and 2008 E.C. This resulted in low use of credit in the 2014/2015 cropping season. Only 12.9 percent of the organic fertilizer adopters and 22.1 percent of the non-adopters of organic fertilizer used credit in the indicated season (Appendix 2). The results presented in Table 5 further showed that on average, organic fertilizer adopters had received average credit of 4100 ETB, while non-adopters had received 3582.98 ETB in the 2014/2015 cropping season. The difference was significant at 5 percent probability level.

Extension service refers to demonstrations, trainings and advice delivered to the farmers mainly by development agents and other agricultural experts. It was measured in terms of the frequency of farmers meeting with extension workers during the previous agricultural season. The results indicated that the overall average frequency of extension contact was about 3.2 (Table 5). In comparison, it was found that the average frequency of extension contact was about 3.67 per season among the adopters of organic fertilizer while that of non-adopters was about 2.86. The difference in the average extension contacts between the adopters and non-adopters of organic fertilizer was significant at 1 percent probability level. The results show that the adopters of organic fertilizer had better access to extension services on average compared to non-adopters justifying that the higher frequency of extension visits may have contributed toward adoption of organic fertilizer. Kassie *et al*. (2009) argued that farmers who have regular contact with agricultural experts are more likely to adopt agricultural technologies. Similarly, Ajewole (2010) claimed that the frequency of extension visits increased the possibility of commercial organic fertilizer adoption in Nigeria.

In relation to the distance to the nearest market place, overall average distance to the nearest market was 3.59 km (Table 5). The household that is closest to the nearest market was situated about 0.01 km while the furthest household was situated about 15 km (Appendix 2). In comparison, the average distance was 3.57 km among the adopters of organic fertilizer and 3.61 km amongst the non-adopters. This shows that the adopters were closer to the nearest market place compared to the non-adopters counteract. A farmer who is closer to the market place is likely be more informed about technologies compared to the one who is furthest from the market place reflecting that the closer farmer could easily adopt organic fertilizer. According to IFPRI (2012), farmers who are on a shorter distance to the market are more likely to have access to agriculture-related information through different channels. This might have compelled the farmers who are close to the market place to engage in adoption of organic fertilizer. On the other hand, Martey *et al.* (2013) posited that distance to the nearest market place is one of the limiting factors of agricultural input use as it determines the transaction costs associated to its use.

Table 5: Results on Group Membership, Access to Credit, Extension Visits, and Distance to the Nearest Market (*N*=368)

	Adopters		Non-adopters		Overall	Test statistics
Characteristics	**Mean**	**SD**	**Mean**	**SD**	**mean**	***t* – value**
Group membership (number)	0.59	0.52	0.31	0.49	0.42	5.31***
Access to credit (amount in ETB)	4100.00	1780.45	3582.98	1978.86	3737.31	-1.55
Extension (number of extension visit)	3.67	2.79	2.86	2.61	3.20	2.85***
Distance to the nearest market (km)	3.57	2.42	3.61	2.30	3.59	-0.71

Note, *** denotes significance at 1% probability level and SD indicates standard deviation.

Information can be accessed through different media such as radio and television where the flow of information through such type of media is mostly unidirectional (two way communications are less available). However, it is the fastest and cheapest mode of communication (Truc *et al.*, 2012). The results indicate that about 75.5 percent of the sampled household had access to information through radio and television while about 24.5 percent did not. Households who had access to information through television, radio or any other social media were considered to have access to information media. Among the adopters of organic fertilizer, about 83.2 percent had access to information through these information media, while the proportion of the farmers who do not have access to information through radio and television was about 69.9 percent among the non-adopters of organic fertilizer. According to Opara (2010), communication; in this case through information media such as radio and television, is at the heart of any change process across the society. As such higher proportion of households who have had information through radio and television were found to be adopters of organic fertilizer. Thus, improvement in access to information could have a positive effect on the decision to adopt organic fertilizer as well as the farmers' perception of organic fertilizer adoption. The results in Table 6 further posited that the relationship between access to information and organic fertilizer adoption was significant at 1 percent probability level.

Table 6: Results of the Households' Access to Information Media (radio and television) (*N*=368)

	Adopters		**Non-adopters**		**Test statistics**
Characteristics	**Freq.**	**%**	**Freq.**	**%**	χ^2 **- value**
Access to information					
Media					18.555 ***
Yes	129	83.2	149	69.9	
No	26	16.8	64	30.1	

Note, *** denotes significance at 1% probability level.

4.2 Organic Fertilizer Adoption

The role of agricultural technologies in increasing overall farm income has been well documented. Organic fertilizer is one of the agricultural technologies which has been believed to reduce direct production costs, improve environmental benefits, and increase crop yields (Kassie *et al*., 2009). Despite these advantages, the rate of adoption of organic fertilizer among the farmers remain low in some places such as Shashemene district. Out of the total sampled farmers in the Shashemene district, about 42 percent were adopters while 58 percent were not. This is presented in Figure 4. The major factors contributing to the low organic fertilizer adoption are discussed in section 4.5 below.

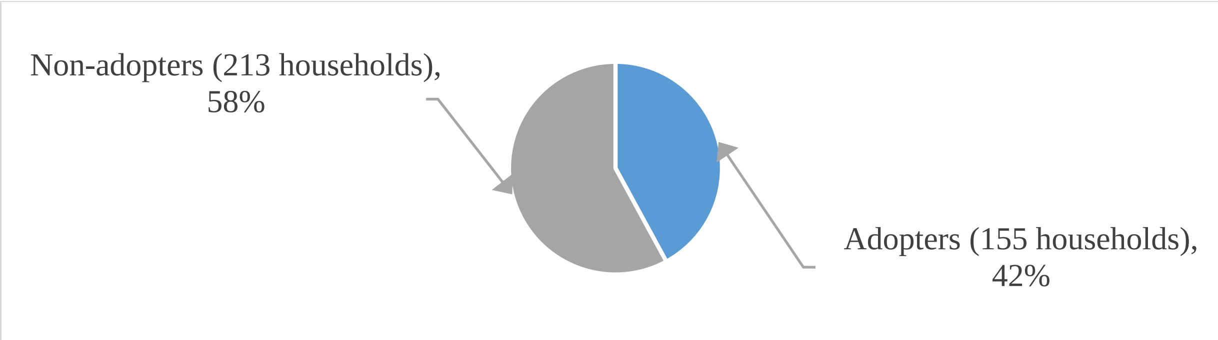

Figure 4: Rate of adoption of organic fertilizer

Source: SWADO (2015)

4.3 Constraints to Adoption of Organic Fertilizer

The major constraint to adoption of organic fertilizer was found to be low livestock holding. This was reported by about 55.4 percent of the organic fertilizer non-adopters. They reported that they do not own enough livestock which may provide them manure. This shows the importance of livestock holding in organic fertilizer adoption where the low livestock ownership could be the cause of low adoption rate of organic fertilizer.

Lack of adequate labour was the second constraint to adoption of organic fertilizer. Organic fertilizer adoption is relatively labour intensive requiring more labour both for its preparation and application on the farm compared to chemical fertilizer. Thus, lack of adequate labour for its preparation could decrease its adoption rate. Due to this, about 22.1 percent of the respondents reported that they do not participate in adoption of organic fertilizer.

Inadequate knowledge related to organic fertilizer adoption in terms of compost preparation was another constraint to adoption of organic fertilizer. This was reported by about 8.9 percent of the non-adopter households. Kassie *et al.* (2009) noted that the preparation of organic fertilizer is knowledge intensive. This implies that low skills related to adoption of organic fertilizer could limit adoption of organic fertilizer as farmers may face difficulty in preparing this fertilizer, specially, composting which has been commonly used in the study area.

High transaction costs associated with adoption of organic fertilizer was also one of the reasons reported as constraints of organic fertilizer adoption. This was primarily for those farmers who lack livestock and tend to find this fertilizer from other sources. For such farmers, high transaction costs coupled with their low capacity to provide finance could limit adoption of this fertilizer. Accordingly, high transaction cost was reported by about 7 percent of the households while lack of capital in terms of financing costs associated with organic fertilizer adoption was reported by about 6.6 percent of the households among the non-adopters of organic fertilizer. The summary results are presented in Table 7 below.

