Factors determining fertilizer adoption of the peasant farm sector in Northern Ethiopia, Tigray Region

Teame Hailemariam Tedla

Norwegian University of Life Sciences
Department of Economics and Resource Management
Master Thesis 30 credits 2011

Factors Determining Fertilizer Adoption of the Peasant Farm Sector in Northern Ethiopia, Tigray Region

Master Thesis

By

Teame Hailemariam Tedla

Supervisor

Stein T. Holden

(Professor)

Department of Economics and Resource Management

Norwegian University of Life Sciences

May, 2011

Dedication

This work is dedicated to my beloved mother, *Zenebu Hagos,* who has been always with me in my long journey!

Acknowledgments

There is no easy and shortcut walk in life, ups and downs are always there. The accomplishment of this work would not have been possible without the support of the Almighty God. Thank you Lord!

I am highly indebted to my honourable supervisor, Professor Stein T. Holden for his persistent guidance and encouragement, brother and fatherhood treatment, and critical comments. Professor, I have learnt from you hard working, cooperation, honesty, kindness, patience and freedom. Though you are my principal supervisor, your valuable contributions to every student of the third batch NOMA program students, starting from the preparation of the questioners till the final outcomes of the theses, are unforgettable. I together with my classmates have spent a good time with you here in Norway, at UMB. Had there been something more than 'Thank you,' you would have been entitled for it. I have come across meeting many instructors and supervisors since my undergraduate level, but yours is so special; indeed, you are real academician! Every student was running to your office for pieces of advice; in short, I call you: "*the father of the third batch NOMA program students.*"

I extend my appreciation to the Norwegian University of Life Sciences for granted me a scholarship through the NOMA program. Mekelle University has indeed created good collaboration with UMB, it deserves my thankful expression! Dr. Hosaena Ghebru, field work was so funny and interesting with you. You extended your cooperation at times of data cleaning and dropped valuable comments, thank you! Little lady and prospective Dr. Bethelhem Legesse, your hardworking in organizing and circulating the data deserves my appreciation!

Lise Thoen (Students coordinator at the Department of Economics and Resource Management), you were almost the only person who was beside of me at times of misfortune. You lifted me up from Mekelle University to UMB on time, God bless you! Ragnar Øygard (Head of School of Economics and Business Norwegian University of Life Sciences)**,** you are easy to deal with and problem solving man, you have made life easy for us at any time we have contacted you, thanks a lot!

I am indebted to thank my parents, brothers and sisters for their encouragement in my stay throughout the whole program. Yeah! Mama, I dedicate this work to you; undeniably, you deserve it!

My classmate, colleague and one of the few intimate friends ever since I have: Achamyeleh Tamiru, we together have spent (and for sure, we will be) a wonderful friendship life in our stay in this program. You share academic, social, political, cultural and many other aspects of life with me. Your funs and jokes; maturity and globalized thinking, are highly appreciable.

Teame H. Tedla
May, 2011
Ås, Norway

List of contents

List of tables

List of figures

List of acronyms

ADLI	Agricultural Development Led Industrialization
BoARD	Bureau of Agriculture and Rural Development
CSA	Central Statistical Agency
DAP	Diammonium Phosphate
EMA	Ethiopian Mapping Authority
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization
FDRE	Federal Democratic Republic of Ethiopia
IFPRI	International Food Policy Research Institute
ILRI	International Livestock Research Institute
m.a.s.l.	Meters Above Sea Level
PMAC	Provisional Military Administrative Council
SAERP	Sustainable Agricultural Environmental and Rehabilitation Program
SSA	Sub-Saharan Africa

Abstract

In this paper, the researcher has investigated the determinants of the likelihood of fertilizer adoption and the intensity of fertilizer use in Tigray region, Ethiopia. A panel data set which consists of a sample of 307 households and 614 observations was used in the analysis. The random effect Panel probit and panel tobit models were employed to examine factors that determine the probability of fertilizer adoption and the intensity of fertilizer use, respectively. The likelihood of fertilizer adoption were mostly explained by the head of the household's education status, labor endowment, farm size, the number of plots that the farmer used, the distance to plots from homesteads, oxen ownership and the distance to market from residence. On the other hand, the intensity of the input use were largely explained by the household head's education status, farm size, manure use, the number of plots the farmer used, the distance to plots from homesteads, and oxen ownership. Geographical locations of households which were supposed to grip geographic, economic, social, political and other related factors differences also significantly affected both the likelihood of adoption and the intensity of the input use. While time had its own significant impact in determining the intensity of the input use, it had less effect on the likelihood of fertilizer adoption in the region.

