SAINT MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DETERMINANTES OF FERTLIZER ADOPTION IN AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

By:

Helen Aklilu

Advisor

Wondmagegne Chekol, PhD

Submitted To:

SCHOOL OF GRADUATE STUDIES

SAINT MARY'S UNIVERSITY

June, 2016

Addis Ababa,Ethiopia

DETERMINANTES OF FERTLIZER ADOPTION IN AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

By:

Helen Aklilu

A THESIS SUBMITTED TO SAINT MARY'S UNIVERSITY, SCHOOL OF GRADUATE STUDIES IN PARTIAL FULLFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF AGRICULTURAL ECONOMICS

June, 2016

Addis Ababa

SAINT MARY'S UNIVERSITY

SCHOOL OF GRADUATE STUDIES

DETERMINANTES OF FERTLIZER ADOPTION IN AMHARA NATIONAL REGIONAL STATE, ETHIOPIA

By:

Helen Aklilu

APPROVED BY BOARD OF EXAMINERS

-----------------------	___________________	_________________
Chairperson	**Signature**	**Date**
-----------------------	------------------------	-------------------------
Advisor	**Signature**	**Date**
---------------------------	___________________	_________________
Internal Examiner	**Signature**	**Date**
-----------------------------	___________________	_________________
External Examiner	**Signature**	**Date**

DECLARATION

I, the undersigned, declare that this Thesis is my original work; prepared under the guidance of Wondmagegne Chekol (PhD). All the sources of materials used for this thesis have been dully acknowledged. I further confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

______________________________   ______________________________

Name   Signature and Date

ENDORSEMENT

This thesis has been submitted to Saint Mary's University, School of Graduate Studies for examination with my approval as a university advisor.

Advisor	Signature and Date

DEDICATION

To my God, The Lord, Who Has helped me reach here.

.

ACKNOWLEDGEMENTS

Above all I would like to praise the Almighty God for His help and Protection throughout my life.

Words fail to convey my deepest thanks to my advisor Dr. Wondmagegne Chekol, I will not pass without mentioning your fatherhood approach throughout my time working with you.

My deepest overwhelming acknowledgment goes for Dr. Gomeraw Adenw for his valuable intellectual comments, supply of the necessary materials and moral support.

I have also to give special thanks to my family, who are always there for me. Specially my mother Etalemahu Yalew, if it were not for your contribution in terms of everything I need, it would be very difficult to me let alone to reach where I am, even to think of it.

Friends, your contribution throughout my study cannot be undermined, you deserve the warmest thanks.

Lastly, I have to acknowledge the Central Statics Agency and Ethiopian Economics Association, for allows me to access their data base, without which it may be very difficult to complete this work.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

ADLI Agricultural Development Led Industrialization.

AISCO Agricultural Input Supply Corporation.

AISE Agricultural Input Supply Enterprise.

CPP Comprehensive Package Program.

CSA Central Statistics Authority.

DAP Di Amonium Phosphet.

EARO Ethiopian Agricultural Research Organization.

EAs Enumeration areas

EDRI Ethiopian Development Research Institute.

EEA Ethiopian Economic Association.

FAO Food and Agricultural Organization.

FFYP First Five Year Plan.

GDP Gross Domestic Product.

GTP Gross Transformation Plan

HYVS High Yielding Variety Seeds.

IFDC International Fertilizer Development Center

MFIs Micro Finance Institutions

MDG Millennium Development Goals.

MDGI Millennium Development Goals Indicator

MPP Minimum Package Programs.

OLS Ordinary Least Square.

PADEP Peasant Agricultural Development Extension Program.

PADETS Participatory Demonstration and Extension Training System.

PSUs Primary sampling units

SFY P Second Five Year Plan.

SNNP Southern Nations and Nationalities Peoples.

SSUs Secondary sampling unit

ABSTRACT

Agricultural development and food security are the major policy objectives of the government of Ethiopia. The need for applying modern agricultural inputs in Ethiopian agriculture is not debatable. Fertilizer is one of the major productivity enhancing inputs. Hence, increased and effective use of fertilizer can be considered as a more plausible alternative in Ethiopia to bridge the wide gap of food shortage at least in the immediate future.

This study is designed to identify factors influencing the adoption and intensity of fertilizer use among small holder farm households were analyzed in Amhara Regional State of Ethiopia. The study was based on the data obtained from CSA 2007E.C agricultural Survey. A total of 8,609 households were considered for this study of which 7792 cases were included in the econometric model. Econometric software called "STATA 13" was employed to estimate the Tobit model to identify factors influencing the adoption of fertilizer and intensity of its use.

Analysis of the extent of fertilizer adoption by the sample households has shown that 48% of the sample households were adopters. It was found that probability of fertilizer adoption and intensity of its use appear to be significantly and positively influenced by Age, education, Household size, extension service, oxen owned, access to input credit, and household farming activity (being a mixed farming. Sex of the farm household was not significantly related to fertilizer adoption and intensity of its use. Based on the result of the study, the recommendation is forwarded for the concerned bodies.

CHAPTER I: INTRODUCTION

1.1. Background of the Study

Agricultural development and food security are the major policy objectives of the government of Ethiopia. Several programs and initiatives were implemented to drive agricultural growth and poverty reduction throughout the country because of the Agricultural sector has an overwhelming influence on the Ethiopian economy. It contributes 47 percent of GDP, employs 85 percent of labor force and supplies over 75 percent of the value of all exports. (Mundi, 2013; EEA, 2015).
Ethiopia is one of the agrarian countries with severe problem of food security. Major known famines repeatedly broke out and took the lives of thousands. Unpredictable weather condition in combination with rapid resource deterioration, lacks of appropriate agricultural technology, limited capital and infrastructure continue to entail famine in a cyclical basis. (Hassen et al, 2012).
The growth and Transformation plan has stipulated that agriculture would "continue" to the major source of growth in Ethiopia over the plan period. Despite all efforts made, the Ethiopia remain one of the world's most food insecure countries, with problems along all key dimensions of food security. Considerable food insecurity challenges remain such as the more than 20 million Ethiopian that will still be hunger even the MDGI is met by 2015(EEA, 2015).

The agricultural sector value added is registered to be 4.9% for 2011/12. But this figure is not consistent with the targeted 8.6% growth by GTP (EEA, 2013). Even though it's is slightly declining, the agricultural sector greatly influences the rate of economic growth in Ethiopia. The percentage share of the agricultural sector from the entire growth rate of the economy was 47.76 with in 2000/01-2004/05, 37.13 between 2005/06-08/09, 35.16 in 2010/11 and 24.41 in 2011/12(EEA, 2013). Partly, the declining growth share is explained by the astonishing development of the service sector which accounts the highest share of GDP and growth of GDP.

Fertilizer is one of the major productivity enhancing inputs. Hence, increased and efficient use of fertilizer can be considered as a more plausible alternative in Ethiopia to bridge the wide gap of food shortage (at least in the immediate future). There is no domestic production of inorganic fertilizer in Ethiopia. Chemical fertilizers are imported from abroad in the form of Di-Amonium Phosphate (DAP) and Urea. Fertilizer import is mainly financed by funds obtained from Donors and Creditors.

More than 90% of all fertilizer is used by small-holder farmers and the remaining 10% is used by private commercial farms, state farms and research centers. Four regions alone (Oromia, Amhara, SNNPRS and Tigray) accounted for more than 87.5% of the total fertilizer consumption of the country (Tirfu Hedeto, 2011; CSA, 2008b).

The utilization of other inputs such as improved seeds and pesticides is also at low level. Of the total cultivated cropland improved seed was applied to 2.7% only. Similarly, of the total seed utilized by farmers only 2.3% was the share of improved seed varieties. This indicates that farmers are mostly using indigenous seeds, which may be due to the cost and/or inadequate availability of improved seeds. Of the total cultivated crop area only 0.7% was irrigated, 4.3% was applied with pesticide and about 9% applied with natural fertilizer (mainly animal dung). In addition, of the total smallholder farmers in the country about 74% were illiterate (CSA, 1999a).

Until mid 1992, fertilizer marketing was fully state controlled. Agricultural Input Supply Corporation (AISCO), now renamed as Agricultural Inputs Supply Enterprise (AISE) was the monopolist parastatal since 1985. Recognizing the role of fertilizer in increasing crop yield, the government of Ethiopia has given top priority to the fertilizer sub-sector. To this effect, the government liberalized the fertilizer market and issued fertilizer policy in 1993 with the main objective of achieving the goal of food security and food self-sufficiency through increased and efficient use of fertilizers (NFIA, 1999).

1.2 Statement of the Problem

The major challenge confronting most of developing countries such as Ethiopia is improving rural as well as urban food security and to stimulate underlying food system development. There is an ever increasing concern that it is becoming more and more difficult to achieve and sustain the needed increase in agricultural production based on intensification, because there are limited opportunities for area expansion). Hence, the solution to food problem would depend on measures aimed at stimulating yield which in turn is determined by sustainable growth in the use of improved technologies, mainly chemical fertilizers.

Fertilizer is one of the major productivity enhancing inputs. Hence, increased and effective use of fertilizer can be considered as a more plausible alternative in Ethiopia to bridge the wide gap of food shortage at least in the immediate future. (Tirfu Hedeto,2011; NFIA, 1999).

Considering the role chemical fertilizer has in increasing production and productivity, strong efforts have been carried out to promote its adoption for the last 40 years in Ethiopia. Despite concrete efforts made by the government of Ethiopia to widely promote fertilizer adoption through improved extension services and access to credit, farmers are still using low amount of fertilizer and there are a lot of farmers who are not still applying commercial fertilizers. From the total number of households who had cultivated the farm land during the crop year 2007/08, 51.1% of farm households had not used chemical fertilizer (Tirfu Hedeto,2011; CSA, 2008b).

Despite all efforts the government exerts to modernize the Ethiopian agriculture fertilizer use is negligible and continuously declining. Moreover, Ethiopia is the biggest chemical fertilizer importer in sub Saharan Africa, fertilizer user per unit of land (50kg/ha on average) is significantly below from recommended levels (about 200 kg/ha) and rapid population growth combined with the degradation of quality of soil is threatening the future of the country (Asenafi, 2006). Therefore, this study was initiated to analyze determinants of fertilizer adoption by smallholder farmers.

Even though, some fertilizer adoption studies were conducted in Ethiopia (e.g. Bezabih, 2000; Lelissa, 1998; Teressa, 1997; Croppensted et al., 1999; Asenafi, 2006; Tesfaye and Alemu, 2001; Mergia, 2002, Tirfu, 2011) the currently available knowledge about the possible factors affecting adoption and intensity of its use is not sufficient. Most of these studies are area specific and are limited in scope and coverage. Area specific studies provide area specific information and hence may not help much in designing a national agriculture and fertilizer policies. Issues identified as a problem in the previous studies may not exist today and new changes or problems might have been encountered in due course. Hence, the present study is hoped to provide recent empirical evidences on factors influencing fertilizer adoption among smallholder farmers so as to suggest policy implications for future intervention strategies.

1.3 Basic Research Questions

- What are the factors that determine the use of fertilizer input in Amhara region?
- What are the factors affecting the intensity to use fertilizer input in Amhara region?

1.4 Objectives of the Study

General objective

The general objective of this study is to empirically examine factors influencing the adoption of chemical fertilizer by smallholder farmers in the in the Amhara region of Ethiopia so as to propose some policy implications to be considered in the future intervention strategies.

Specific objectives

- To empirically examine factors influencing the adoption of fertilizer use by smallholder farmers.
- To empirically examine factors influencing the intensity of fertilizer use by smallholder farmers.

1.5 Definition of Terms

Enumeration Area (E.A): - an enumeration area in the rural parts of the country is a locality that is in most of the cases less than and only in some cases equal to a farmers' association in geographical area and usually consists of 150-200 households

Household: - a household may be either:

a) A one person household that is a person who makes provisions for his own living with out Combining with any other person to form part of a multi- person household or

b) A multi-person household, that is, a group of two or more persons who live together and make common provisions for food and other essentials of living. The persons in the group may pool their incomes and have a common budget to a greater or lesser extent. They may be related or unrelated persons or a combination of both. These persons are taken as members of the household.

Agriculture: - The growing of crops and/or rising of animals for own consumption and /or sale.

Agricultural Household: - a household is considered an agricultural household when at least one member of the household is engaged in growing crops and/or raising livestock in private or in combination with others.

Fertilizer: – refers to anything that is added to the soil and intended to increase the amount of plant nutrients available for crop growth. In this survey data is elicited on two types of fertilizers (Natural and Chemical). The Natural fertilizer consists of the farm yard manure and wood ashes while the chemical type consists of DAP (Di- Ammonium phosphate) and UREA (Ammonium Nitrate).

Meher (Main) Season Crop: -any temporary crop harvested between Meskerm (September) and Yekatit (February) is considered as Meher season crop.

Field: - a field is defined as any plot of land which is a parcel or part of a parcel under the same or mixed crops or any other form of private holding.

1.6 Significance of the study

The significant of production growth in agricultural sector of the world mainly comes from the technological improvements. It is proved from the Asian countries that green revolution is able to increase the productivity of the farmers very significantly.