Table 7: Constraints to Adoption of Organic Fertilizer (*N*=213; Non-adopters of organic fertilizer)

Description	Freq.	Percent	Cum.
High transaction costs	14	6.6	6.6
Lack of livestock	118	55.4	62.0
Low skill	19	8.9	70.9
Lack of capital	15	7.0	77.9
Inadequate labour	47	22.1	100
Total	213	100	

4.4 Transaction Costs Associated with Organic Fertilizer Adoption

This section presents results on the transaction costs associated with adoption of organic fertilizer. Costs of searching for information, bargaining, policing and enforcement, and quality ensuring costs are included under this section. Time taken to complete each activity before any transaction is made was calculated in terms of the best alternative forgone.

Majority of the respondents reported that the cost of searching for information was the most common type of transaction cost in adoption of organic fertilizer in Shashemene district. The average transaction cost in relation to searching for information was found to be 124.53 ETB. This was mainly associated with travel costs whereby some farmers use money for transport to search for information instead of other cheaper means such as telephone calls. Another cost related to organic fertilizer adoption was bargaining costs. Regarding bargaining, the average cost incurred for bargaining was found to be 53.33 ETB. Compared to search for information, costs incurred as a result of bargaining during the transaction was found to be lower in the study area. In this case, it was found that telephone was the most commonly used communication media among the farmers leading them to incur relatively lower transaction costs. Martey *et al.* (2013) noted that high transaction costs in terms of transporting inputs normally limit the extent of the agricultural technology adoption such as chemical fertilizer. It can also put limitations on adoption of organic fertilizer.

In relation to transportation, the average transaction cost was found to be 68.23 ETB per hectare. The other sources of transaction costs such as policing and enforcement costs were not reported among the farmers implying less availability of organic fertilizer transaction through the contracts. During transportation, donkeys are used as pack animals by some farmers. However, majority of the farmers use donkey pulled carts to transport organic fertilizer to their farmstead. Some farmers who own the donkey but lack the cart use the donkey as pack animal to transport the organic fertilizer to their farm. Since the quantity of organic fertilizer to be transported is large (nearly 73 quintal per hectare on average) most farmers prefer use of cart. Some farmers own both the cart and donkey while those farmers who do not own normally hire from those who already own. Further, the maximum transaction cost reported was 375 ETB while 5 ETB was the minimum. The summary results are presented in Table 8.

Table 8: Transactions Costs Related to Organic Fertilizer Adoption (*N*=155; Adopters of Organic Fertilizer)

Sources of transaction costs	Mean	Min.	Max.	SD
Bargaining	53.33	20	100	27.64
Search for information	124.53	5	375	122.56
Transportation cost	68.23	35	100	20.69
Total transaction costs	155.83	5	570	135.12

4.5 Econometric Analysis of Factors Influencing Adoption and Use Intensity of Organic Fertilizer

4.5.1 Results of Multicollinearity, Outliers and Statistical Specification Tests

Regression models assume that perfect collinearity does not exist among the explanatory variables. If it exists, however, it leads to a problem of multicollinearity. Multicollinearity indicates existence of exact linear relationship among the explanatory variables. The higher the degree of multicollinearity, the more difficult the problem is. In this study, using variable inflation factor

(VIF), the average VIF was found to be 1.79 which was less than 10 showing that multicollinearity was not a serious problem among the continuous explanatory variables (Appendix 3). The contingency coefficients also revealed that there were no strong correlations among categorical variables hence no explanatory variable was dropped. Availability of heteroscedasticity was tested using White's test. On the test result, probability greater than χ^2 was given by 0.4622 implying that the model had no problem of heteroscedasticity. Finally, using Ramsey regression specification-error test for omitted variables (ovtest), the survey results revealed that the model had no problem of omitted variables. Therefore, it was concluded that the model was the most robust and complete.

4.5.2 Factors Affecting Adoption and Use Intensity of Organic Fertilizer

To determine the major factors affecting adoption and use intensity of organic fertilizer, Cragg's double hurdle model was employed. The Chi^2 value given by 82.09 and the corresponding likelihood ratio statistic ($p < 0.000$) suggests that the null hypothesis of all the coefficients of the explanatory variables being simultaneously zero, should be rejected. This shows that the explanatory variables included in the model are capable of explaining the farmers' probability of participating in adoption of organic fertilizer and the extent of organic fertilizer use. Marginal effects were estimated to predict the actual magnitude of the effect of the explanatory variables on the adoption decision of organic fertilizer while the coefficients were used in the second hurdle to explain the extent of organic fertilizer adoption. The estimated coefficients in the probabilistic models such as probit do not have direct interpretation rather they are just values which maximize likelihood function.

***First hurdle*: Factors Affecting Adoption Decision**

The first stage of the double hurdle model deals with the adoption decision of organic fertilizer. Farmers were assigned 1 if they are adopters of organic fertilizer and 0 otherwise. The results of the Cragg's double hurdle model presented in Table 9 revealed that the household size, the number of livestock units, extension services, access to information media and membership in local farmers based associations had significant effect on household's adoption decision.

The results showed that an increase in the size of the household by one member decreased likelihood of adopting organic fertilizer by about 2.3 percent. Thus, an increase in the household size tends to discourage adoption of organic fertilizer significantly at 5 percent probability level.

Although a given household reports large family size, some members may not be available for farm work due to several reasons such as migration, schooling and so on. For example, Kpadonou *et al.* (2015) noted that although migration may provide additional income to the household through remittances, it may also result in a smaller workforce for farming activities. In addition, Mutimba *et al.* (2011) found that the household size is negatively related to adoption of compost in Malawi. They explained that majority of the adopters of compost manure were middle aged (30 - 49 years) with their children still at school and not available for making compost. Thus, having large family size *per se* does not necessarily mean all family members are available for the farm work. On the other hand, Tedla (2011) found that household size has positive effect on decision to adopt agricultural technology. He elaborated that larger household size is associated with expectation of more labour in the family. Further, Terefe *et al*. (2013) showed that the household size has no significant influence on the adoption of organic fertilizer in Ethiopia.

Results on the number of livestock owned indicate that an increase in the number of livestock by one animal increased the likelihood of adopting organic fertilizer by about 3.9 percent. The results were statistically significant at 1 percent probability level. The availability of more animal manure as the number of livestock unit increases possibly justify the positive correlation between livestock ownership and organic fertilizer adoption. Animal manure is the potential source of organic fertilizer. It is the main ingredient during composting. Thus, households who own large number of livestock's are likely to get more manure and therefore adopt organic fertilizer. The finding was consistent with Tefera *et al*. (2013). They explained that the households with more livestock holding are likely to adopt organic fertilizer due to their better capacity to have animal manure. Akpan *et al.* (2012) also noted that domestic animals constitute a good source of organic manure serving as a good substitute for chemical fertilizer.

In relation to extension services, the results show that one additional meeting with extension workers increased the likelihood of organic fertilizer adoption by about 2.3 percent. Thus, extension service was found to have positive effect on adoption of organic fertilizer. One of the most important role of extension service is to raise farmer's awareness about agricultural productivity through providing them important information related to adoption of agricultural technologies. According to Kassie *et al.* (2009), in most cases, extension workers establish demonstration plots where farmers get hands-on learning and can experiment with new farm technologies which enhance adoption of new technologies. The results of the study therefore confirm that better information dissemination through extension workers could enhance adoption of organic fertilizer by improving knowledge about the advantage of new technology. Thus, for a given household, the more the frequency of meeting extension workers, the higher the likelihood of organic fertilizer adoption. The results were statistically significant at 1 percent probability level. The finding was in line with Kassie *et al.* (2009). They argued that farmers who have regular contact with agricultural experts are more motivated to participate in agricultural technology adoption due to intensive information they may get from the experts.

Access to information through media increased possibility of adopting organic fertilizer by about 10.9 percent revealing its positive influence on the adoption of organic fertilizer. Farmers who have had access to information through television, radio or any other social media were considered to have access to information media. Better access to information could likely empower farmers to seek for agricultural technologies which may improve their farm productivity. This is mainly because access to information could enable one to have more knowledge and awareness about different technologies. For example, in adoption of organic fertilizer, farmers can have information such as how to prepare, apply on the farms and so on with better access to information. Thus, such a farmer can possibly intensify adoption of this technology compared to other groups of farmers who have no access to information through these media. Access to information through information media had statistically significant effect on adoption of organic fertilizer at 10 percent probability level. Several recent studies on agricultural technology adoption in Ethiopia did not include this variable in their analysis (Berhe, 2014; Terefe *et al*., 2013).

Membership to one additional local farmers based association increased the possibility of organic fertilizer adoption by about 10.1 percent. The results show that membership to farmer groups influenced decision to adopt organic fertilizer positively and significantly at 5 percent probability level. The positive effect might be due to increase in possibility of meeting with other farmers as one becomes a member of different farmer groups and be informed about the new technology. Farmers based organizations in rural areas make possibility of information transfer easier among the famers through increasing frequency of discussion among the members (Berhe, 2014). Thus, households whose membership belong to farmer groups such as associations and cooperatives can easily access fertilizer technology (Martey *et al.*, 2013). This possibly may level up adoption rate of organic fertilizer among the farmers.

Table 9: Results of Cragg's Double Hurdle Model (Probit Output) on Determinants of Decision of Adoption of Organic Fertilizer

Variables	Coef.	Std. Err.	*z* – value	dy/dx
Age	-0.003	0.011	-0.28	-0.001
Gender	-0.002	0.263	-0.01	-0.001
Household size	-0.076	0.035	-2.17	-0.023**
Household head education	0.006	0.026	0.23	0.002
Farm income	0.000	0.000	-0.56	0.000
Experience	-0.002	0.011	-0.19	-0.001
Farm size	0.210	0.200	1.05	0.064
Soil fertility	-0.111	0.159	-0.69	-0.034
Livestock number	0.126	0.019	6.48	0.039***
Credit amount	0.000	0.000	-0.68	0.000
Extension number	0.074	0.028	2.70	0.023***
Access to information media	0.356	0.196	1.82	0.109*
Membership	0.331	0.153	2.16	0.101**
Distance to nearest market	0.018	0.033	0.55	0.006
Marital status	0.270	0.218	1.24	0.082
Labour	-0.005	0.048	-0.11	-0.002
Family's highest education	0.016	0.029	0.56	0.005
Constant	-1.518	0.881	-1.72	
N	367			
Log likelihood	-939.093			
Wald chi^2 (17)	82.09			
Prob. > χ^2	0.000			

Note, ***, ** and * indicate significance at 1%, 5% and 10% probability level respectively while dy/dx denotes marginal effects.

***Second hurdle*: Factors Affecting Use Intensity of Organic Fertilizer**

Most households in Shashemene district use some sources of organic fertilizer such as manure without measuring its amount. Due to this, it was difficult to know the exact amount (intensity) of organic fertilizer used by the farmers on their farms. However, households who use compost use m^3 (cubic meter) measurement when preparing and *quintal (*a unit of weight equal to 100 kg) when transporting it to their farms. Thus, the application level of compost is better known by farmers compared to other types of organic fertilizer such as manure. Therefore, in this stage, using the compost as a proxy to evaluate intensity of organic fertilizer adoption, only respondents who reported positive and greater than or equal to the optimum use intensity of compost were included. The optimum adoption intensity was determined as the average level of compost usage per hectare in the study area. The results of the double hurdle model presented in Table 10 show that the farm income, farm size, membership in farmer based organizations and frequency of organic fertilizer application had significant influence on use intensity of organic fertilizer.

The results indicated that an increase in household farm income by 1 Birr decreased use intensity of organic fertilizer by about 0.002 quintal per hectare. This shows that the household income had negative effect on use intensity of organic fertilizer. Households' farm income had significant effect on use intensity of organic fertilizer at 1 percent probability level. A household with high income may prefer to use chemical fertilizer compared to organic fertilizer which can be substitute for each other. If farmers can afford to buy chemical fertilizers, then the propensity of using labour intensive fertilizers such as manure decreases (Ketema and Bauer, 2011). Organic fertilizer preparation (for instance composting) is also time intensive requiring more time. Due to this, a household with better income may prefer to buy and use chemical fertilizer within short period of time. In addition, little cash holding households are likely to prefer more organic fertilizer as it is relatively cheaper compared to chemical fertilizer. According to Martey *et al.* (2013), investment of financial resources in interest earning assets which are associated with high income are likely to explain low fertilizer use with increase in income though the components of fertilizer was not captured.

Regarding farm size, the results indicate that an increase in farm size by a unit hectare increased use intensity of organic fertilizer by about 26.11 quintal per hectare. Farm size is a significant determinant of organic fertilizer adoption at 1 percent probability level. The positive impact of farm size on use intensity of organic fertilizer can be justified in relation to better economies of scale associated to larger farm size. The farmers with larger farm size would also use organic fertilizer as it is less costly compared to inorganic fertilizer. These could have encouraged farmers to use organic fertilizer in the study area. The results were consistent with the findings of Kassie *et al.* (2009). They noted that ownership of the farm land increases assurance of future access to the returns of the investments thus increasing probability of using organic fertilizer such as compost.

Membership to one additional local farmers based association increased use intensity of organic fertilizer by about 10.62 quintal per hectare. This shows that membership in farmers based organizations had positive effect on use intensity of organic fertilizer. The results were significant at 10 percent probability level. Several reasons have been pointed out in the first hurdle of this model regarding positive correlation between a membership to farmers group and adoption decision of organic fertilizer. Furthermore, farmers based associations serve as a platform for accessing and dissemination of information and technology (Martey *et al.*, 2013) consequently enhancing communications for development (Berhe, 2014). These could possibly allow farmers to share ideas and experiences therefore likely intensifying per hectare use of organic fertilizer.

In relation to frequency of organic fertilizer application, the results show that application of organic fertilizer in a given season decreased its reapplication in the following season by about 28.86 quintal per hectare. The negative relationship between the frequency of organic fertilizer application and intensity of organic fertilizer use could be mainly due to farmer's expectation of residual value of this fertilizer. In the study area, most farmers believe that the farm can stay fertile for a period of about four years once organic fertilizer is applied on it. Due to this, once they apply on their farms, the following season, they relatively apply less amount. The results further indicated that the frequency of organic fertilizer use had significant effect on use intensity of organic fertilizer at 5 percent probability level. Frequency of application was found to have highest (nearly 30 quintal per hectare decrease every season) influence on use intensity of organic fertilizer. It also seems that the farmers in the study area were uncertain about the length of the time that compost maintain soil fertility. Thus, efforts to bring the exact time period of applying this fertilizer coupled with its right amount per hectare could be the best strategy to enhance use intensity of organic fertilizer. Several recent studies related to adoption of organic fertilizer did not include frequency of application in the analysis (Lavison, 2013; Tefera *et al*., 2013; Ajewole, 2010).

Table 10: Results of Cragg's Double Hurdle Model (Truncated output) on Factors Affecting Intensity of Organic Fertilizer Adoption

Variables	Coef.	Std. Err.	*t* – value
Age	-0.313	0.446	-0.70
Gender	3.180	9.573	0.33
Household size	-1.418	1.365	-1.04
Education of household head	0.114	0.893	0.13
Farm income	-0.002***	0.00	-3.57
Experience	-0.060	0.449	-0.13
Farm size	26.112***	6.269	4.17
Soil fertility	0.354	5.483	0.06
Livestock number	0.958	0.693	1.38
Credit amount	0.002	0.002	1.03
Extension contacts	1.527	1.023	1.49
Access to information media	3.213	7.847	0.41
Membership	10.621*	5.460	1.95
Distance to the nearest market	0.560	1.190	0.47
Marital status	1.618	8.225	0.20
Labour	-1.783	1.786	-1.00
Family's highest education	0.197	1.190	0.17
Application frequency	-28.858**	13.129	-2.20
Constant	122.638	43.019	2.85
/sigma			
Constant	30.65***	1.998	15.34
N	155		
Wald chi^2 (18)	82.09		
Prob. > χ^2	0.000		

Note, ***, ** and * indicate significance at 1%, 5% and 10% probability level respectively.