Hence in the countries like Ethiopia where agriculture is the mainstay of the economy there is a severe poverty and food shortage, the role of productivity enhancing technologies is enormous, so identifying those factors which contribute for adoption decision and intensity to use fertilizer input can play an important role. Knowing the factors can contribute to accelerate the adoption process of the technology and get the maximum possible benefit out of it. In order to use the modern inputs continuously, there should be appropriate incentives for those who adopt the technology, hence analyzing the productivity gains from the modern inputs also vital. It is observed that, in most African countries, the technologies imitated from Asian countries do not contribute to the productivity growth of the sector. So analyzing the productivity effects of the technologies may give an insight to the necessary, customization to the specific country's agro-climatic condition.

Further, the study can also give some evidences to policy makers, which could be used in their decision making process. In addition the paper is also believed to contribute for the existing literature in the area and initiates future researchers.

1.7 Scope and limitations of the study

The main purpose of the study is to show those factors which significantly affect the fertilizer adoption decision of the farmers and intensity to use fertilizer in Amhara region. To achieve this objective the study used secondary data obtained from CSA as a result, the output obtained from the study must be interpreted very carefully. Although survey information include the most important characteristics of the farmers it also exclude the important variable that determine the adoption characteristics of the farmer, like the distance of input supply institutions from the household house, distance to the credit supply institution not only these the amount of credit that the farmer get is also not mention.

1.8 Organization of the Thesis

This study is divided into five chapters. The first chapter is "Introduction" that includes background, objectives, statement of the problem, significance of the study, scope and limitation of the study. Chapter two deals with an overview of fertilizer use and policy in Ethiopia and also includes conceptual framework and definition and empirical adoption studies. Chapter three deals with research methodology. Results and discussion are detailed in chapter four. Chapter five draws conclusion and suggests policy implications on the basis of the results of the study.

CHAPTER II

LITERATURE REVIEW

2.1 Brief History of Fertilizer Use and Extension Service

In Ethiopia traditional land fallowing and crop rotation practices used to maintain soil fertility have been gradually reduced due to high population pressure and limited availability of cultivable land. The use of manure to add organic materials to the soil is also hampered by the increased use of dung and crop residues as a source of energy (Setotaw *etal*., 2000). Thus, in order to restore plant nutrients to the depleted soils provision of chemical fertilizer to farmers has been one of the major activities of the extension programs in Ethiopia. Since the inception of the agricultural extension program in Ethiopia, promoting the use of chemical fertilizer has been the major work of extension personnel. For the sake of convenience major historical events that had influenced the path of fertilizer use in Ethiopia are briefly outlined under different political regimes.

The first period refers to the imperial regime that had prevailed prior to 1974. It was at this time that inorganic fertilizer was first introduced to Ethiopia following three years (1967-69) of simple fertilizer demonstration carried out by the government with the assistance of Food and Agriculture Organization's (FAO) Freedom from Hunger Campaign. The objectives of this program were to create awareness among the smallholder farmers on the use of inorganic fertilizer, to conduct field trials to determine optimum rate of application and to define sound policies, strategies and institutional set up that would help introduce efficient fertilizer distribution system. The crops under trials were cereals and the introduced inorganic fertilizers were DAP and Urea.

A package approach that would be limited to a specific area providing inputs and other services was initiated by the Ethiopian Government in 1967, with the assistance of the Swedish

International Development Authority (SIDA). To this effect, the Chilalo Agricultural Development Unit (CADU) was established in 1967. CADU played a leading role in popularizing fertilizer use and other complementary inputs such as improved seeds with credit. Encouraged by access to credit and increased yields farmers' demand for fertilizer and other inputs exceeded expectation at the early stage. Based on the experience gained from CADU, other comprehensive package projects with varying objectives and approaches were initiated. These include: the Welamo Agricultural Development Unit established in 1970; the Ada District Development Project established in 1972 and Sothern Region Agricultural Development Project founded in the vicinity of Awassa. However, it was only CADU that was operational until it was phased out in 1986 (Belay, 1999).

Although the programs could increase crop productivity in the regions they were established, it was realized that the results of the comprehensive package were reaped by landlords and commercial farms who were entitled to land and able to finance the use of inorganic fertilizers and other inputs (Bezabih, 2000). It was also criticized that the comprehensive package projects were expensive both financially and in terms of trained manpower requirements to apply in other parts of the country. As a result, the comprehensive package approach was abandoned and less expensive rural development program called Minimum Package Program (MPP-I) was launched in 1971. MPP-I was prepared for 1971-1974 period and was designed to provide small-scale farmers with essential services considered to be the minimum essential elements for agricultural development. The essentials include credit, marketing, extension advice and provision of chemical fertilizer and improved seeds (Bezebih 2000). It was also in 1971 that the government established the Extension and Project Implementation Department (EPID) under the Ministry of Agriculture in order to coordinate the implementation of all rural development projects including the minimum package program (NFIA, 2001). After a number of trials conducted from 1971 to 1976, EPID recommended an application rate of 100kg DAP and 50 kg Urea per hectare.

In conclusion, during the imperial regime fertilizer history was mainly characterized by the state control of import and distribution of fertilizer and restricted use of fertilizer by a handful of farmers in a few districts who have access to land and credit.

The second period refers to the military regime that prevailed from 1974 up to 1991. Following the 1974 socialist revolution, the government enforced land reform in 1975 which made all rural land public property. During the period the MPP-I was redefined as Minimum Package Project – II (MPP-II) in 1975. Although it was planned to be implemented during the period 1975-1980, MPP-II was implemented during the period 1980-85, due to the political instability and major structural changes. MPP-II had the same objectives as MPP-I, but it was envisaged to cover more districts and reach as many farmers as possible through peasant associations and cooperatives. MPP-II did not attain its stated objectives since very few extension agents were made to cover as wide areas as possible without adequate facilities. In addition, extension agents were required to do some additional assignments such as collecting taxes, promoting cooperatives, collecting loan repayment, etc. (Belay, 1999).

Based on the experience of the two phase minimum package programs the Peasant Agriculture Development Extension Program (PADEP) was launched in 1985. The program was designed to bring perceptible changes in peasant agriculture through concerted efforts in the areas of agricultural research and extension. The extension strategy underscored the importance of stratifying the country into relatively homogenous zones by giving more emphasis to the surplus districts. The PADEP employed a modified Training and Visit extension system where an extension agent was assigned to work with 1300 farmers in the surplus districts. The PADEP was effective in increasing the performance of contact farmers involved in the program. It was criticized that the program gave better access to limited number of farmers and as a result, hampered rapid diffusion of the available innovations.

Through the period of the military regime (1974-1991) total fertilizer consumption has increased on average by 15% annually. Until 1986 the growth rate of urea consumption was by far lower than the growth rate of DAP consumption. During the period 1987-1991, although the growth rate of Urea consumption was higher than that of DAP the actual consumption of DAP was more than fivefold of Urea (appendix 1 and Fig. 1). Complete government control of the fertilizer sub-sector, priority attention to agricultural cooperatives and state farms in input delivery and limited number of extension agents compared to the coverage expected were the main features characterizing the fertilizer sub-sector and extension service during the military regime.

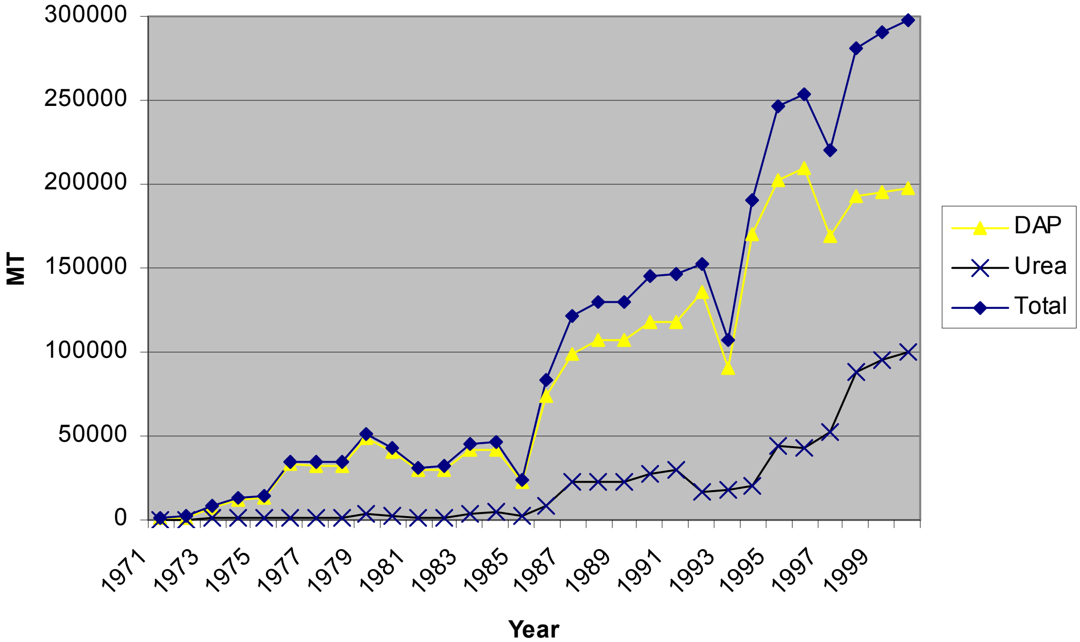

Figure 1. Fertilizer Consumption Trend in Ethiopia.

Source: NFIA, 2000

The third period starts from 1991 (i.e. the decentralized and market oriented economic system). Following the change in government in 1991, the T & V extension approach was adopted until its replacement by the Participatory Demonstration and Training Extension System (PADETES) in 1995. Recognizing agriculture as an engine for the economic development of the country, the government of Ethiopia has formulated a strategy known as Agricultural Development Led Industrialization (ADLI) in 1993. The strategy gives top priority to the peasant agriculture. Increased availability of mineral fertilizer, facilitating input credit availability and provision of technical support through extension services demonstrate the priority given to the agricultural sector. With a framework of ADLI, a new agricultural extension system known as Participatory Demonstration and Training Extension System (PADETES) was launched in 1994/95. The implication is rapid agricultural growth enough to produce sufficient food for the citizens, exportable products to generate foreign currency and release surplus of raw materials and labour for agro-industries. The PADETES was based on the experience of Sasakawa Global 2000 (SG2000) extension strategy, which was launched in 1993. The principle of PADETES is to demonstrate to farmers the benefits of package of inputs, notably integrated use of fertilizer, improved seeds, pesticides and better cultural practices. An attempt has been made to bring about balanced use of nutrients through PADETES.

It is during this period that the consumption of Urea has shown a remarkable growth and on the average it increased by about 13% annually while DAP consumption increased by about 5% (Fig. 1). The increase in the consumption of Urea can be mainly attributed to the extension service and relatively lower retail price compared to that of DAP.

2.2 Fertilizer Policy and Achievements

In the past, several institutional reforms have taken place in fertilizer promotion and marketing in Ethiopia. From 1970 to 1984 various agencies namely, Agricultural and Industrial Development Bank, Agricultural Inputs Marketing Services (AIMS), and Agricultural Marketing Corporation (AMC) handled fertilizer procurement and distribution. From 1985 up to 1992, the whole activity of import, distribution and retailing of fertilizers was monopolized by the parastatal Agricultural Inputs Supply Corporation (AISCO), now renamed as the Agricultural Inputs Supplies Enterprise (AISE). To provide guidelines and to further facilitate the promotion and development of the sub-sector, the government of Ethiopia issued National Fertilizer Policy in

1993. The general objective of the policy is to achieve the national goal of food security through increased and efficient use of fertilizers along with other enabling environments. The specific objectives of the policy include:

- Promoting competitive fertilizer marketing system.
- Providing the necessary support to the national research and extension system to generate packages of technologies.
- To control fertilizer quality and promote environmentally safe use of fertilizer.
- Encouraging and promoting the establishment of fertilizer manufacturing plants.
- To develop the farmers effective demand for fertilizer.
- To ensure that fertilizers are available to smallholders in the required quantity, product mix, at a time needed and at reasonable price (National Fertilizer Policy, 1993).

Moreover, encouraging the private sector to fully participate in the fertilizer trade, promoting cooperatives on voluntary membership basis, monitoring prices of agricultural outputs and fertilizer and deregulation of the pan territorial pricing system are key issues indicated in the policy.

Following the fertilizer market liberalization, six private importers/distributors joined the public parastatal that is AISE. These are: Ambassel Trading House, Guna Trading House, Ethiopia Amalgamated Limited, Fertiline Private Company, Wondo Trading Company and Dinsho Trading Company. While the first four private companies and AISE are active importers, the operation of the last two companies (Dinsho and Wondo) is limited to local distribution only (although they have import license). The share of private companies from total import increased from 19% in 1995 to 52% in 2000 (Appendix 3). Similarly, the share of private importers/distributors in the total sales of fertilizer increased from 19% in 1995 to 69% in 2000.

Elimination of fertilizer subsidy, complete deregulation of fertilizer prices, announcement of fertilizer manufacturing and trade law and construction of soil testing laboratories in different regions of the country can be considered as achievements of the national fertilizer policy. Nevertheless, some drawbacks are observed in meeting the policy objectives. For instance, at early period of the fertilizer market reform (1993-1996) many private wholesalers and retailers were attracted to the fertilizer business and their number was more than 2,300 in 1996 (Mulat and Techane, 1999). However, most of these wholesalers and retailers ceased operation due to the following main reasons:

1. The new input credit delivery system in which regional governments took the authority of administering credit has restricted credit sales to importers and distributors leaving no room for small wholesalers and retailers.
2. Unattractive profit margin compared to other businesses.
3. Lack of working capital. These small wholesalers and retailers are not in a position to obtain distribution credit, as they cannot provide the collateral required by Banks.