4.6 Results of Propensity Score Matching for Impact of Organic Fertilizer on Income

The propensity score matching (PSM) technique was used to compute the impact of organic fertilizer adoption on households' farm income. The household's agricultural income per hectare of farm land for the year 2014/15 was used. Taking participation (adoption decision) as 1 if the household has been participating in adoption of organic fertilizer and 0 otherwise, propensity scores were estimated using probit regression. All variables hypothesized to influence adoption decision of organic fertilizer were included to predict the probability of each households' participation in organic fertilizer adoption. These variables include: age, gender, household size, education level of household head, farm income, experience, farm size, perception of farm fertility, number of livestock units, access to credit, extension visits, access to information through information media, membership to farmer groups, labour, marital status, distance to the nearest market and highest education level among the family members. This section is however not interested in assessing the influence of these covariates on farmer's decision of adoption of organic fertilizer. Factors influencing decision of adoption of organic fertilizer are already presented and discussed in section 4.5.2. Thus, this section assess the impact of organic fertilizer adoption on outcome variable (per hectare farm income) using the estimated propensity scores.

The overall estimated propensity scores lie between 0.033 and 0.902 (Table 11). Amongst the adopters of organic fertilizer, the propensity scores vary between 0.109 and 0.902 while amongst the non-adopters it lie between 0.033 and 0.790. This shows that the region of common support would lie between 0.109 and 0.790 dropping observations with propensity scores below 0.109 and above 0.790. Out of 368 households, 9 of them (9 from the adopters and 0 from the non-adopters of organic fertilizer) were dropped from the analysis because of their propensity scores falling outside the region of common support (Appendix 4). Thus, it seems that the included observations (359 households) were sufficient to predict the impact of organic fertilizer on household's farm income for this study. Furthermore, the propensity scores results showed that the overall average propensity score among the sampled households was about 0.42 implying that the average probability of participating in adoption of organic fertilizer for individual sampled households was about 42 percent. The diagram which shows the matching distribution of propensity scores is presented in Figure 5 below.

Table 11: Distribution of the Estimated Propensity Scores

Categories	Obs	Min	Mean	Max	SD
Organic fertilizer non-adopters	213	0.033	0.360	0.790	0.166
Organic fertilizer adopters	155	0.109	0.507	0.902	0.187
Total	368	0.033	0.422	0.902	0.189

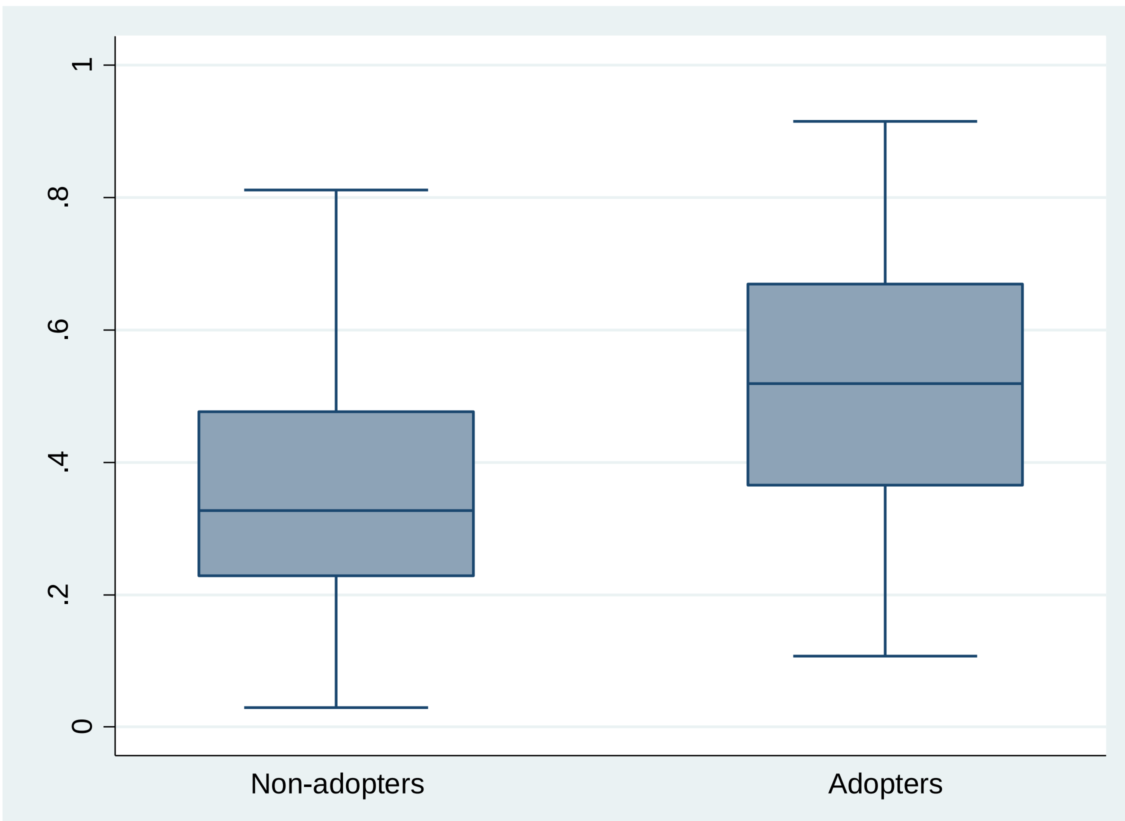

Figure 5: Matching distribution

4.6.1 Choice of Matching Algorithms

The choice of matching algorithms was guided by the criteria's such as number of balanced covariates after matching (number of covariates with no statistically significant mean difference between adopters and non-adopters of organic fertilizer after matching), Pseudo-R^2 and matched sample size. A matching estimator which balances all covariates and bears low psuedo-R^2 value as well as with large matched sample size is preferable for impact assessment (Tolemariam, 2010) After looking in to the results presented in Table 12, based on the above discussed criterion, kernel matching and nearest neighbour matching (NN (6)) were equally found to be the best matching methods in assessing the impact of organic fertilizer adoption on household's farm income. Therefore, both matching algorithms were used in the impact assessment of this study. Since the results of performance analysis for kernel matching showed equal number of balanced covariates, equal Psuedo-R^2 and equal matched sample size for all included band width (0.06, 0.1, 0.25, and 0.5), any one of the listed band width can be used to perform the analysis. This study has therefore chose the band width of 0.06.

Table 12: Results on Performance of Different Matching Algorithms (*N*=368)

	Performance evaluation criterion		
Matching estimators	**Balancing test***	**Psuedo-R^2**	**Matched sample size**
Nearest neighbour matching			
NN(1)	15	0.020	359
NN(2)	15	0.016	359
NN(3)	15	0.007	359
NN(4)	15	0.008	359
NN(5)	15	0.007	359
NN(6)	15	0.004	359
Radius matching			
Calliper of 0.01	15	0.005	348
Calliper of 0.25	14	0.02	359
Calliper of 0.50	11	0.08	359
Kernel matching			
Band width 0.06	15	0.004	359
Band width 0.10	15	0.004	359
Band width 0.25	15	0.004	359
Band width 0.50	15	0.004	359

Note, * Number of covariates exhibited no significant mean difference after matching between adopters and non-adopters of organic fertilizer.

4.6.2 Testing the Balancing Properties of Propensity Scores and Covariates

Before estimating the impact of organic fertilizer adoption on household's farm income, the balancing properties of propensity scores should be checked to test whether the observations have had the same distribution of propensity scores or not. According to Tolemariam (2010), balancing test seeks to examine if at each value of the propensity score, a given characteristic has the same distribution for the treated and comparison groups. The results presented in Table 13 showed that five variables exhibited significant mean difference before matching while no variable showed significant mean difference after matching. This implies that there is high degree of covariate balance between the sample participants and non-participants of organic fertilizer adoption. Therefore, it was concluded that the specification was successful in terms of balancing the distribution of covariates between the matched adopters and non-adopters of organic fertilizer.