Studies conducted by NFIA in 2001 have indicated that the existing private importers do not seem comfortable with the existing fertilizer procurement and distribution system. First, the existing import procedure is too long (it takes up to seven months) and hence makes Ethiopian markets unattractive to foreign suppliers. Second, 100% counterpart fund that has to be deposited during the opening of Letter of Credit (L/C) is found to be very expensive to importers as the fertilizer business requires huge capital. Third, there is no level playing field in some regions as some local authorities are alleged to favor regional based companies. Initially the regional governments came to the picture of input distribution and input credit management to fill the gap created between Banks and farmers as banks were not voluntary to extend credit to farmers without collateral due to large number of defaulters in the previous years. Although the involvement of regional governments is considered as a temporary gap filling initiative, their present excessive intervention doesn't seem conducive for the development of the desired competitive fertilizer marketing system.

Documents show that in Ethiopia larger proportion of fertilizer sales to farmers is on credit basis. The credit sales are either channeled through cooperatives or agricultural offices, (on auction or negotiation basis). Although their share from the total credit extended to farmers is very low, there are some regional based micro-finance institutions that are dealing with input credit. These are: Dedebit Credit and Saving Institution (in Tigray) and Amhara Credit and Saving Institute.

According to importers, the auction system is relatively transparent in Oromia and Tigray region and lacks transparency in SNNPRS (Field Survey reports of NFIA, 1997, 1998, 1999 and 2000). While transparency and lower wholesale fertilizer price can be considered as advantages of the existing fertilizer auction system (where it is genuinely implemented), it has also a number of draw-backs. First, it doesn't encourage small private wholesalers and retailers (since importers directly participate); second, it does not allow timely availability of fertilizers (as suppliers are not sure whether they win the bid or not); third, it doesn't encourage infrastructure development such as storage construction by suppliers and fourth, although it is said transparent, it is not free from the intervention of local governments and hence, not attractive to the market participants.

2.3 Conceptual Framework and Definition

Several authors defined adoption of technologies in different times (e.g. Dasgupta, 1989; Feder et al., 1985; Rogers,1962; Reardon et al.,1999). Dasgupta (1989) defined adoption as the continued use of recommended idea or practice by individuals over a reasonably long period of time. He further noted that adoption is not a permanent behavior. An individual may decide to discontinue the use of an innovation for a variety of personal, institutional or social reasons, one of which might be the availability of an idea or practice which is better in satisfying his/her need.

Feder etal. (1985) also classified adoption as individual (farm level) adoption and aggregate adoption. Final adoption at the individual farmer's level is defined as the degree of use of new technology in long-run equilibrium when the farmer has full information about the new technology and it's potential. In the context of aggregate adoption behavior they defined the diffusion process as the process of spread of new technology within a region.

According to Dasgupta (1989), the adoption process is conceptualized to include several mental stages through which an individual passes after first hearing about an innovation and finally deciding to adopt or reject it. The process generally includes five stages: awareness, interest, evaluation, trial and adoption. As noted by *Feder etal*. (1985) and Dasgupta (1989), farmers are divided, according to their tendency to adopt as innovators, early adopters, followers and laggards.

The cumulative proportions of persons first adopting a practice will tend to approximate S–shaped growth curve when plotted by successive years (Dasgupta, 1989). Mansfield (1961) hypothesized that the S-shaped adoption curve is a function of the extent of economic merit associated to the new technology, the amount of initial financial requirement to adopt, accessibility to information, the degree of risks associated with the new technology. Thus, the S-shaped adoption curve implies that a small proportion of farmers adopt an innovation when it is first introduced to a social system. Through interaction with the first adopters and observing the results, a few more farmers come to know about the innovation and its usefulness and eventually adopt it. Over a period of time, a large number of farmers become familiar with the innovation and decide to adopt the practice. This is the period which is reflected in the up word slope of the S-shaped diffusion curve. The S-shaped curve has a gentler slope until the entire village adopts the innovation (Dasgupta, 1989).

Many of the adoption studies stressed the role of communication in their attempt to explain the S-shaped pattern of aggregate diffusion over time assuming that the driving force of the diffusion process is imitation (e.g Rogers, 1969; Mansfield, 1961; Dasgupta, 1989). Dasgupta (1989) noted that it is the first few adopters of an innovation who influence the other members of a community to adopt the innovation as they interact with them. After the innovation is adopted by a few farmers, they influence a few others who in turn offer new stimulus to the remaining ones. Other studies (such as Benor *etal.* 1984; Arnon, 1987) emphasized the role of agricultural extension service in facilitating the process of communicating an information and changing the attitude of farmers. Benor *etal.* (1989) noted that without extension's guide, farmers often are unable to exploit completely the opportunities available to them. Even in advanced countries, it is not possible to encourage farmers to adopt new technologies and practices without farmers clearly understanding them.

According to Reardon et al. (1999), for a given household fertilizer demand is a general term that includes adoption as a subset (the distinction between zero and positive use); diffusion concerns the spread over households of adoption. They further indicated that fertilizer demand of a given farm household arises from the economic and technical relationships perceived by the farmer. The main economic relationship is that between the use of fertilizer and its profitability. The choice of level and type of fertilizer used depends on what the farmer perceives about the responsiveness of yield to fertilizer use for crop under question, controlling for other conditions such as use of other inputs, and other factors such as rainfall, managerial ability and land quality. Dasgupta (1989) also noted that, although the economic profitability is an important incentive, it is not always sufficient to induce farmers to adopt recommended farming practices. Social and cultural factors exert important influences on the adoption behavior of farmers.

A complete analytical framework for investigating adoption processes at the farm level should include farmer's decision making model determining the extent and intensity of use of the new technology at each point throughout the adoption process and a set of equations of motion describing the time pattern of parameters which affect the decision of the farmer (*Feder etal*., 1985). In support of the above statement Dasgupta (1989) noted that, the goal of diffusion research is to identify factors, which influence the adoption and diffusion of agricultural innovations.

The intensity of adoption of new technologies which are divisible (new seed varieties or new variable inputs) can be measured at the individual farm level in a given time period by the amount of share of farm area utilizing the technology or by the per hectare quantity of input used where applicable (*Feder etal.,* 1985). Nkonya *etal.* (1997) also defined the rate of adoption as the percentage of farmers who have adopted a given technology. The intensity of adoption is the level of adoption of a given technology. The amount of chemical fertilizer applied per hectare will be referred to as the intensity of adoption of fertilizer.

2.4. Empirical Literatures

Factors determining technology adoption and productivity differ from one sector to the other and from one region to the other in the same sector. Especially, dealing with agricultural technologies where the sector has its own peculiar characteristics like seasonality of production and its high dependence on the vagaries of natures makes it different from the other sectors. Moreover, there is a significant difference in terms of the characteristics of agriculture in developing and developed countries. In developing countries, the agricultural sector is characterized by its high dependence on natural phenomenon, highly constrained by shortage of resources and undertaken by less educated farmers.

As a result, the empirical literature part covered in this paper emphasizes only on adoption and productivity studies undertaken in developing countries agricultural sector. This part has two parts, the first deals with different adoption and productivity studies in developing countries and the second concentrates on adoption and productivity studies in Ethiopia.

2.4.1. Adoption studies in developing countries

Most of the adoption studies in developing countries are under taken in Asia and Latin American countries where the Green Revolution took place and was successful.

Different authors have emphasized on different factors as a significant determinants of adoption decision. Perrin and Weinkelman (1976) summarized adoption studies on wheat and maize in six countries, namely Kenya, Colombia, El-Salvador, Mexico, Tunisia, and Turkey and reported that the difference in adoption rates in these countries are explained by difference in information, agro-climatic and physical environments, availability of inputs, difference in market opportunities for the crops, and difference in farm size and farmers' risk aversion characteristics.

For the detail analysis of the factors determining the adoption of fertilizer, this part of the literature is classified in to household head's characteristics, farm characteristics, institutional and agro-climatic factors and the characteristics of the technology.

In relation with the household head's characteristics, the two most important variables considered in most literatures are education and age. Most of the adoption studies undertaken in developing countries, using the probit model show that education level of the household head has a positive and significant effect on the adoption decision of modern agricultural technologies (Jha *etal*, 1990; Strauss *etal*, 1991; Lin, 1991;Akinola and young, 1985) But other researchers like Shakya and Flinn (1985) and Pitt and Sumodiningrat (1991), using the same probit model found the impact of education on technology adoption to be non-significant. It could be argued that the role of education on technology adoption may not be an important factor in the case where there is effective extension service and the technologies are simple like fertilizer and HYVS. But in the absence of effective extensions service and complex technologies, education becomes an important factor in determining the farmer's decision.

Concerning age of the household head, different authors have reported opposing results using the same probit model. For Jha *etal*. (1990), Akinola (1987) and Akinola and Young (1985) reported negative relationship between technology adoption and the age of the household head. But Zegeye (1989) and Mahabub (1988) found a positive relationship between technology adoption and the household head's age.

They argued that older farmers have more experience and hence better knowledge of the use of the technologies than younger farmers. The effect of age as a determinant of adoption decision depends on experience and education level. Older farmers may have experience and resource that would allow them more possibilities for trying a new technology. On the other hand, younger farmers are more likely to adopt new technology because they have had more schooling than the older generation. Therefore, the effect of age on adoption depends on specific conditions in the population and area where the new technology is introduced. Hence, in developing countries where most of the farmers are uneducated, the role of experience should not be underestimated.

Coming to farm characteristics, the two most common variables considered are family size (which is mostly used as proxy to labor availability) and farm size.

The impact of family size on the technology adoption decision of a farmer mainly depends on the characteristics of the technology. If a technology is labor saving like tractors, harvesters, pesticides and the like its impact will be negative, while if a technology is labor intensive like fertilizer and HYVS, its impact will be positive. Shields *etal.* (1993) and Green and Ng'ong'ola (1993), found a positive association between family size and fertilizer adoption in Swaziland and Malawi respectively using the logit model. But Akinola (1987), using the probit model and Igodan *etal*.(1988), using the logit model found negative relationship between family size and technology adoption. Their argument is that in rural areas, subsistence pressure is more on large households and this pressure has a negative implication for technology adoption both in terms of ability to purchase the inputs and their attitude towards risk. Looking at farm size, Akinola (1987), David and Otsuka (1990), and Jha *etal*. (1990), found positive and significant effect on the adoption decision of the farmer using a probit model. But others like Low (1982), Mann (1989), and Alauddin and Tisdell(1988), using both OLS and logit have found a negative relationship. There are other like Ramasamy *etal*. (1992), using a probit model and Adesina and Zinnah (1993), using tobit model who found farm size to be non significant determinant of adoption decision. Further, the inverse relationship between farm size and productivity is reported by many researchers like Carter (1984), Rao and Chotigeat (1981) and Deolalikar (1981).Here, whether farm size affects the adoption decision depends on the characteristics of the new technology. If the technology is of divisible nature, it is scale neutral and hence small farmers can adopt it as large farmers do. But in the case of lumpy technologies, there is a high probability for large farmers to adopt than small farmers do. But for Feder and O'Mara (1981), even if divisible technologies are neutral to scale, the record of adoption and diffusion experiences throughout the world show that adoption rates and the time patterns of adoption are related to farm size. The argument for this is the differences in information acquisition costs, which is higher for small farmers than large farmers which may discourage adopting the technology. For Ruttan (1977), farm size plays a significant role at the early stage in the adoption process. It is true that large farmers adopt technology early because of the relative advantage they have, but as adoption progresses, their relative advantage will diminish and the small farmers will catch up. Hence at the latter stage of the adoption process, farm size will be a non-significant factor. In the institutional and agro-climatic factors, we have extension service, credit, off farm income, input and output prices and climatic and infrastructural factors.

To start with the impact of extension service on the adoption of modern agricultural technologies, many authors reported a positive and significant effect using the probit model (Igodan *etal.* 1988; Gerhart, 1975; Shakya and Flinn, 1985; Feder and Slade,1984).

Further, Binswanger and Braun (1991) stated that extension is the major instrument to speed up the adoption process. Lack of knowledge about correct crop fertilization and low level of the extension service are the most important determinants of fertilizer use in the context of developing countries (Anthieu and Verga, 1978). At the beginning, lack of knowledge is an obstacle to the adoption of modern technologies and hence the role of extension service is so crucial. But once farmers started technology adoption, knowledge disappears as a problem and same for the role of the extension service.

Hence extension service provided by effective and efficient institutions can contribute for the fast adoption process of a given technology, especially in developing countries where farmers are less educated.

In developing countries, where farmers have only limited capacity to finance investment in new technologies, the role of credit cannot be overestimated (*Feder etal*., 1985; Bhalla, 1979).Almost all the literatures reviewed found a positive and very strong relationship between availability of credit and the farmer's decision to adopt a new technology in developing countries (Akinola, 1987; Pitt and Sumodiningrat, 1991;Shakya and Flinn, 1985) using the probit model and (Green and Ng'ong'ola, 1993)using the logit model. Off farm income, which could increase the farmer's cash income for the purchase of modern inputs have also the same effect as credit. This is supported by the empirical works of Low (1986) and Parton (1993).