Table 13: Balancing Test of the Covariates Based On Kernel Matching Method

	Pre-matching (N = 368)			**Post-matching (N = 359)**		
Covariates	**Treated**	**Control**	***t*-test**	**Treated**	**Control**	***t*-test**
Age	43.99	44.20	-0.17	44.00	43.48	0.40
Gender	0.88	0.89	-0.10	0.88	0.87	0.09
Household size	7.26	7.02	0.71	7.18	7.08	0.27
Household head education	6.35	5.74	1.61	6.26	6.27	-0.02
Experience	23.97	23.89	0.07	23.95	23.78	0.13
Farm size	1.06	0.86	4.06***	1.02	0.99	0.57
Soil fertility	1.79	1.81	-0.37	1.81	1.80	0.17
Credit amount	529.03	828.17	-1.55	561.64	527.84	0.19
Extension visits	3.67	2.86	2.85 ***	3.59	3.64	-0.14
Access to information media	0.83	0.70	2.95 ***	0.82	0.82	0.00
Membership	0.59	0.31	5.31***	0.55	0.57	-0.20
Distance to nearest market	1.08	0.98	1.53	1.06	1.02	0.44
Marital status	2.08	2.05	0.63	2.07	2.09	-0.51
Labour	3.27	2.95	1.11	3.23	3.12	0.32
Family's highest education	10.65	10.10	1.75*	10.57	10.57	-0.01

Note, *** and * indicate significance at 1% and 5% probability level respectively.

In addition to the above results, the overall (joint) test statistics for the balancing properties showed that Pseudo-R^2 was 0.004 for the matched observations which was fairly low. The *p*-value for the corresponding Pseudo-R^2 and likelihood ratio test was insignificant at conventional probability level ($p > chi^2 = 0.999$) confirming that both the treated (adopters of organic fertilizer) and control (non-adopters of organic fertilizer) groups had the same distribution of covariates after matching. This further shows that the employed model was the most robust and complete therefore allowing comparison of household's per hectare average farm income between the adopters and non-adopters of organic fertilizer who share common support in terms of propensity scores. The results of the chi-square test for the joint significance of variables are presented in Table 14.

Table 14: Results of Chi-Square Test for Joint Significance of Variables

Sample	Pseudo R^2	LR chi^2	p – value
Before matching	0.113	56.74	0.000***
After matching	0.004	1.50	0.999

Note, *** indicates significance at 1% probability level.

4.6.3 Impact of Organic Fertilizer Adoption on Households Farm Income

The impact of organic fertilizer adoption on households per hectare farm income was estimated in this section. The results presented earlier (section 4.6.1) showed that the kernel based matching algorithm and nearest neighbour matching with six closest neighbour could give the best results of impact assessment for this study. However, according to Becker and Ichino (2002), consideration of several matching algorithm in tandem is advantageous as it allows measuring the robustness of the impact estimates. Thus, in addition to kernel matching and nearest neighbour matching, radius matching and stratification matching methods were also employed to compare the difference of average farm income between the samples of adopters and non-adopters of organic fertilizer. Accordingly, the results indicated that the households who adopted organic fertilizer had earned 2661 ETB to 2959 ETB more average per hectare farm income compared to non-adopters of organic fertilizer (Table 15). This implies that adoption of organic fertilizer is crucial to increase farmer's farm income. The nearest neighbour matching, stratification matching and kernel based matching results were significant at 5 percent probability level while the results for radius matching were significant at 1 percent probability level. Kassie *et al.* (2013) posited that the use of compost had led to significant increase in yield of wheat, barley and *teff* grains in Tigrai region of Ethiopia while Lavison (2013) noted that there was better net income when vegetable producing farmers used organic fertilizer instead of chemical fertilizer in Accra, Ghana. According to ISD (2007) and IFPRI (2010), farm productivity can be increased by more than 10 percent when organic fertilizer is used compared to when chemical fertilizer is used. Moreover, the results suggest that adoption of organic fertilizer contributes to increased farm income among the farmers in Shashemene district of Ethiopia.

Table 15: Propensity Score Matching Results

Matching Algorithms	Number of treated	Number of controlled	ATT	Std. Err.	*t*-value
NNM	146	213	2733.54	1045.75	2.61**
KM	146	213	2665.22	1011.87	2.63**
SM	147	217	2660.66	1016.20	2.62**
RM	135	213	2958.62	923.53	3.2***

Note, *** and ** show significance at 1%, and 5% probability level respectively.

Where, NNM is nearest neighbour matching (NN (6)), KM is kernel matching (band width = 0.06), SM is stratification matching and RM is radius matching (calliper = 0.01).

4.6.4 Results of Simulation Based Sensitivity Analysis

This section analyses the robustness of the estimated treatment effects using *sensatt command*. The main purpose of this analysis is to check or estimate the degree at which the estimated treatment effects were free of unobserved covariates. This could be done through comparing baseline treatment effects and simulated treatment effects or through comparing the values of outcome effects and selection effects generated by *sensatt* with the predetermined values of outcome and selection effects (both outcome and selection effects should be greater than 1). The results presented in Table 16 show that the simulated outcome effect was 1.2 for the nearest neighbour matching and kernel matching while it was 1.22 for radius matching. The selection effects were 19.23, 18.85, and 19.19 for nearest neighbour matching, radius matching and kernel matching methods respectively. According to Nannicini (2007), outcome effect measures the observed effect of unobserved covariates on untreated outcome while selection effects measure the effect of unobserved covariates on the selection in to the treatment. This means, for the estimated impact of organic fertilizer adoption on household's farm income to be invalid, there would have been unobserved confounder that can increase the relative probability of organic fertilizer adoption by a factor of 18.85 - 19.23 and also increase positive treatment outcomes by a factor of 1.2 - 1.22 which is not plausible. On the other hand, comparing the simulated and base line ATT, the initial estimates were free of unobserved covariates by about 95 percent for the nearest neighbour and radius matching while the estimates were free of unobserved covariates by about 94 percent for the kernel based matching algorithm. This shows that the matching results were almost insensitive to the potential unobservable bias and therefore the estimated ATT were pure effects of organic fertilizer adoption.

Table 16: Simulation Based Sensitivity Analysis Results

Matching Algorithms	**Simulated ATT**	**Std. Err.**	**Outcome effects**	**Selection effects**
NNM	2592.35	1875.20	1.20	19.23
RM	2799.64	1096.02	1.22	18.85
KM	2512.14	.	1.20	19.19

Where, NNM is nearest neighbour matching, RM is radius matching and KM is kernel matching.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

This section presents summary of the major findings in the study, conclusions drawn and recommendations.

5.1. Summary

This study aimed at identifying the major constraints of organic fertilizer adoption and income effect in Shashemene district of Ethiopia. To select respondents for the study, four *kebeles* were selected purposively based on the intensity of adoption of organic fertilizer and similarity in agro-climate environment. Accordingly, primary data was collected from 368 respondents of which 155 were adopters and 213 were non-adopters of organic fertilizer.

In order to examine determinants of adoption of organic fertilizer and income effect, the study assessed transaction costs associated with adoption of organic fertilizer, factors affecting adoption and use intensity of organic fertilizer and impact of organic fertilizer adoption on households' farm income. Descriptive statistics and Cragg's double hurdle model as well as propensity score matching method were employed for analysis. During analysis, different software's such as Excel, SPSS, and Stata were used.

In relation to transaction costs, the results showed that the average transaction costs through bargaining, searching for information and transportations were 68.23 ETB, 53.33 ETB and 124.85 ETB respectively. Policing and enforcement costs were uncommon among the farmers. The household size, livestock number, extension visits, access to information media and membership to farmers group had significantly influenced decision of adoption of organic fertilizer. The household size negatively influenced organic fertilizer adoption while the remaining four factors influenced adoption decision of organic fertilizer positively. Regarding use intensity of organic fertilizer, households' farm income and the application frequency of organic fertilizer had negative influence on use intensity of organic fertilizer while farm size and membership to farmers group had positively influenced use intensity of organic fertilizer. Propensity score matching revealed that the adoption of organic fertilizer increased farmers per hectare farm income by between 2661 ETB and 2959 ETB.

5.2. Conclusions

The results showed that the highest transaction costs related to adoption of organic fertilizer were information search costs followed by transportation cost and bargaining costs. Most of these costs were associated with means of communication and transportation where communication through phone calls resulted in lower transaction costs and traveling to search for information resulted in relatively higher transaction costs. Policing and enforcement costs were not reported, implying less availability of organic fertilizer transactions through contracts.

An increase in the household size discouraged adoption of organic fertilizer showing that having large family size *per se* does not necessarily mean farmers have enough labour supply for their farm work. As domestic animals constitute a good source of organic manure serving as a good substitute for chemical fertilizer, households who owned large number of livestock are likely to get more manure and thus they are likely to adopt organic fertilizer. Better information dissemination about organic fertilizer through information media also enhanced adoption and use intensity of organic fertilizer by improving knowledge about the advantage of new technology. A household with lower income prefers to use organic fertilizer compared to chemical fertilizer. It was thus concluded that lower costs in relation to use of organic fertilizer on larger farm size encouraged farmers to use organic fertilizer intensively in the study area.

Further, households who had adopted organic fertilizer earned better average per hectare farm income compared to the non-adopters. This implies that the adoption of organic fertilizer had positive impact on households' farm income in the study area therefore farmers should be encouraged to use organic fertilizer.

5.3. Policy Recommendations

For the smallholder farmers to benefit from the adoption of organic fertilizer, the policy makers should take the following core issues in to consideration.

Better extension service should be provided to the farmers aiming at increasing farmers' contacts with agricultural experts. Although the development agents are available in all *kebeles* of the district, it was not all farmers who have had extension services and the frequency of contact was low for those who already had the services. Thus, in addition to assigning the extension workers to the respective *kebeles* in the district, attention should also be given to ensure that farmers get the expected services.

Access to information plays crucial role in enhancing technology adoption. Information can be obtained through membership to different organizations, from information media or through extension workers. Based on the results, being non-member to farmers group coupled with low access to extension services and information media could result in low adoption of organic fertilizer. To counter this, the policy makers should target at enabling farmers to have access to information media such as radio, in addition to encouraging farmers' group formation and membership to such organizations.

Households with more livestock are more likely to adopt organic fertilizer. This shows that households with less or no livestock are less likely to adopt organic fertilizer. To enable such households have access to organic fertilizer, the government and other development partners should encourage commercialization of the organic fertilizer. The fact that organic fertilizer processing factories have been limited in Ethiopia might be the major constraint for commercialization. However, governments and NGO's should focus on providing incentives to investors and entrepreneurs through credit and others. This could increase organic fertilizer processing plants and composting sites among others which also plays crucial role in reducing transaction costs associated with organic fertilizer adoption as farmers can get this fertilizer easily at lower costs. In relation to the farm size, large scale farming should be encouraged. This could be supported through providing training to the farmers which is aimed at the use of organic fertilizer.

Generally, organic fertilizer has a potential to increase farmers farm income. As such, the smallholder farmers should be encouraged to adopt organic fertilizer so as to increase their farm income and improve their livelihood.

5.4. Areas for Further Studies

The conclusions drawn on this study were based on the cross sectional data of the year 2015/16. However, the effect of the currently significant variables as well as the non-significant variables should also be checked using time series data. There is also a need to examine the determinants of organic fertilizer adoption as well as income effect in different regions of the country. In addition, it was observed that majority of the farmers were uncertain about how frequent the application of organic fertilizer should be. Thus, to fill these gaps, further study is required.

REFERENCES

Abadie, A., Drukker, D., Herr, J. L. and Imbens, G. W. (2004). Implementing Matching Estimators for Average Treatment Effects in Stata. *The Stata Journal*, 4(3):290–311.

Acheampong, P. and Owusu, V. (2014). Impact of Improved Cassava Varieties' Adoption on Farmers' Incomes in Rural Ghana. CSIR- Crops Research Institute, Ghana.

Adelman, S., Alderman, H., Gilligan, D. and Lehrer, K. (2008). The Impact of Alternative Food for Education Programs on Learning Achievement and Cognitive Development in Northern Uganda. Unpublished report.

Ajewole, C. (2010). Farmer's Response to Adoption of Commercially Available Organic Fertilizers in Oyo State, Nigeria. *African Journal of Agricultural Research*, 5(18): 2497-2503.

Akpan, S. B., Nkanta, V. S. and Essien, U. A. (2012). A Double-Hurdle Model of Fertilizer Adoption and Optimum Use among Farmers in Southern Nigeria. *Tropicultura*, 30(4): 249-253.

Awotide, B., Diagne A. and B. Omonona (2012). Impact of Improved Agricultural Technology Adoption on Sustainable Rice Productivity and Rural Farmers' Welfare in Nigeria: A Local Average Treatment Effect (LATE) Technique. A Paper Prepared for Presentation at the African Economic Conference. Kigali, Rwanda.

Becker, S. O. and Caliendo, M. (2007). mhbounds - Sensitivity Analysis for Average Treatment Effects. Discussion Paper Series, No. 2542.

Berhe, Y. (2014). The Impact of Row Planting of Teff Crop on Rural Household Income: A Case of Tahtay Maychew Wereda, Tigrai, Ethiopia. M.Sc. Thesis. Mekelle University, Ethiopia.

Birungi, P. (2007). The Linkages between Land Degradation, Poverty and Social Capital in Uganda. Unpublished PhD Dissertation. University of Pretoria, South Africa.

Byerlee, D., Spielman, J., Alemu, D., and Kelemework, D. (2010). Policies to Promote Cereal Intensification in Ethiopia: A Review of Evidence and Experience. IFPRI discussion paper 00707.

Challa, M. and Tilahun, U. (2014). Determinants and Impacts of Modern Agricultural Technology Adoption in West Wollega: The Case of Gulliso District. *Journal of Biology, Agriculture and Healthcare*, 4(20):63 - 77.

Chi, T. and Yamada, R. (2002). Factors Affecting Farmers' Adoption of Technologies in Farming System: A Case Study in Omon District, Can Tho Province, Mekong Delta. *Omonrice*, 10:94-100.

Coase, H. (1937). *The Nature of the Firm*. *Economica*, New Series, 4(16):386-405, London.

Cragg, J. (1971). Some Statistical Models for Limited Dependent Variables with Application to the Demand for Durable Goods. *Econometrica*, 39: 829- 844.

Endale, K. (2011). Fertilizer Consumption and Agricultural Productivity in Ethiopia. EDRI Working Paper 003. Addis Ababa, Ethiopia.

Enete A. A. and Igbokwe, E. M. (2009). Cassava Market Participation Decision of Household in Africa. *Tropicultura*, *27*(3):129-136.

Ethiopian National Planning Commission (2015). The Second Growth and Transformation Plan (2015/16-2019/20). Addis Ababa, Ethiopia.

Greene, W. (2002). *Econometric analysis, Fifth edition.* New Jersey, Prentice Hall.

Grilli, L. and Rampichini, C. (2011). Propensity Scores for the Estimation of Average Treatment Effects in Observational Studies. Training Sessions on Causal Inference. Bristol.

Gujarati, D. (2004). *Basic Econometrics, Fourth Edition*. New York: McGraw−Hill.

Institute for Sustainable Development (2007). Organic Chain Development in Ethiopia. Participatory Networking Workshop. Addis Ababa, Ethiopia.

International Fertilizer Development Centre (2012). Ethiopian Fertilizer Assessment. African Fertilizer and Agribusiness partnership. USA.

International Food Policy Research Institute (2012). Gender Differences in Access to Extension Services and Agricultural Productivity. Working paper No. 49.

International Food Policy Research Institute (IFPRI) (2010). Economic Importance of Agriculture for Sustainable Development and Poverty Reduction: The Case Study of Ethiopia. Global Forum on Agriculture, 29 – 30 November 2010. Paris.

J. Bonabana-Wabbi (2002). Assessing Factors Affecting Adoption of Agricultural Technologies: The Case of Integrated Pest Management (IPM) in Kumi District, Eastern Uganda. M.Sc. Thesis. University of Virginia, Blacksburg.

Jagwe, J. N. (2011). The Impact of Transaction Costs on the Participation of Smallholder farmers and Intermediaries in the Banana Markets of Burundi, Democratic Republic of Congo and Rwanda. PhD Thesis. University of Pretoria, South Africa.

Kassa, H., Kassa, A. and Weldegiorgis, K. (2014). Adoption and Impact of Agricultural Technologies on Farm Income: Evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics*, 2(4):91-106.

Kassie, M., Zikhali, P., Manjur, K., and Edwards, S. (2009). Adoption of Organic Farming Techniques: Evidence from a Semi-Arid Region of Ethiopia. Discussion Paper Series, DP 09-01.

Ketema, M. and Bauer, S. (2011). Determinants of Manure and Fertilizer Applications in Eastern Highlands of Ethiopia. *Quarterly Journal of International Agriculture,* 50(3):237-252.