Taking the farmer as a profit maximizing firm, the price of inputs and outputs has a significant effect on the farmer's adoption decision. The theory suggests that lower input price and higher output prices encourage the farmer to adopt the technology. The study by Kimuyu et al. (1991), using OLS method and Shields et al. (1993), using the logit model has concluded as the theory do. But in most adoption studies, the ratio of the two prices is assumed to be constant. The same is true in this study since the data used are cross sectional where there is less room for price fluctuation.

The availability of infrastructures (like roads, transportation, irrigation and the likes) and good agro-climatic conditions (like rainfall, soil fertility, salinity, and the likes) have also a positive impact on the adoption of modern technologies, while drought has a negative impact on the adoption decision (Pitt and Sumodiningrat, 1991;Jansen *etal.,* 1990), using the probit and logit model respectively. Lastly, concerning the characteristics of technology, the farmer's preference, evaluation of the varietals characteristics and perception of specific traits like test, yield, cooking quality and the like strongly affect the farmer's decision to adopt the new technology (Smale *etal.*, 1995 and Adesina and Zinnah, 1993), using the tobit model and (Heisay *etal*., 1993), using the multinomial logit.

2.4.2. Adoption Studies in Ethiopia

Different studies regarding technology adoption in general and fertilizer in particular were conducted in Ethiopia by different researchers (e.g. Tesfai 1975 Bisrat 1980, Legesse 1992,Techane, 2002; , Peter and David, 2003; Shimelis, 2004; Stefan and Luc , 2005; John *etal.,* 2009.. etc). Most of the adoption studies in Ethiopia are not regional or countrywide, rather undertaken in specific areas, especially in the areas where the package and the extension approach are applied as a model. For the sake of convenience, in this part, the reviewed articles are presented chronologically.

A study by Tesfai (1975), using the probit model in Arsi zone reported that the probability of the adoption of improved varieties and fertilizer strongly increase with farm size and extension service. The availability of cash for down payment, membership in local association and literacy also increase the probability of adoption but less strong than the above two factors. He further reported that tenants are less likely to adopt improved varieties and fertilizer as compared to owner cultivators.

The study in Bako and Jimma area by Bisrat (1980), reported that the difference in the rate of adoption of fertilizer between regions is explained by profitability and risk associated with fertilizer use. He also reported that the effect of farm size on the rate of adoption was not significant.

Itana (1985) studied factors influencing agricultural technology adoption in Holen komi and Woliso areas of the central Ethiopia using the probit model and reported that literacy, farm size, price of farm inputs, adequacy of rainfalls, availability of cash for down payment, and extension center positively affect the adoption of new technologies. But family size had no effect on the adoption decision.

Yohannes *etal.* (1991), using the logit model in Tegulet and Bulga area of North Shewa zone found that the adoption of modern technologies are positively affected by farm size, family size, education, farm and off farm income, exposure to outside information and experience as represented by age. But debt and degree of risk aversion had a negative influence.

According to Legesse (1992) using the probit and tobit models, access to credit, expected yield, cash availability for down payment, participation in farm organization as a leader and close exposure to technology had positive impact on the probability of adopting HYVS, intensity of fertilizer and herbicides.

Mulugeta (1994) studied the relative importance of the variables influencing farmers' adoption decision in Arsi zone using the logit and tobit models and found that access to credit, herbicide use and timely availability of fertilizer were the most important determinants of fertilizer adoption. Farm size, family size, number of oxen owned, extension contact and application of herbicide had also significant effect on adoption and use of fertilizer. But age of the household head was negatively related to the adoption of fertilizer.

Similarly, Chilot *etal*. (1996) studied the adoption of wheat technologies in Welmera and Addis Alem areas using both the probit and logit models and found that profitability of the new wheat technology and timely availability of fertilizer and herbicide have significant effect on the farmers' adoption decision. They also found that distance of respondents from the extension center negatively affect the adoption decision. But farm size and experience of farmers doesn't have significant effect.

In Lume district of the central Ethiopia, Teressa (1997), using the logit model found that extension service, oxen, labor, access to credit and off farm income were the major variables contributing to fertilizer adoption and intensity of its use.

According to Lelissa (1998) the most important determinants of fertilizer use and intensity in Ejere district of west Shewa zone are agro-climatic conditions, land tenure systems, credit, extension service, oxen ownership, age of the farmer, family size, farmers level of education, manure, ratio of price of crops to fertilizer cost, distance to fertilizer distribution center and cropping pattern.

Legesse (1998) studied adoption and diffusion of agricultural technologies in East and West Shewa zones using probit and tobit models and found that location, ox ownership, distance to market, credit, gender and degree of risk aversion had significant impact on the adoption decision of the new technologies. But education and the index of awareness had no effect on the adoption decision. He also found that the impact of increase in output price on the probability of adopting modern technology is very high.

Beyene (2000), using the probit model, reported that in West Shewa and East Wallaga zone, the most significant determinants of farmers' technology adoption decision are distance from the road, family size, number of oxen, farm size, household head's education level, access to credit, access to extension service and availability of package. But, household head's age was found to be non significant determinant.

A study by Geremew (2000) using Cobb-Douglas production function model, in two districts of Sidama zone, namely Aroressa and Hula reported that in Aroressa, distance from all weather road and price of output are the most important determinant f productivity while in Hula, number of sloughing, farm size and wealth are major determinants of productivity.

Nigussie (2001) using the Cobb-Douglas production function model, reported that land under extension rarely resulted in better yield response than non extension in three villages of Ethiopia, namely, Sribana-Godeti, Eteya and Shashemene. But improved seed varieties, recommended rate of DAP and Urea, farm management practices and environmental factors had significant impact on productivity. This study further showed that most farmers didn't use improved seed varieties and the recommended rate of fertilizer which could enhance productivity.

Techane (2002) used Tobit model to analyze determinants of fertilizer adoption in the major cereal producing areas of Ethiopia. In his study, a total of sixteen explanatory variables were included in the model and concluded that probability of fertilizer adoption and intensity of its use appear to be significantly and positively influenced by education, extension service, area under improved seed, total livestock owned, access to input credit, number of active family labor, access to hired labor and gender difference (being a male), while the influence of illness of the household head, off-farm employment and ratio of steep slope land to total cultivated land were negatively significant. Age of the farm household and manure application were not significantly related to the dependent variable. Furthermore, his study showed that regional differentials also influence the probability of adoption and intensity of fertilizer use showing that households are operating under different natural conditions, different input supply system, and vary in their accessibility to infrastructure that would facilitate the adoption of fertilizers. Concerning age, other studies (Shimelis, 2004; Taha 2007and Jebessa, 2008) on the contrary found that the age of household had statistically negative and significant influence with the adoption of technology.

Mulat and Bekele (2003), using the Cobb-Douglas production function model studied the determinant of yield of major cereals in 18 sites of the four major regions in Ethiopia, namely Amhara, Tigray, Oromiya and Southern Nations and Nationalities Peoples (SNNP). They reported that, DAP and Urea alone are not solutions for the productivity problems in Ethiopian agriculture and the contribution of extension to yield is not significant, holding other factors constant. According to this study, farmers' education is one of the explanatory variables with consistently significant and positive coefficient in determining productivity. The rate of fertilizer application, quantity of labor used, use of herbicide and sex were found to be significant determinants of the productivity of teff and wheat but ownership of oxen were not significant. In the case of barely, fertilizer coefficient was not significant but contact with extension, literacy, farm size, seed rate and labor intensity positively affects the productivity.

Lastly, a study by Assefa and Gezahegn (2004) on the adoption of improved technologies in Ethiopia, using probit and logit models reported that age of the farmer and the distance of the farmer from the market center had a negative impact on the adoption decision of the farmer. On the other hand, household size, farm size and farmers contact with extension agent had strong and positive effect on the adoption of improved technologies in Ethiopia. They further reported that religion is also an important factor in the adoption decision. According to this study, both Muslim and Orthodox farmers are less likely to adopt new technologies as compared to farmers practicing other religions. But literacy, formal education, number of oxen owned and credit were found to be non significant determinants in the adoption decision of the farmer.

Oladele (2005) applied Tobit model to analyze factors that predispose farmers to discontinue the adoption of innovation among farmers in South Western Nigeria. The result of the study revealed that, variables which include attitude, extension visit, feedback provision, marketability and input availability are strongly significant in farmers' discontinuance behavior. Similarly, Motuma *etal*., (2009) used bivariate Probit model to investigate factors explaining discontinuous of hybrid maize seed adoption in central Western Ethiopia. The study showed that while adoption is influenced by extension, non-adoption is largely determined by the asset portfolio of farmers and by the structure of markets for credit, labor and by maize seeds. Moreover, Adegbenga and Taye (2009) have analyzed factors influencing consistency of technology adoption among farmers in Northern Nigeria using product moment correlation model for crop technology adoption. The study pointed out that variables like income, social status, education and other variables which create strata in the community are important in stimulating adoption of agricultural technologies across crops.

The study undertaken by John *etal.,* (2005) used econometric analysis to explore determinants of fertilizer adoption and use intensity. Econometric estimation results showed that age, education, credit, presence of cash crop, distance to fertilizer market and agro ecological potential were statistically significant in influencing the probability of adopting fertilizer. Furthermore, the study revealed the strongest determinants of fertilizer use intensity were gender, dependency ratio, credit, presence of cash crops, distance to market, extension service and agro ecological potential.

Almaz (2008) applied Tobit model to identify factors influencing adoption and intensity of adoption of chickpea technology package. Her study revealed that sex of household head, land holding, social participation, contact with extension agent, attitude towards chickpea technology package, innovation proneness, and knowledge level of household head were found to have positive and significant influence on adoption and intensity of adoption of improved chickpea production package.

Daniel (2008) conducted the study to assess adoption and intensity of use of *tef* technology package and revealed that household's annual income, access to market and extension services as well as perception of improved *tef* varieties were important variables influencing adoption and intensity of use of *tef* technology package.

The study conducted in Mozabique by Uaiene *etal*., (2009) applied Probit and Logit model to identify determinants of agricultural technology adoption. Several dependent variables such as whether or not the farm household used improved seed, fertilizer, pesticide, animal traction or mechanization and explanatory variables like gender of farm household, age of household, level of formal education of farm household, distance to center, access to credit, membership to agricultural association, land accessibility and whether the household grows cotton and/or tobacco were analyzed. The results of this study have shown that households with access to credit and extension delivery services as well as members of agricultural associations, and households with higher level of education are more likely to adopt new agricultural technologies. In summary, different studies conducted by different researchers using different analytical tools were reviewed to see the influence of different demographic, psychological, socio-economic and institutional variables on farmers adoption and non-adoption of technologies (fertilizer by large) in different countries (including Ethiopia). Such review is very important to suggest hypotheses that can be tested empirically. Changes are taking place on the determinants of technology adoption over time. Hence, conducting such studies in different localities at different times is very helpful to capture the effects of the changing situations on the adoption decision by farmers.

CHAPTER III

RESEARCH DESIGN AND METHODOLOGY

3.1. RESEARCH DESIGN

To achieve the stated objectives, the data is obtained from Ethiopian central statics agency (CSA), collected in 2014/2015. The list containing EAs of Amhara region and their respective households obtained from the 1999 E.C Population and Housing census frame was used as the sampling frame in order to select the primary sampling units (EAs). Consequently, all sample EAs were selected from this frame based on the design proposed for the survey. The second stage sampling units, households, were selected from a fresh list of households that were prepared for each EA at the beginning of the survey.

In order to select the sample a stratified two-stage cluster sample design was implemented. Enumeration areas (EAs) were taken to be the primary sampling units (PSUs) and the secondary sampling units (SSUs) were agricultural households. The sample size for the 2014/15 agricultural sample survey was determined by taking into account of both the required level of precision for the most important estimates within each domain and the amount of resources allocated to the survey. In order to reduce non-sampling errors, manageability of the survey in terms of quality and operational control was also considered.

Even if the data is available for the four regions; Tigrai, Amhara, Oromia and SNNP, this paper considers only the case of Amhara. This region is selected for two major reasons; first the region well known for being one of the major cereal producer of the country and second, this region highly affected by soil degradation because of overproduction which results in high food insecurity. Because of these two basic reasons, the need for applying modern agricultural inputs in the region must be a priority over other areas.

3.2. Methodology

3.2.1 Location and physical features

The Amhara regional state made up of 11 administrative namely Wag Himra, North Wollo, North Gondar and South Gondar, South Wollo, North Shewa, Oromia, East Gojjam, West Gojjam, Awi and Bahir Dar. These administrative are divided into a total of 113 woredas and 3,216 kebeles. The regional State shares common borders with the state of Tigray in the north, Afar in the east, Oromiya in the south, Benishngul/Gumuze in the south west, and the Republic of Sudan in the west. Finally, the State of Amhara covers an estimated area of 161,828.4 Sq.km. This land consists of three major geographical zones.

The altitude ranges from a low of 500metres to a high of 4,620 meters found at the peak of Ras Dashen. This is Ethiopia's highest point and Africa's fourth highest mountain. There are highlands (above 2,300 meters above sea level), semi-highlands (1,500 to 2,300 meters above sea level) and lowlands (below 1,500metres above sea level) accounting 20 percent, 44 percent, and 28 percent respectively

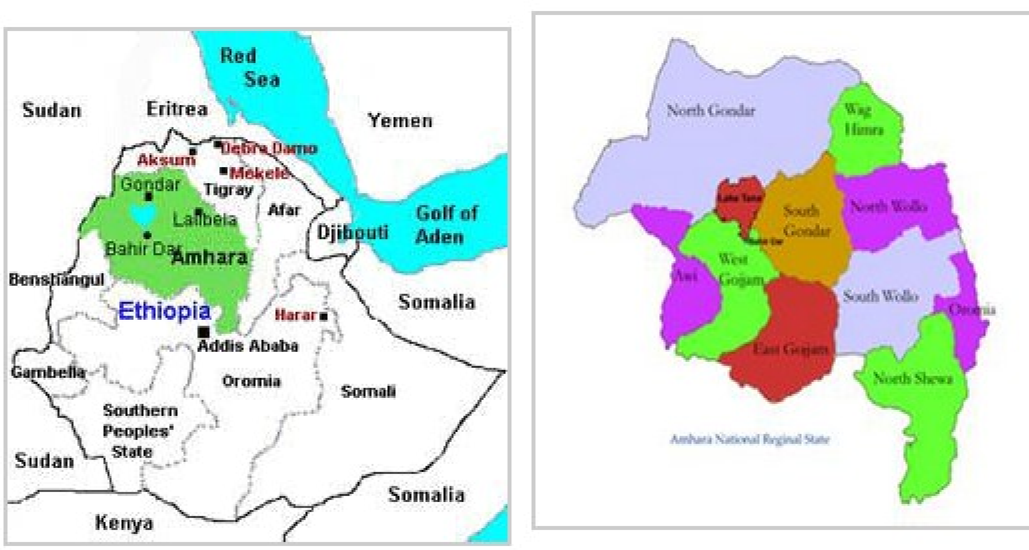

Fig-2 map for Amhara region.

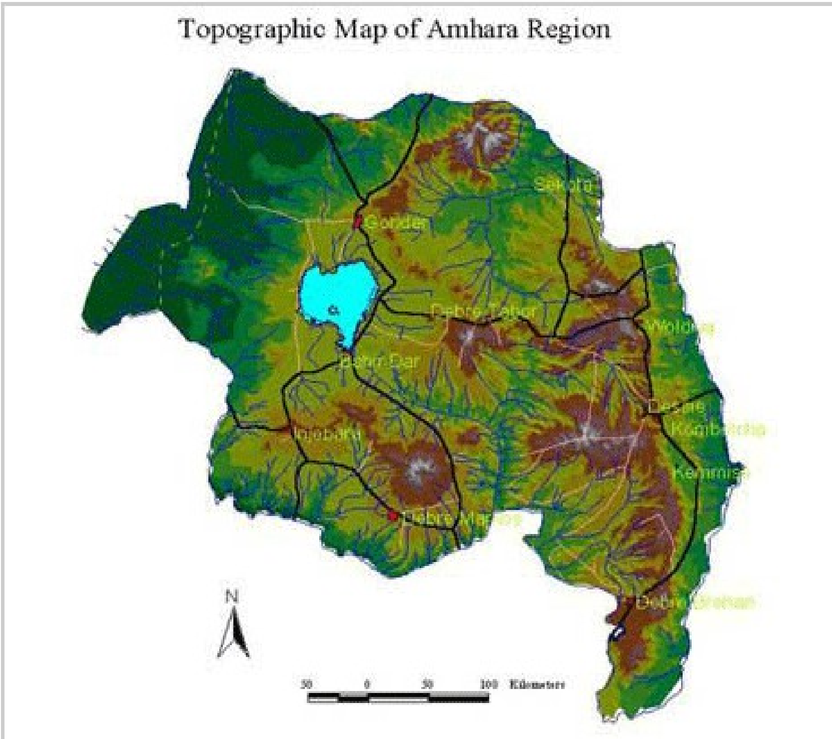

Fig-3 Topographic map for Amhara region.

The CSA's total population estimate for the Amhara region for mid-2008 is 20,136,000 with a fifty-fifty split between the sexes. Of these 2,408,000 (only 12%) are urban residents. The percentage of the urban population is below the national average. A wereda level analysis for the 105 Weredas in the Amhara region shows an uneven population distribution with Weredas, although it is more densely populated than other states in Ethiopia.

The USAID estimated a population growth rate of 3% per year and a doubling time of 25 years. This is also true nationally. This rapid population growth rate has led to severe land shortages and rapid natural resource degradation.

3.3. Methods of Data Analysis

Farmers' adoption behavior, especially in low income countries, is influenced by a complex set of socio-economic, demographic, technical, institutional and biophysical factors (Feder *etal.*, 1985). Modeling farmers' response to agricultural innovations has, therefore, become important both theoretically and empirically.

Several models are available to analyze factors affecting technology adoption. The choice of one may depend upon several factors. Some of these alternative models are briefly discussed below.

i. Discrete Regression Models

Discrete regression models are models in which the dependent variable assumes discrete values. The simplest of these models is that in which the dependent valuable Y is binary (it can assume only two values denoted by 0 and 1) (Amemiya, 1985; Gujarati, 1988 and Maddala, 1997). According to Amemiya (1985); Gujarati (1988) and Maddala (1997), the three most commonly used approaches to estimating such models are the Linear Probability Model (LPM), the Logit model and the Probit model. The Linear Probability Model is the model, which expresses the dichotomous dependent variable (Y) as a linear function of the explanatory variable (X). Because of its computational simplicity, LPM has been used in econometric applications especially during and before the 1960s. However, as indicated by Maddala (1997), Amemiya (1985) and Gujarati(1988) the linear probability model has an obvious defect in that the estimated probability values can lie outside the normal 0-1 range. The fundamental problem with the LPM is that it is not logically a very attractive model because it assumes that the marginal or incremental effect of explanatory variables remain constant, that is $Pi = E(y=1/X)$ increases linearly with X (Maddala, 1997 and Gujarati, 1988).

The defects of the linear probability model suggest that there is a need to have an appropriate model in which the relationship between the probability that an event will occur and the explanatory variables is non-linear (Gujarati, 1988; Maddala, 1997). The authors suggested that the sigmoid or S-shaped curve which very much resembles the Cumulative Distribution Function (CDF) of random variable is used to model regressions where the response variable is dichotomous, taking 0-1 values. The Cumulative Distributions Functions (CDFs) which are commonly chosen to represent the 0-1 response models are the Logit (logistic CDF) model and the Probit (normal CDF) Model.

Logit and Probit models are the convenient functional forms for models with binary endogenous variables (Johnston and Dinardo, 1997). These two models are commonly used in studies involving qualitative choices. To explain the behavior of dichotomous dependent variable we will have to use a suitably chosen Cumulative Distribution Function (CDF). The Logit model uses the cumulative logistic function. But this is not the only CDF that one can use. In some applications the normal CDF has been found useful. The estimating model that emerges from normal CDF is popularly known as the Probit model (Gujarati, 1995). The logistic and Probit formulations are quite comparable, the chief difference being that the logistic has slightly flatter tails that is the normal curve approaches the axes more quickly than the logistic curve. Therefore, the choice between the two is one of mathematical convenience and ready availability of computer programs (Gujarati, 1988).

ii. The Tobit Model

Adoption studies based up dichotomous regression models have attempted to explain only the probability of adoption versus non-adoption rather than the extent and intensity of adoption. Knowledge that a farmer is using high yielding variety may not provide much information about farmer behavior because he/she may be using 1 percent or 100 percent of his/her farm for the new technology. Similarly, with respect to adoption of fertilizers, a farmer may be using a small amount or a large amount per hectare area. A strictly dichotomous variable often is not sufficient for examining the extent and intensity of adoption for some problems such as fertilizers (Feder *etal*., 1985).

There is also a broad class of models that have both discrete and continuous parts. One important model in this category is the Tobit. Tobit is an extension of the Probit model and it is really one approach to dealing with the problem of censored data (Johnston and Dinardo, 1997). Some authors call such models limited dependent variable models, because of the restriction put on the values taken by the regressand (Gujarati, 1995).

Examining the empirical studies in the literature, many researchers have employed the Tobit model to identify factors influencing the adoption and intensity of technology use. For example, Nkonya et al. (1997), Lelissa (1998), Bezabih (2000), Croppenstedt *etal.* (1999) used the Tobit model to estimate the probability and the intensity of fertilizer use. According to Adesina and Zinnah (1993), as cited by Shiyani *etal*. (2000), the advantage of the Tobit model is that, it does not only measure the probability of adoption of technology but also takes care of the intensity of its adoption.

3.4 Specification of the Tobit Model

The econometric model applied for analyzing factors influencing adoption and intensity of fertilizer use is the Tobit model shown in equation (1). This model was chosen because, it has an advantage over other adoption models (LPM, Logistic, and Probit) in that, it reveals both the probability of adoption of fertilizer and intensity of its use.

Following Maddala (1992), Amemiya (1985) and Johnston and Dinardo (1997), the Tobit model can be defined as:

$$Y_i^* = \beta X_i + u_i \qquad i = 1,2,\ldots\ldots n$$

$$Y_i = Y_i^* \text{ if } Y_i^* > 0 \qquad (1)$$

$= \ 0$ if $Y_i^* \leq 0$

Where,

Y_i = the observed dependent variable, in our case amount of fertilizer applied

per hectare.

Y_i^* = the latent variable which is not observable.

X_i = vector of factors affecting adoption and

Intensity of fertilizer use

β_i = vector of unknown parameters

u_i = residuals that are independently and normally distributed with mean

zero and a common variance σ^2.

Note that the threshold value in the above model is zero. This is not a very restrictive assumption, because the threshold value can be set to zero or assumed to be any known or unknown value (Amemiya, 1985). The Tobit model shown above is also called a censored regression model because it is possible to view the problem as one where observations of Y^* at or below zero are censored (Johnston and Dinardo, 1997).

The model parameters are estimated by maximizing the Tobit likelihood function of the following form (Maddala, 1997 and Amemiya, 1985).

$$L = \prod_{yi^*>0} \frac{1}{\sigma} f\left(\frac{Y_i - \beta_i X_i}{\sigma}\right) \prod_{Yi^* \leq 0} F\left(\frac{-\beta_i X_i}{\sigma}\right) \qquad (2)$$

Where f and F are respectively, the density function and cumulative distribution function of Y_i^*.

$\prod_{Y_i^* \leq 0}$ means the product over those i for which $Y_i^* \leq 0$, and $\prod_{Y_i^* > 0}$ means the product over those i for which $Y_i^*>0$.

An econometric software known as "Limdep" was employed to run the Tobit model. It may not be sensible to interpret the coefficients of a Tobit in the same way as one interprets coefficients in an uncensored linear model (Johnston and Dinardo, 1997). Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of changes in the exogenous variables.

As cited in Maddala (1997), Johnston and Dinardo (1997) and Nkonya *etal*., (1997), McDonald and Moffit proposed the following techniques to decompose the effects of explanatory variables into adoption and intensity effects. Thus, a change in X_i(explanatory variables) has two effects. It affects the conditional mean of Y_i^* in the positive part of the distribution, and it affects the probability that the observation will fall in that part of the distribution. Similar approach is used in this study.

1. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(Y_i)}{\partial X_i} = F(z)\beta i \qquad (3)$$

Where, $\frac{\beta_i X_i}{\sigma}$ is denoted by z, following Maddala, (1997)

2. The Change in the probability of adopting a technology as independent variable X_i changes is:

$$\frac{\partial F(Z)}{\partial X_i} = f(z)\frac{\beta_i}{\sigma} \qquad (4)$$

3. The change in intensity of adoption with respect to a change in an explanatory variable among adopters is:

$$\frac{\partial E(Y_i / Y_i^* > 0)}{\partial X_i} = \beta_i \left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right] \qquad (5)$$

Where, F(z) is the cumulative normal distribution of Z, $f(z)$ is the value of the derivative of the normal curve at a given point (i.e., unit normal density), Z is the z-score for the area under normal curve, β is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

Using descriptive statistics it is also possible to clearly compare and contrast different characteristics of the sample households along with the econometric model. Hence, descriptive statistics such as mean, percentage and standard deviation were computed to analyze the collected data. T-test and χ^2-test were also employed.

Hypothesis and Definition of Variables

In the course of identifying factors influencing farmer's decision to use fertilizer, the main task is to analyze which factor influence how and by how much. Therefore, in the following section potential variables that are supposed to influence adoption and intensity of fertilizer use will be explained.

The Dependent Variable of the Model (FERTRAT)

The dependent variable of the Tobit model has continuous value. As observed in different empirical studies this variable can be expressed in terms of ratio, actual figure and log form depending on the purpose of the study. For example, in their study of factors influencing adoption of fertilizer, Nkonya *etal*. (1997) considered fertilizer applied per hectare as the dependent variable of the Tobit model. Likewise, Shiyani *etal*. (2000) considered the proportion of area under chickpea varieties in their study of adoption of improved chickpea varieties. Consequently, in the present study actual fertilizer applied per hectare (only fertilized area considered) was taken as the dependent variable of the Tobit model.