Kpadonou, R. B., Barbier, B., Denton, F. and Owiyo, T. (2015). Linkage Between and Determinants of Organic Fertilizer and Modern Varieties Adoption in the Sahel. A paper presented at the 29th International Conference of Agricultural Economists. Mila, Italy.

Lavison, R. (2013). Factors Influencing the Adoption of Organic Fertilizers in Vegetable Production in Accra, Gahna. M.Sc. Thesis. University of Ghana, Legon, Ghana.

Makokha, S., Kimani, S., Mwangi, W., Verkuijl, H., and Musembi, F. (2001). Determinants of Fertilizer and Manure Use in Maize Production in Kiambu District, Kenya. Kenya Agricultural Research Institute (KARI).

Martey, E., Wiredu, A.N., Etwire, P.M., Fosu1, M., Buah, S. S. J., Bidzakin, J., Ahiabor, B. D. K., and Kusi, F. (2013). Fertilizer Adoption and Use Intensity among Smallholder Farmers in Northern Ghana: A Case Study of the AGRA Soil Health Project. *Sustainable Agricultural Research*, 3(1):24 - 36.

Mendola, M. (2007). Agricultural Technology Adoption and Poverty Reduction: A Propensity-Score Matching Analysis for Rural Bangladesh. *Food Policy*, 32(2007):372-393.

Mendola, M. (2007). Farm Household Production Theories: A Review of “Institutional” and “Behavioral” Responses. *Asian Development Review*, 24(1):49-68.

Ministry of Agriculture and Rural Development (2010). Ethiopia’s Agriculture Sector Policy and Investment Framework (PIF) 2010-2020. Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (2010). Growth and Transformation Plan Annual Progress Report for F.Y. 2009/10. Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (2012). Growth and Transformation Plan Annual Progress Report for F.Y. 2010/11. Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (2013). Growth and Transformation Plan Annual Progress Report for F.Y. 2011/12. Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (2014). Growth and Transformation Plan Annual Progress Report for F.Y. 2012/13. Addis Ababa, Ethiopia.

Ministry of Finance and Economic Development (2015). Second Phase Growth and Transformation Plan. Volume – I, Amharic version, Addis Ababa, Ethiopia.

Mustafa-Msukwa, A. K., Mutimba, J. K., Masangano, C., and Edriss, A. K. (2011). An Assessment of the Adoption of Compost Manure by Smallholder Farmers in Balaka District, Malawi. *Journal of Agricultural Extension,* 39:17-25.

Mwangi, M. and Kariuki, S. (2015). Factors Determining Adoption of New Agricultural Technology by Smallholder Farmers in Developing Countries. *Journal of Economics and Sustainable Development*, 6(5): 208 -216.

Nannicini, T. (2007). Simulation-Based Sensitivity Analysis for Matching Estimators. *The Stata Journal,* 7(3): 334-350.

Nguezet, M., Diagne, A., Okoruwa, O., and Ojehomon, V. (2011). Impact of Improved Rice Technology on Income and Poverty among Rice Farming Household in Nigeria: A Local Average Treatment Effect (LATE) Approach. Contributed paper prepared for the 25th conference of the Centre for the Studies of African Economies (CSAE). University of Oxford, UK.

Njane, P. (2007). Determinants of Adoption of Improved Wheat Varieties and Fertilizer Use by Smallholder Farmers in Njoro and Kieni West, Divisions, Kenya. M.Sc. Thesis. University of Egerton, Kenya.

Obisesan, A. (2014). Gender Differences in Technology Adoption and Welfare Impact among Nigerian Farming Households, MPRA Paper No. 58920.

Okuthe, K., Ngesa, U. and Ochola, W. (2013). The Socio-Economic Determinants of the Adoption of Improved Sorghum Varieties and Technologies by Smallholder Farmers: Evidence from South Western Kenya. *International Journal of Humanities and Social Science,* 3(18):280-292.

Opara, U. N. (2010). Personal and Socio-Economic Determinants of Agricultural Information Use by Farmers in the Agricultural Development Programme (ADP) Zones of Imo State, Nigeria. Retrieved July 15, 2016, from *http://unllib.unl.edu/LPP/opara.htm.*

Orinda, A. (2013). Analysis of Factors Influencing Sweet Potato Value Addition amongst Smallholder Farmers in Rachuonyo South District, Kenya. M.Sc. Thesis. Egerton University, Ethiopia.

Profile for Organic Fertilizer Processing Plant. Retrieved January 25, 2016, from http://www.ethioembassy.org.uk/trade_and_investment/Investment%20Profiles%20EIA/Chemicals%20and%20Pharmaceuticals/Fertilizer.

Profile for Organic Fertilizer Processing Plant. Retrieved January 25, 2016, from http://www.ethioembassy.org.uk/trade_and_investment/Investment%20Profiles%20EIA/Chemicals%20and%20Pharmaceuticals/Fertilizer.pdf .

Rosenbaum, P., and Rubin, D. (1983). The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika*, 70:41-55.

Runge-Metzger, A. (1988). Variability in Agronomic Practices and Allocative Efficiency among Farm Households in Northern Ghana: A Case Study in On-farm Research. Nyankpala Agricultural Research Report No. 2.

Scotti, R., Bonanomi, G., Scelza, R., Zoina, A., and Rao, M. A. (2015). Organic Amendments as Sustainable Tool to Recovery Fertility in Intensive Agricultural Systems. *Journal of Soil Science and Plant Science*, 15(2):333 -352.

Shashemene Woreda Agricultural Development office (2015). Shashemene Woreda Agricultural Plan for the Year 2015/2016. Shashemene, Ethiopia.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *Quarterly Journal of Economics* 70: 65-94.

Systematic Sampling. (n.d). Retrieved January 15, 2016, from https://en.wikipedia.org/wiki/Systematic_sampling#cite_ref-ken_black_india_1-0.

Tedla, H. (2011). Factors Determining Fertilizer Adoption of the Peasant farm sector in Northern Ethiopia, Tigray Region. M.Sc. Thesis. Norwegian University of Life Sciences, Norway.

Terefe, T., Ahmed, H. and Gebremariam, G. (2013). Adoption and Extent of Use of Organic Fertilizer in Arsi Negelle District, Oromia Regional State of Ethiopia: What are the Sources? *Advanced Journal of agricultural Research*, 1(004):061-071.

Uaiene, R., Arndt, C., and Masters, W. (2009). Determinants of Agricultural Technology Adoption in Mozambique. Discussion paper No 67E. Retrieved December, 24, 2015, from http://cebem.org/cmsfiles/publicaciones/Determinants_of_agricultural_technonolgy_adoption_in_Mozambique.

World Bank, (2015). 4th Ethiopia Economic Update: Overcoming Constraints in the Manufacturing Sector: World Bank Report. Addis Abeba, Ethiopia.

Yamane, T. (1967). *Statistics: An Introductory Analysis, 2nd edition,* New York: Harper and Row.

Yu, B. and Nin-Pratt, A. (2014). Fertilizer Adoption in Ethiopia Cereal Production. Journal of Development and Agricultural Economics, 6(7):318-337.

Zeller, M., Diagne, A., and Mataya, C. (1998). Market Access by Smallholder Farmers in Malawi: Implications for Technology Adoption, Agricultural Productivity and Crop Income. *Agricultural Economics*, 19:219-229.

APPENDICES

Appendix 1: Questionnaire

Dear respondent,

This questionnaire is prepared to find out "**Determinants of Adoption of Organic Fertilizer by smallholder farmers and income effect in Shashemene district".** Your responses to the questionnaire will help the researcher to determine constraints of organic fertilizer adoption and impact of organic fertilizer use on farm income. All your responses will be treated in the strictest confidence. All questionnaire will be shredded once the data has been extracted. You will not be identified for the information you provide and no information about individuals will be given to any organization. Please, answer the questions freely.

INSTRUCTION: **Read each question carefully and encircle questions with two or more alternatives. For questions not having alternatives, write your response on the space provided.**

Note**:** ETB represents Ethiopian Birr. As of 23rd February 2016, **1 USD = 21.3235 ETB**.

SECTION A: HOUSEHOLD CHARACTERISTICS

1. Age ______________
2. Gender ____________
3. Marital status of household. 1 = Single, 2 = Married, 3 = Divorced, 4 = Widowed
4. What is the total number of your family? ___________
5. Based on question 4, how many of them are females?
6. Based on question 4, how many of them are males?
7. What is the number of working (18 years and above) family members in your home? ______
8. What is the level of your education in years? (Years of schooling).______________
9. What is the highest education level of any of your family member in years? ____________
10. What is the major source of your income?