The Independent Variables

Farmers' decision to use fertilizer and the intensity of its use in a given period of time is hypothesized to be influenced by a combined effect of various factors such as household characteristics, socio-economic and physical environments in which farmers operate. Based on the brief literature review in this study and availability of secondary data in CSA, a total of 8 variables were hypothesized to explain fertilizer adoption and the intensity of its use by the sample households. Brief explanation of the selected explanatory variables is presented below:

Age of the household head (AGE): Older farmers may accumulate more wealth than younger ones so as to finance fertilizer purchase. Moreover, this variable can be considered as a proxy for experience in using fertilizer. Farmers who have experience use higher rate of fertilizer. Therefore, this variable was hypothesized to positively influence fertilizer adoption and the intensity of its use.

Sex of the household head (SEXDM): This is a dummy variable which takes a value 1 if the household head is male and 0 otherwise. Evidence in the literature indicates that female-headed households have less access to improved technologies, credit, land and extension service (Green et al. 1993; Ellis (1992). Therefore, it is expected that male-headed households have more access to fertilizer use.

Education of the household head (EDUCDM): This is a dummy variable, which takes a value 1 if the household head is literate (can read and write) and 0 otherwise. Some empirical studies have demonstrated that literacy is the important factor influencing farmer's adoption decision and intensity of fertilizer use (Nkonya *etal*.,1997, Croppenstedt and Mulat, 1996). Farmers with ability to read and write are expected to have an advantage in obtaining information and understand the benefit of fertilizer use. Therefore, education was hypothesized to positively influence adoption decision and intensity of fertilizer use.

Access to Extension Service (EXTDM): This is a dummy variable, which takes a value 1 if the household received extension service and 0 otherwise. The variable representing extension service as a source of information has influence on farm households' fertilizer adoption decision (Bezabih, 2000; Nkonya *etal.,* 1997). Therefore, it was hypothesized that this variable positively influences adoption and intensity of fertilizer use.

Access to input credit (CREDITDM): This is a dummy variable, which takes a value 1 if the farm household has access to input credit and 0 otherwise. Several studies have shown that access to credit plays a significant role in enhancing the use of chemical fertilizer (Bezabih, 2000; Ngongola *etal.* 1993; Lelissa, 1998; Croppenstedt *etal.,* 1999; Reardon *etal.,* 1999 and Teressa, 1997). In the present study, it was hypothesized that access to input credit would have positive influence on adoption and intensity of fertilizer use.

Household SIZE (HH size): It is indirectly represents family labor available for agricultural activities. It is expected to have a positive effect on the farmers' fertilizer adoption decision (Shields *etal*., 1993; Green and Ng'ong'ola, 1993; Mulugeta, 1994 and Yohannes *etal*., 1991). Moreover, labor availability is a variable which affects farmers' decisions regarding adoption of new agricultural practices or inputs (*Feder etal*., 1985). New technologies such as fertilizer increase the seasonal demand of labour so that adoption is more attractive to households with a large number of active labourforce. In addition, much of the farm work in Ethiopia is done by family members (Croppenstedt *etal.,* 1999). Therefore, it was expected that this variable would have a positive impact on adoption and intensity of fertilizer use.

Number of pair of oxen (No_ox): it is the total number of oxen the household had. Since ox is the major means of production in the country, it is expected to have a positive effect on adoption (Mulugeta, 1994; Teressa, 1997; Lelissa 1998; Legesse, 1998 and Beyene, 2000).

CHAPTER IV

RESULTS AND DISCUSSION

4.1. Descriptive Analysis

Improved technology such as improved seed and breed, fertilizers and herbicides have played a significant role in enabling farmers to increase the production and hence improved the standard of living of smallholder farmers. The process of adoption of improved agricultural technologies is the interest of many agricultural economists.

In order to understand the socio-economic and institutional characteristics of the adopters and non adopters, the descriptive analysis is summarized and discussed under household characteristics, and other basic characteristics. The statistical test for comparisons between the groups is undertaken using the usual t-test and chi square test.

4.1.1 Household Characteristics

Table 1: Distribution of sample households by fertilizer adoption

Adoption	Total obs.	Adopter	Non Adopter
Number	8609	4,114	4,495
Percentage	100	47.79	52.21

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

As shown in Table 1, of the total interviewed households, 4114 (47.8%) households were adopters of inorganic fertilizers (DAP or Urea) while 4495 (52.2%) households were non-adopters.

Table 2: Distribution of sample households by Age

Age	Total obs.	Adopter	Non Adopter	t-test
Number	8609	4495	4114	0.4418
Mean	44.74527	44.607	44.87	
Std. Dev.	15.93286	14.80036	16.90366	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

As indicated in table 2, the average age of the sample respondents is about 44.74 years. The average age of adopters was about 44.6 years, while that of non-adopters was 44.8 years with no statistical mean difference significant at 10% level (Table 1).

Table 3: Distribution of sample households by Household size

Age	Total obs.	Adopter	Non Adopter	t-test
Number	8609	4114	4495	0.000
Mean	4.643977	4.911279	4.399333	
Std. Dev.	2.018783	1.900684	2.091594	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

The average family size of the sample households was 4.64, with significant difference between adopters and non-adopters (Table 3). While the average family size of the adopters was 4.9, that of the non-adopter was 4.40. This implies that large families could provide relatively more of labor forces required for fertilizer application and farm operations associated with its use (such as weeding and land preparation, etc.).

Table 4: Distribution of sample households by Numbers of Oxen

Age	Total obs.	Adopter	Non Adopter	t-test
Number	7793	3930	3863	0.000
Mean	1.186321	1.396183	0.9728191	
Std. Dev.	1.017522	1.013543	0.9764373	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

As it is indicated in Table 4, on the average, adopters have more number of oxen (1.4) than non-adopters (1.0), with mean difference significant at 1% level. The number of oxen that the farmer has is usually an indicator of wealth in the rural area. Thus the above result may indicate that the adopter have more farm land than the non-adopters.

Table 5: Distribution of Sample respondents by household head sex

sex	Adopter	Non adopter	Total	X^2- test
Male	3,608 (87.70%)	3,395 (75.52%)	7,003 (81.34%)	0.000
Female	506 (12.30%)	1,100 (24.48%)	1,606 (18.65%)	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

As it is confirmed in table 5, the sample was composed of both male and female headed households. Of the total sample household heads 81% were males and 19% were females. Of non adopter household heads 24% were female while from adopters only 12% were females with percentage difference significant at 1%. This implies that situations to use fertilizer are not conducive for females compared to males.

Table 6: Distribution of Sample respondents by Type of holding

Type of holding	Adopter	Non adopter	Total	X^2- test
Crop only	315 (7.65%)	624 (13.88%)	939 (10.91%)	0.000
Livestock only	2 (0.004%)	445 (9.90 %)	447 (5.19%)	
Crop and livestock	3,797 (92.29%)	3,426 (76.22%)	7223 (83.90%)	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

Farmers were also asked regarding the type of agricultural activities they are involved in (crop, livestock or both). Out of the total sampled households, the majority of them (84%) reported that they involved in mixed farming (I,e both crop and livestock). More proportion of adopters (92%) than non-adopters (76%) involved in mixed farming, with percentage difference significant at 1%. However, the non-adopters were more involved in single farming activities, crop only and livestock only than the adopters. About 21% of the sampled household reported that they left land fallow. There is no significant difference between adopters and non-adapters with regard to land left fallow (Table 6).

Table 7: Distribution of Sample respondents by Educational background

Variable(education)	Adopter	Non adopter	Total	X^2- test
Illiterate	3,208 (71.38%)	2,416 (58.73%)	5,624 (65.33%)	
Informal education	555 (12.35%)	824 (20.03%)	1,379 (16.02%)	
Elementary school completed	631 (14.05%)	787 (18.97%)	1418 (16.47%)	**0.000**
High school completed	86 (2%)	81 (2%)	167 (16.47%)	
Above grade twelve	14 (0.31%)	6 (0.15%)	20 (0.23%)	
Total	4494 (100%)	4114 (100%)	8608 (100%)	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

Concerning the educational status of the sample household heads, about 65% of the interviewed households were illiterate and 16% of have informal education (can read and write) and the rest 19% at least complete elementary school level. 71% of the adopters and 57% of the non-adopter were illiterate, while only 12% of adopters and 20% of non adopters can read and write with percentage difference significant at 1%. This implies that there is a strong positive relationship between education and fertilizer adoption (Table 7).

4.1.2 Institutional Services

The major institutional services discussed under this section are extension service, and accessibility to input credit from formal sources. It is widely accepted that substantial productivity increases could be achieved when farmers get appropriate extension services. The survey result has shown that the number of farmers visited by the Development Agents (DA) was very high. During the study year, about 81% of the total sample households had got various agricultural extension services. Among adopters about 54% were received an extension services, while 46% of non adopters were received an extension services, with percentage difference significant at 1% (Table 8).

Table 8: Distribution of the Sample Household by Access to Extension Service

Access to Extension	**Adopter**	**Non adopter**	**Total**	**X^2- test**
Yes	3,785 (54.27%)	3,189 (45.73%)	6974 (81.01%)	0.000
No	329 (20.12%)	1306 (79.88%)	1635 (18.99%)	
Total	4,114 (100%)	4495 (100%)	8,609 (100%)	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10%

Credit is very important to resource poor farmers who cannot finance agricultural input purchase from their own savings especially at the early stage of adoption. However, as long as farmers properly used fertilizer, it is expected that they can get better yield and hence better income to finance their fertilizer requirement by their own. Although documents indicate that about 80% of fertilizer sales in the country are on credit basis, only few farmers in the study sites have reported to have access to input credit from formal sources. The survey result has shown that only 29% of the total sample farmers obtained input credit from formal sources. Among adopters 70% obtained input credit from formal sources while only about 29% of non-adopters obtained credit, with percentage difference significant at 1% (Table 9).

Table 9: Distribution of the Sample Household by Access to Formal Credit Services

Access to Credit	**Adopter**	**Non adopter**	**Total**	**X^2- test**
Yes	1,743 (70.51%)	729 (29.49%)	2,472 (28.71%)	0.000
No	2,371 (38.63%)	3766 (61.37%)	6,137 (71.29%)	
Total	4,114 (100%)	4495 (100%)	8,609 (100%)	

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10 respectively

4.2 Results of the Econometric Model

4.2.1. Multi-collinearity and Heteroscedasticity Tests

Prior to running the Tobit model, the hypothesized explanatory variables were checked for the existence of multi-collinearity and heteroscedasticity. Very often data we use in regression analysis cannot give decisive answers to the questions we pose. This is because the standard errors are very high or the t-ratios are very low. This sort of situation occurs when the explanatory variables display little variation and/or high inter-correlations. The situation where the explanatory variables are highly intercorrelated is referred to as multicollinearity (Maddala, 1992).

Before running the model all the hypothesized explanatory variables were checked for the existence of multi-collinearity problem. There are two measures that are often suggested to test the existence of mulit-collineality. These are: Variance Inflation Factor (VIF) for association among the continuous explanatory variables and contingency coefficients for dummy variables.

According to Maddala (1992), VIF can be defined as: VIF(xi) = $\frac{1}{1 - R_i^2}$

Where R_i^2 is the squared multiple correlation coefficient between Xi and the other explanatory variables. A statistical package known as SPSS was employed to compute the VIF values. Once VIF values were obtained the R2 values can be computed using the formula. The VIF values displayed in Table 10 have shown that all the explanatory variables have no serious multi-collineartity problem.

Table 10: Variance Inflation Factor for Explanatory Variables

Variables	Variance Inflation Factor(VIF)
Age	1.12
Hhsex	1.24
Educ	1.11
Hh size	1.24
Htype	1.13
Credit	1.04
Exten	1.07
Oxen	1.22

Source: Computed from the CSA survey data

One of the assumptions in regression analysis is that the errors ui have a common variance σ^2. If the errors do not have a constant variance we say they are heteroscedastic (Maddala, 1992). In the general linear model, OLS estimates are consistent but not efficient when the disturbances are heteroscedastic. In the case of the limited dependent variable models (such as Tobit), the estimate of the corresponding regression coefficient is upward biased in the presence of heteroscedasticity. But nothing can be said about the other coefficients and the direction of the bias. It is more practicable to make some reasonable assumptions about the nature of heteroscedasticity and estimate the model than just to say that Maximum Likelihood estimates are inconsistent if heteroscedasticity is ignored (Maddala, 1997).

In this study heteroscedasticity was tested for some suspected variables by running, heteroscedatic Tobit in STATA 13 using Brush-Pagan test. It is found that there is no heteroscedasticity problem (Annex II).

4.2.2 Determinants of Adoption and Intensity of Fertilizer use

Estimates of the parameters of the variables expected to determine the adoption and intensity of fertilizer use are displayed on Table 11. A total of 8 explanatory variables were considered in the econometric model out of which seven variables were found to significantly influence the adoption probability and intensity of fertilizer use among farm households.

The results have shown that the age of farm households (Age) was negatively influencing adoption and intensity of fertilizer use (significant at 10% level). The negative sign indicates that older households were less likely to adopt chemical fertilizers. A one year increase in a household age decreases the probability of adoption by 12.9%. This result is in conformity with earlier studies by Shimelis, 2004; Taha 2007and Jebessa, 2008.

The results have shown that gender differentials among the farm households (sex) were not statistically influencing adoption and intensity of fertilizer use. This result is not in conformity with the priori hypothesis. The possible explanation is that there may not be gender discrimination.

As expected, Education (educ) was positively influencing the probability of adoption and intensity of fertilizer use (significant at 1% level). Education (the change in status of household head from illiterate to literate) increases the probability of fertilizer adoption by 2.92%. This suggests that ability to read and write would improve access to information so that farmer can easily understand the benefit of fertilizer use. This result supports the findings of earlier researches on technology adoption (e.g. Mulat and Bekele (2003), Adegbenga and Taye (2009), and Lelissa, 1998).

Household family size (Hh size) was also positively related with adoption and intensity of fertilizer use (significant at 1% level). Each additional unit of active family size increases the probability of fertilizer adoption by 2.06%. This suggests that adoption of chemical fertilizers is more attractive to households with large number of active labour force. The result was in conformity with the earlier studies (Lelissa, 1998 and Assefa and Gezahegn, 2004).

Of interest is the finding that household farming activity (Hhtype) has positive relationship with adoption and intensity of fertilizer use (significant at 1% level). Changing the involvement from single activity like only cropping to mixed farming (both crop & livestock) increases the probability of fertilizer adoption by 6.07%.

Access to input credit (Credit) positively influenced fertilizer adoption and intensity of its use (significant at 1% level). Access to credit increases the probability of fertilizer adoption by 48.6%. This suggests that credit plays a very important role in determining access to fertilizers. Availability of credit minimizes liquidity constraint and there by enhances adoption of fertilizer and rate of its application. Similar results were reported by John *etal.,* (2005), Techane (2002), Bezabih (2000), Teressa (1997), and Lelissa (1998).

Access to extension service (Exten) also positively influenced adoption of chemical fertilizer and its intensity (significant at 1% level). Access to extension services increases the probability of adoption by 53.9%. Extension service as a source of information regarding the benefit of fertilizer use, its application rate, etc., has a strong influence on the farmer's adoption decision and intensification. Similar results were reported by Oladele (2005), Assefa and Gezahegn (2004), Techane (2002), Bezabih (2000), and Lelissa (1998).

Oxen ownership is another factor, which was positively related to the dependent variable (significant at 1% level). Each additional unit of oxen increases the probability of fertilizer adoption by 26.8%. The implication is that oxen are important sources of cash income in rural area, which can be used for purchasing of fertilizer. In addition, farmers who owned a large number of livestock like oxen have the capacity to bear risks of using chemical fertilizers. oxen ownership suggests that, farmers who have larger number of livestock have large number of oxen to plough their field timely and are encouraged to use more fertilizer. Similar result was reported by Techane (2002), Bezabih (2000).

Table 11: Estimated Result of Tobit model

Explanatory Variables	**Estimated Coefficients**	**Standard Error**	**t**	**p>(t)**	**Change in probability** $\frac{\partial F(z)}{\partial X_i} = f(z)\frac{\beta_i}{\sigma}$
Age	-.2731193	.1605766	-1.70	0.089*	-.1289387
Hhsex	.7268079	7.222375	0.10	0.920	.3431235
Educ	6.196759	.9323666	6.65	0.000***	2.925469
Hh size	4.365424	1.277778	3.42	0.001***	2.060902
Htype	12.8699	4.227346	3.04	0.002***	6.075834
Credit	103.069	4.874278	-12.15	0.000***	48.6585
Exten	114.1456	7.292577	-15.65	0.000***	53.88773
Oxen	56.76175	2.425623	23.40	0.000***	26.79703
-cons	167.8591	20.68665	8.11	0.000***	
Sigma	**176.7182**	**2.138472**			

LR chi2(8) = 1781.94, Prob > chi2 = 0.0000 Pseudo R2= 0.0307,

Log likelihood = -28139.939

Source: Computed from the CSA survey data

***, ** and * Represents level of significance at 1%, 5% and 10 respectively

To identify those factors which contribute significantly for the adoption of modern agricultural inputs in Amhara region, a Tobit model with a number of observation 7792 household heads were applied. The model is found to be strongly statistically significant (at $P<0.01$).

Further, the model has correctly classified more than 80 percent of the farmers. The results obtained from the model are presented in tables. Being male house head have a positive and strongly significant (at $p<0.01$). Male headed families a better adopter than those of female headed family. This could due to the allocation of resources in the community is biased towards males.

As can be shown from the table, among many variables that contributes to the farmers decisions of modern input adoption, the type of farm holding the household affect the decision positively and significantly (at $P<0.01$). The marginal effect shows that, an additional asset that the families get increase the probability of being an adopter by 12 percent.

The other positive and strongly significant (at $P<0.01$) factor in the input adoption decision of the farmer is an education. Those farmers who are attend primary or secondary education found to a better adopter than those who didn't attend education in any level. As expected the increasing the family size have a positive and strongly significant (at $P<0.01$). This also due to the exhaustive effort made by these kind of families in order to use the limited plot of land effectively. Whereas, access to credit and advisory service have a negative relation with the adoption but statically significant.

In Amhara region, the number of oxen owned by the household is found to have a significant and positive at less than 1% level of significance effect on the adoption decision of the farmers. Having an additional ox will increase the probability of being adopted by 56 percent. This is mainly because; ox is the major means of production in the agricultural sector of the area. Hence, having more oxen may mean being able to plough the land at the appropriate time than waiting for hired oxen. As a result, farmers having more oxen can plough their land at the right time and extract higher yield which could be an incentive and source of income for adopting the modern inputs.

The model result indicates that as the age increases by one year, the intensity of fertilizer use of farm households increases by 0.2%. However, this may diminish, as the household head gets older. Being male, have an access to credit and advisory service are inversely related to the intensity of use of fertilizer at less than 1% level of significance. Having an access to education also increase the intensity to use of fertilizer by 5%.

CHAPTER FIVE

CONCLUSIONS & RECOMMENDATIONS

5.1. Conclusions

The need for applying modern agricultural inputs in Ethiopian agriculture is not debatable. The agricultural sector of the country is well known for its being traditional and use of backward technologies. Hence the application of modern inputs and practices, as evidenced from the Green Revolution applied in Asia and Latin America, can contribute a lot for productivity enhancement of the sector. The fate of the sector in terms of increasing its contribution to the overall growth of the economy and securing food self sufficiency depends on the development and application of appropriate technologies.

In this study factors influencing the adoption and intensity of fertilizer use among small holder farm households were analyzed in Amhara Regional State of Ethiopia. The study was based on the data obtained from CSA 2007E.C agricultural Survey. A total of 8,609 households were considered for this study of which 7792 cases were included in the econometric model. In addition, secondary data obtained from relevant institutions were used.

Analysis of the extent of fertilizer adoption by the sample households has shown that 48% of the sample households were adopters.

Econometric software called "STATA 13" was employed to estimate the Tobit model to identify factors influencing the adoption of fertilizer and intensity of its use. The Tobit model was chosen since it has advantage over other adoption models in revealing both the probability of adoption and the intensity of fertilizer use.

Probability of fertilizer adoption and intensity of its use appear to be significantly and positively influenced by Age, education, Household size, extension service, oxen owned, access to input credit, and household farming activity (being a mixed farming. Sex of the farm household was not significantly related to fertilizer adoption and intensity of its use.

5.2. Recommendations

On the basis of the results of this study, the following policy implications are suggested so as to be considered in the future intervention strategies which are aimed at the promotion of production increasing technologies such as chemical fertilizers. These may be broadly viewed as strengthening agricultural extension service, development of human capital and improve farmer's access to financial capital.

1. Development of Human Capital

The study has shown that labour supply (that of family and hired), education, sex and health status of the household head are among the significant variables affecting the probability of adoption and intensity of fertilizer use. This underscores the importance of human capital development through improving farmers' access to education and health service facilities.

2. Strengthening Agricultural Extension Services

The result of the econometric model showed that access to extension service is a very important variable that positively influenced the adoption and intensity of fertilizer use. In addition, descriptive analysis revealed that only few sample households were visited by extension agents, farmers are using sub-optimal level of chemical fertilizers and the utilization of improved seed is at low level. Therefore, to sustain the positive contribution of the extension service to the adoption and intensity of fertilizer use strengthening agricultural technology outreach services is necessary. In addition, strengthening research support to the extension service through identification and release of improved seed varieties and developing appropriate fertilizer application rates taking in to consideration the specific characteristics of soils in different localities is the other issue that requires due attention.

3 Improve Farmer's Access to Financial Capital

According to Reardon *etal*.(1999), wealth lowers aversion to risk and thus increases the use of (risky) technologies like fertilizer. The sources of financial capital in rural areas are livestock sales, cash crop sales, credit and off-farm income. The analysis of determinants of adoption and intensity of fertilizer use revealed that wealth of the farm households (mainly total livestock owned) and access to input credit have significant positive effects. Therefore, efforts aimed at promoting productivity enhancing inputs such as fertilizers should also take into account the importance of the livestock sub-sector. In addition to their own financial sources, larger proportion of farmers depends on the availability of credit to buy fertilizer. Hence, to sufficiently extend input credit to resource poor farmers' establishment of rural finance institutions contributes very much for such purpose.

Reference

Akinola, A. A. (1987) "An Application of Probit Analysis to the Adoption of Tractor Hiring Service Scheme in Nigeria," Oxford Agrarian Studies, 16: 70-81.

Akinola, A. A. and T. Young (1985) "An Application of the Tobit Model in the Analysis of Agricultural Innovation Adoption Process: a Study of the Use of Cocoa Spraying Chemicals among Nigerian Cocoa Farmers," Oxford Agrarian Studies, 37: 395-404.

Amemiya, T. (1981)"Qualitative Response Models: A Survey," Journal of Economic Literature, 19: 1483-1536.

Anthieu, M. and J. de la Verga (1978) "Constraints Increased Fertilizer Use in Developing Countries and Means to Overcome them," The Fertilizer Society, Proceeding No. 173, Alembis House, London.

Assefa Admassie and Gezahegn Ayele (2004) "Adoptions of Improved Technologies in Ethiopia," Ethiopian Development Research Institute, Research Report 3.

Assenafi (2006) "Determinates of technology adoption in Amhara and Tigery Region"

Belay Kassa .1999. Constraints to Effective Extension Work in Ethiopia: The Insiders view. A

paper presented on the Ninth Annual Confrence of the Ethiopian Economy (unpublished).

Beyene Tadesse (1998)"The Impact of Agricultural Extension on Maize Production: A Case Study on Sasakawa Global-2000 Extension Project in Bako Area, Msc. Thesis, Addis Ababa University, Ethiopia.

Beyene Tadesse, Assefa Admassie and Andre Croppenstdent (2000). "The Impact of

Agricultural Extension on Farm Productivity," Ethiopian Journal of Agricultural Economics, Vol. 4, No. 1

Bezabih Emana .2000. The Role of New Varities and Chemical Fertilizer under Risk: The Case of Smallholders in Eastern Oromia, Ethiopia. Ph.D. dissertation, University of Hannover, Shaker Verlung, Germany

Bisrat 1980)" Technological Change and Communication in Agriculture," The World Bank Research Observer, 6:57-80.

Carter (1984), Rao and Chotigeat (1981) and Deolalikar (1981). Principles of Agricultural Economics: Markets and Prices in Less Developed Countries. Cambridge, Cambridge University Press CSA (2001) Central Statistics Authority Statistical Abstract, Addis Ababa, Ethiopia.

Chilot Yirga, Shapiro, B.I. and Mulat Demeke.1996. "Factors Influencing Adoption of New Wheat Technologies on Wolmera and Addis Alem Areas of Ethiopia." *Ethiopian Journal of Agricultural Economics.* 1:63-84.

Croppenstedt, A., Mulat Demeke and Meshi, M. 1999. "An Empirical Analysis of Demand for Fertilizer in Ethiopia." *Ethiopia Journal of Agricultural Economics.* 3: 1-27.

CSA (Central Statistical Authority). 1999. Agricultural Sample Survey: Report on Farm Management Practices (Private Peasant Holdings, Meher Season). Statistical Bulletin 3.

CSA (2014/15) Central Statistics Authority Statistical Abstract, Addis Ababa, Ethiopia.

Dasgupta, S. 1989. Diffusion of Agricultural Innovations in village India. Wilery Eastern Limited.

EEA (2015) "Annual Report on the Ethiopian Economy," Vol III, 2014/2015, The Ethiopian Economic Association.

Ellis, F. (1993) Peasant Economics: Farm Households and Agrarian Developments, Second Edition Cambridge University press, Cambridge.

FAO (2002) Food and Agricultural Organization, Annual Report, Addis Ababa, Ethiopia.

Feder, G. and R. Slade (1984) "The Acquisition of Information and Adoption of New Technology," American Journal of Agricultural Economics, 66: 312-320.

Feder, G., R.E. Just and D. Zilberman (1985) "Adoption of Agricultural Innovations in Developing Countries: A Survey," Economic Development and Cultural Change, 33: 255-299.

Geremew Garje (2000) Determinants of Productivity of Smallholder Farmers in Ethiopia: The Case of Wheat Production in Two Districts of Sidama Zone, M. Sc. Thesis, Addis Ababa University.

Green, G. A. D. and D. H. Ng'ong'ola (1993)"Factors Affecting Fertilizer Adoption in Less Developed Countries: An Application of Multivariate Logistic Analysis in Malawi," Journal of Agricultural Economics, 44:99-109.

Gujarati, D.N. 1988. *Basic Econometrics*. Second Edition. McGraw – Hill Book Company, New York.