    1= Agriculture, 2 = Government salary, 3 = Non-agriculture private work,

    4 = other, specify__________
11. Based on your choice for question 10, what is the state of your employment for the choice you made?

1 = Part time, 2 = Full time, 3= Not at all.

12. If your answer for question 10 is agriculture, what is the level of your income per year in ETB? __________________

13. If your answer for question 10 is not agriculture, what is the level of your income per month or year in ETB? _______________

14. What is your total income per month/year in ETB irrespective of its sources? ______________

15. For how long have you been practiced farming? _____________________________

SECTION B: FARM CHARACTERISTICS

16. Do you own land? 1 = Yes 0 = No

17. If question 16 is yes, what is the size of your land? ___________________

18. What is the current size of your plot under crop production in hectare?___________________

19. Which types of crops are you growing? ___________, ________________, ______________, __________________

20. How do you rate your plots fertility? 1 = Not fertile, 2 = Medium, 3= Fertile

21. Do you own livestock? 1= Yes 0 = No

22. If question 21 is yes, how many animals? Cattles_____, Sheep_______,

    Goats______, Others_______

SECTION C: USE OF ORGANIC FERTILIZER

23. Do you use organic fertilizer? 1= Yes 0 = No

24. If question 23 is no, what makes you not to use organic fertilizer?

    1 = High transaction costs, 2 = Have no animals which may provide manure,

    3 = Low skill of know how to prepare and use, 4 = Shortage of finance,

    5 = Have no enough labor, 6 = others, specify and list them________.

25. If your choice for question 24 is 1 or 4, based on your choice, how much would you have been spend to get organic fertilizer for one hectare of your plot in ETB? _____________

26. If question 23 is yes, answer the questions (a – d) in the following table.

    a. Which type of organic fertilizer do you use? 1= Manure, 2 = Compost

       3 = other, specify_____________

i. If your answer for the above question on (**a)** is compost, fill the following table depending on your plot productivity before and after the use of compost for the given crops. Your answer should only include those crops you have been producing from the listed crops.

How many quintals of the following crops do you harvest per hectare in 2014/15?				
	When you use compost.		**When you don't use compost.**	
	Productivity/hec	**Income/hec**	**Productivity/hec**	**Income/hec**
Wheat				
Maize				
Teff				
Beans				

b. For how long have you been using organic fertilizer in years? ____________________

c. What quantity of organic fertilizer do you apply on your farm per hectare per growing season in kg? ________________________

d. How frequent do you apply organic fertilizer? 1 = every season, 2 = per two season, 3 = per three season, 4 = above three season.

SECTION D: INSTITUTIONAL FACTORS

27. Do you have access to credit? 1=yes 0= no
28. If question 27 is yes, how much did you get last season? ______________________
29. Who is/are the sources of credit?
30. Do you have extension services? 1=yes 0 = no
31. If question 30 is yes, how many times did you met extension workers last season? _________
32. Do you have access to TV, radio or any other social media? 1= yes 2= no
33. Is there any farmer's organizations in your village? 1= yes 2= no
34. If question 33 is yes, how many organizations are available? _____________________
35. Based on question 34, are you a member of that organization/s 1= yes 2= no
36. If question 35 is yes, to how many organizations are you a member in? _____________

37. Based on question 36, how frequent do you meet with other organization/s members per month? _____________
38. How far is your village from the nearest market in km? ______________________
39. How many hours does it take to you to reach the nearest market from your village? _______

SECTION E: TRANSACTION COSTS

40. Do you produce your own organic fertilizer? 1 = Yes, 2 = No
41. If question 40 is no, from where do you get it? 1 = Market, 2 = From government, 3 = Farmer based association, 4 = other, specify ___________
42. If question 40 is not a market, can you get organic fertilizer from the nearest market? 1= yes 2= no
43. Is there any other sources to buy organic fertilizer? (other than markets) 1=Yes, 0 = No
44. If question 43 is yes, how far are these sources from your village in km? _________________
45. How long does it take to identify the sources of organic fertilizer in days? ______________
46. When you search for the sources of organic fertilizer, what do you use? (more than one option is possible) 1= Phone call, 2 = SMS, 3 = Internet, 4 = Transportation, 5=others,
47. Based on question 45, how much does it cost in ETB when you use;
    a. Phone call ___________ c. SMS_______________________
    b. Transport ____________ d. Others, specify sources and the amount of costs.
48. How long does it usually take from searching for to getting the organic fertilizer in days? _____________
49. Do you bargain when buying organic fertilizer? 1 = Yes 0 = No
50. If question 49 is yes, what is the cost of bargaining in ETB and how long does it take in time?

    Time: __________________________ Cost: ____________ (Cost per hectare __________.)
51. In trying to get this fertilizer do you forgo any benefit? 1 = Yes 0 = No
52. If question 50 is yes, what is the amount of the benefit you forgo in ETB? ______________
53. If question 50 is yes and the total amount of the benefit is unknown, list the benefits you would have obtain._______, ____________, ___________, _________

SECTION F: FARM PRODUCTIVITY FOR SELECTED CROPS (this section is to be filled only by non-adopters of organic fertilizer)

54. Fill the following table based on your plot productivity. Your answer should only include those crops you have been producing from the listed crops.

How many quintals of the following crops do you harvest per hectare in 2014/15?	Productivity/hec	Income/hec
· Wheat		
· Maize		
· Teff		
· Beans		

Appendix 2: Descriptive Statistics for Age, Education, Household Size, Labour, Livestock Holding, Farm Size, Experience and Credit

	Adopters		Non-adopters	
	Freq.	Perc. (%)	Freq.	Perc. (%)
Age				
22 – 30	21	13.6	30	14.1
31 – 40	47	30.3	68	31.9
41 – 50	54	34.9	63	29.6
50 – 60	21	13.6	28	13.2
above 60	12	7.7	24	11.2
Household head education				
Illiterate	19	12.3	17	8.0
Primary	88	56.8	140	65.7
High school	41	26.4	52	24.4
College	5	3.2	4	1.9
University	2	1.3	0	0.00
Highest education in family				
Primary	30	19.4	54	25.4
High school	58	37.4	88	41.3
College	14	9.0	20	9.4
University	53	34.2	51	24.0
Household size:				
1 – 5	40	27.1	73	34.3
6 – 10	91	58.7	103	48.3
More than 11	22	14.2	37	17.4

Appendix 2: Continued

Labour				
1 – 5	122	78.7	174	81.7
6 – 10	31	20.1	36	16.9
More than 11	2	1.2	3	1.4
Livestock holding:				
No	6	3.8	77	36.2
Yes	149	96.2	136	63.8
Farm size				
0 – 0.75	86	55.5	151	70.9
1 – 1.75	58	37.4	57	26.8
2 – 3	11	7.1	5	2.3
Experience (years)				
1 – 10	23	14.9	36	16.9
11 – 20	48	30.9	63	29.5
21 – 30	51	32.9	59	27.7
31 – 40	21	13.6	39	18.3
41 – 50	12	7.8	16	7.5
Access to credit:				
No	135	87.1	166	77.93
Yes	20	12.9	47	22.07

Appendix 3: Results of VIF for Multicollinearity Test

Variables	**VIF**	**1/VIF**
Labour	3.27	0.31
Age	3.12	0.32
Experience	2.60	0.38
Household size	2.18	0.46
Farm size	1.66	0.60
Livestock number	1.61	0.62
Education of household head	1.49	0.67
Family’s highest education	1.43	0.70
Farm income	1.41	0.71

Appendix 3: Continued

Membership	1.23	0.81
Distance to the nearest market	1.09	0.91
Credit amount	1.07	0.94
Extension contacts	1.06	0.95
Mean VIF	**1.79**	

Appendix 4: Overall Region of Common Support and Number of Discarded Observations

	Region of common support [0.109, 0.790]		
Treatment assignment	**Off-support**	**On-support**	**Total**
Non-adopters	0	213	213
Adopters	9	146	155
Total	**9**	**359**	**368**

Appendix 5: Kernel Density Estimate Graph