Hassen,Bezabih,Belay,Jema, 2012 " determinates of inorganic fertilizer adoption in weoldiya"

Igodan, C. O., P. E. Ohaji and J. A. Ekpere (1988) "Factors Associated with the Adoption of Recommended Practice for Maize Production in the Kainji Lake Basin of Nigeria," Agricultural Administration and Extension, 29: 149-156

Itana Ayana (1985) An Analysis of Factors Affecting the Adoption and Diffusion Patterns of Package of Agricultural Technologies in Subsistence Agriculture: A Case study in Two Extension Districts of Ethiopia. M.Sc. Thesis, Addis Ababa University.

Johnston, J. And Dinardo, J. 1997. *Econometrics Methods*. Fourth Edition. The McGraw-Hill Companies, Inc, New York.

Lelissa Chalchissa Argeta. 1998. The Determinants of Adoption, Intensity and Profitability of

Fertilizer use: the case of Ejere District, West Showa. M.Sc. Thesis. Addis Ababa University,

Ethiopia, PP. 1-90.

Legesse Dadi (1998) Adoption and Diffusion of Agricultural Technologies: A Case of

East and West Shewa Zones, Ethiopia, PhD Thesis, university of Manchester, School of Economics Studies, UK.

Kimuyu, P. K., M. A. Jama and W. M. Mutari (1991)" Determinants of Fertilizer Use on

Small Holder Coffee and Maize in Murang'a District, Kenya," East African Economic Review, 7: 45-49.

Lipton, M. and R. Longhurst (1989) New Seeds and Poor People. London: Unwin Hyman.

Low, A. (1982) Farm Households Theory and Rural Development in Swaziland, Development Study No. 3 London, James Currey, In: Rauniyar, G. P. and M. Goode (1996) (eds).

Low, A. (1986) Agricultural Development in South Africa: Farm-Household Economics and the Food Crises. London: James Currey Ltd.

Maddala, G.S. 1997. *Limited Dependent and Qualitative Variables in Econometrics*. Cambridge

University press.

Mulat Demeke (1999). "The Challenge of increasing Food Production in Ethiopia," In: Alemayehu Geda and Berhanu Nega (1999) (eds.), The Ethiopian Economy: Performance and Evaluation, Proceedings of the Eighth Annual Conference on the Ethiopian Economy Nazareth, Ethiopia.

Mulat Demeke and Techane Adugna. 2000. Institutional Constraints to Input. Marketing in

Ethiopia. The case of Fertilizer. Proceedings of the Ninth Annual Conference of the Ethiopian

Economy.

Mulat Demeke (2003) and Nigussie Tefera "The Productivity and Profitability of Wheat and Teff Technologies: Comparison Between Extension and Non- Extension Plots in Three Selected Villages of Ethiopia,"

Mulat Demeke, Alemu Mekonnen, Assefa Admassie and Dejene Aredo (2003) (eds). Technological Progress in Ethiopian Agriculture: Proceedings of the National Workshop or Technological Progress in Ethiopian Agriculture, Addis Ababa Pitt, M. M. and G. Sumodiningrat (1991) "Risk, Schooling and the Choice of Seed Technology in Developing Countries: A Meta Profit Function Approach," International Economic Review, 32: 457-473.

NFIA. 1999. Field Assessment Report on Fertilizer Marketing, National Fertilizer Industry Agency (unpublished).

Nkonya, E.T. Schroeder, T. and Norman, D. 1997. "Factors Affecting Adoption of Improved Maize seed and fertilizer in Northern Tanzania." *Journal of Agricultural Economics.* 4: 1-11

Ramasamy et al. (1992 "The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables," American Journal of Agricultural Economics, 66: 405-413.

Reardon, T., Kelly, V., Yanggen, D. and Crawford, E. 1999. Determinants of Fertilizer Adoption by African Farmers: Policy Analysis Framework, Illustrative Evidence, and Implication. Staff paper No. 99-18. Michigan State University.

Rogers, E. 1969. *Modernization among Peasants*: The Impact of Communications, New York.

Setotaw Ferede, Verkuijl, H.,Tanner, D.G. and Takele Gebre. 2000. Optimizing Fertilizer Use in Ethiopia. Results of Baseline Survey of Fertilizer Adoption in Arsi Zone.

Shiyani, R.L., Joshi, P.K, Aokan, M. and Bantilan,M.C.S. .2000. "Adoption of Improved Chickpea Varieties: Evidences from Tribal Region of Gujarat.*" Indian Journal of Agricultural Economics.* 55:179-170

Shultz, T.W. (1964) Transforming Traditional Agriculture, Yale University Press, New Haven.

Smale, M., W. Heisey and H. D Leathers (1995) "Maize of the Ancestors and Modern Varieties: The Microeconomics of High-Yielding Variety Adoption in Malawi," Economic Development and Cultural Change, 43:351-368.

Teressa Adugna. 1997. "Factors Influencing the Adoption and Intensity of Use of Fertilizer: The Case of Lume district, Central Ethiopia." *Quarterly Journal of International Agriculture.* 36: 173-187.District, Shoa Province." *Journal of Agricultural Economics.*4:27-43.

Tesfai Tekle (1975)"Application of Multivariate Probit Analysis to Adoption Model of New Agricultural Practices," Ethiopian Journal of Development Research, 2:43-56.

Tirfu Hedeto (2011) "Determinates of inorganic fertilizers use and intensity of use by smallholder farm households; in the case of Girar jarso district, oromia region ‚Ethiopia"

Zegeye Hailu (1989) Adoption of Modern Farm Practices: The Role of Location, Market Structures and Household Characteristics in North Ghana. Paper Prepared for the European Seminar of Agricultural Economics, "Producers and Consumers Versus Agricultural and Food Policy in Africa- A Challenge to Knowledge," Montpellier, May-June 1989.

Annex

Annex I: Mean and percentage estimates for Determinants of fertilizer Input Adoptions

tabulate fertadopt

tabulate fertadopt

fertlizer adoption in catgory	Freq.	Percent	Cum.
non-adopter	4,495	52.21	52.21
adopter	4,114	47.79	100.00
Total	8,609	100.00	

```
. ttest age, by(fertadopt)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-adop |    4495    44.87164     .252125    16.90366    44.37735    45.36592
 adopter |    4114    44.60719    .2307491    14.80036     44.1548    45.05959
---------+--------------------------------------------------------------------
combined |    8609    44.74527    .1717186    15.93286    44.40866    45.08188
---------+--------------------------------------------------------------------
    diff |            .2644402    .3437822               -.4094553    .9383357
------------------------------------------------------------------------------
    diff = mean(non-adop) - mean(adopter)                         t =   0.7692
Ho: diff = 0                                     degrees of freedom =     8607

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.7791         Pr(|T| > |t|) = 0.4418          Pr(T > t) = 0.2209


. ttest hhsize, by(fertadopt)

Two-sample t test with equal variances
------------------------------------------------------------------------------
   Group |     Obs        Mean    Std. Err.   Std. Dev.   [95% Conf. Interval]
---------+--------------------------------------------------------------------
non-adop |    4495    4.399333     .031197    2.091594    4.338171    4.460494
 adopter |    4114    4.911279    .0296331    1.900684    4.853182    4.969376
---------+--------------------------------------------------------------------
combined |    8609    4.643977    .0217577    2.018783    4.601327    4.686628
---------+--------------------------------------------------------------------
    diff |            -.511946    .0432097               -.5966474   -.4272446
------------------------------------------------------------------------------
    diff = mean(non-adop) - mean(adopter)                         t = -11.8479
Ho: diff = 0                                     degrees of freedom =     8607

    Ha: diff < 0                 Ha: diff != 0                 Ha: diff > 0
 Pr(T < t) = 0.0000         Pr(|T| > |t|) = 0.0000          Pr(T > t) = 1.0000

. tabulate fertadopt hhsex, chi2 column

+-------------------+
| Key               |
|-------------------|
|     frequency     |
| column percentage |
+-------------------+

  fertlizer |
adoption in |          Sex
    catgory |      Male     Female |     Total
------------+----------------------+----------
non-adopter |     3,395      1,100 |     4,495 
            |     48.48      68.49 |     52.21 
------------+----------------------+----------
    adopter |     3,608        506 |     4,114 
            |     51.52      31.51 |     47.79 
------------+----------------------+----------
      Total |     7,003      1,606 |     8,609 
            |    100.00     100.00 |    100.00 

          Pearson chi2(1) = 209.7264   Pr = 0.000
```

```
. tabulate fertadopt exten, chi2 column
```

Key
frequency
column percentage

fertlizer adoption in catgory	Do you get advisory services? Yes	No	Total
non-adopter	3,189	1,306	4,495
	45.73	79.88	52.21
adopter	3,785	329	4,114
	54.27	20.12	47.79
Total	6,974	1,635	8,609
	100.00	100.00	100.00

Pearson chi2(1) = 619.0951   Pr = 0.000

```
. tabulate fertadopt htype, chi2 row
```

Key
frequency
row percentage

fertlizer adoption in catgory	Type of Holding/Farming Crop only	Livestock	Both	Total
non-adopter	624	445	3,426	4,495
	13.88	9.90	76.22	100.00
adopter	315	2	3,797	4,114
	7.66	0.05	92.29	100.00
Total	939	447	7,223	8,609
	10.91	5.19	83.90	100.00

Pearson chi2(2) = 543.9793   Pr = 0.000

```
. tabulate educ fertadopt, chi2 column
```

Key
frequency
column percentage

Education (Highest Grade)	fertlizer adoption in catgory non-adopt	adopter	Total
Illitrate - previous	3,208 71.38	2,416 58.73	5,624 65.33
Informal education	555 12.35	824 20.03	1,379 16.02
Grade one completed	53 1.18	42 1.02	95 1.10
Grade two completed	74 1.65	82 1.99	156 1.81
Grade threee complete	96 2.14	154 3.74	250 2.90
Grade four completed	127 2.83	142 3.45	269 3.13
Grade five completed	86 1.91	128 3.11	214 2.49
Grade six completed -	87 1.94	101 2.46	188 2.18
Grade seven completed	53 1.18	57 1.39	110 1.28
Grade eight completed	55 1.22	81 1.97	136 1.58
Grade nine completed	25 0.56	19 0.46	44 0.51
Grade ten completed -	54 1.20	54 1.31	108 1.25
Grade eleven complete	1 0.02	1 0.02	2 0.02
Grade twelve complete	6 0.13	7 0.17	13 0.15
Above grade twelve -	14 0.31	6 0.15	20 0.23
Total	4,494 100.00	4,114 100.00	8,608 100.00

Pearson chi2(14) = 182.0597 Pr = 0.000

Annex II: Multicollinearity and Hetroscdatcity test results

```
. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
       hhsex |      1.24    0.804765
      hhsize |      1.24    0.806902
        oxen |      1.22    0.822159
       htype |      1.13    0.888392
         age |      1.12    0.892510
        educ |      1.11    0.900585
       exten |      1.07    0.934425
      credit |      1.04    0.959227
-------------+----------------------
    Mean VIF |      1.15


. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of fertusge1

         chi2(1)      =  3896.54
         Prob > chi2  =   0.0000

. estat hettest, fstat

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of fertusge1

         F(1 , 7790)  =   458.10
         Prob > F     =   0.0000
```

```
. margins, dydx( age hhsex educ hhsize htype credit exten oxen)

Average marginal effects                          Number of obs   =       7792
Model VCE    : OIM

Expression   : Linear prediction, predict()
dy/dx w.r.t. : age hhsex educ hhsize htype credit exten oxen
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	-.2731193	.1605766	-1.70	0.089	-.5878435	.041605
hhsex	.7268079	7.222375	0.10	0.920	-13.42879	14.8824
educ	6.196759	.9323666	6.65	0.000	4.369354	8.024164
hhsize	4.365424	1.277778	3.42	0.001	1.861025	6.869823
htype	12.8699	4.227348	3.04	0.002	4.584446	21.15535
credit	-103.069	4.874278	-21.15	0.000	-112.6224	-93.51555
exten	-114.1456	7.292577	-15.65	0.000	-128.4387	-99.85237
oxen	56.76175	2.425623	23.40	0.000	52.00762	61.51589

```
. margins, predict(ystar(0,.)) dydx(age hhsex educ hhsize htype credit exten oxen)

Average marginal effects                          Number of obs   =       7792
Model VCE    : OIM

Expression   : E(fertusge1*|fertusge1>0), predict(ystar(0,.))
dy/dx w.r.t. : age hhsex educ hhsize htype credit exten oxen
```

	dy/dx	Delta-method Std. Err.	z	P>|z|	[95% Conf.	Interval]
age	-.1289387	.0758246	-1.70	0.089	-.2775521	.0196747
hhsex	.3431235	3.409631	0.10	0.920	-6.339631	7.025878
educ	2.925469	.4394913	6.66	0.000	2.064082	3.786856
hhsize	2.060902	.6034755	3.42	0.001	.8781117	3.243692
htype	6.075834	1.995661	3.04	0.002	2.16441	9.987257
credit	-48.6585	2.278757	-21.35	0.000	-53.12479	-44.19222
exten	-53.88773	3.451384	-15.61	0.000	-60.65232	-47.12314
oxen	26.79703	1.146201	23.38	0.000	24.55052	29.04354