Key words: Fertilizer, adoption, peasant, Tigray, Ethiopia

1. INTRODUCTION

Ethiopia[1], a country which was a net exporter of grains about half a century ago, is now confronted with the challenge of keeping food production at pace with its population growth, preventing declining per capita food production, and reducing its dependence on food aid. With severe land degradation and low use of soil fertility inputs, crop yields remain low. Despite demonstrated potential to boost agricultural production, sustaining productivity increase has not been achieved (Gebremedhin et al., 2006).

The 2007 population and housing census showed that the total population of Ethiopia to be 75 million, growing at 2.6 percent a year, of which about 84 percent is rural areas (FDRE, 2008). The country has a consistent set of policies and strategies for agriculture and rural development that reflect the importance of the sector. The policy framework is based on the concept of the strategy of Agricultural Development-Led Industrialization (ADLI). ADLI has been the central pillar of its development vision since the 1990s. However, the sector is dominated by a subsistence, low input-low output, and rain-fed farming system (Adugna, 2010).

Ethiopia's policy and investment framework for the year 2010/11-2019/20 also provides a strategic framework for the prioritization, and planning of investments that will drive the county's agricultural growth and development. This is of course anchored to, and aligned with, the national vision of becoming a middle income country by 2025 and the recently announced Five-Year Growth and Transformation plan (Ibid).

In a nutshell, the researcher realizes that the current government has put agriculture at the heart of its policies. As a result of which, there is particular emphasis on promoting adoption of fertilizer[2], improved seeds and the efficiency of input marketing and distribution. Moreover, the investigator of this study has come to notice that few previous analyses look at the decision to use inorganic fertilizer over multiple years of data in the study area. According to Linder et al., (1979); for instance, although the dynamic process

[1] Map of Ethiopia showing the location of Tigray region is available in appendix 1
[2] Represents DAP and Urea

of adoption is recognized in the theoretical literature, almost all reviewed studies in Ethiopia used cross-sectional data due to the scarcity of micro-level data over time. Consequently, the results obtained in most studies stand in isolation and cannot be shown to be consistent and robust over time. In this research paper, the investigator therefore has used a regional representative panel data set for the years 2001 and 2010 to analyze the factors which influence the likelihood of adoption of inorganic fertilizer as well as intensity of fertilizer use of smallholder farmers. Random effect probit and Tobit models were employed in the analysis.

There is widespread agreement that increased use of fertilizer and other productivity-enhancing inputs is a precondition for rural productivity growth and poverty reduction. For many agricultural scientists, economists and institutions too, increased fertilizer use is the key to increasing productivity in African agriculture. However, while the benefits of using fertilizer are widely known, its utilization rate is very low across the region. The intensity of use has remained at low level in Sub-Saharan Africa though it has rapidly increased in other parts of the world. For instance, while it has increased from 38 kilograms per hectare in 1982 to 101 kilograms per hectare in 2002 in South Asia, it increased only from 7 to 8 kilograms per hectare during the same period in Sub-Saharan Africa. This negligible fertilizer use partly explains lagging agricultural productivity growth in Sub-Saharan Africa (Morris et al., 2007 cited in Yamano and Arai, 2010). Low fertilizer use and high levels of nutrient losses have been identified in African farming system (Stoorvogel and Smaling, 1990).

It is not surprising today therefore that governments, experts and policy makers agree on the urgent need to increase the use of inorganic fertilizer in Africa. Taking the current economic policies and strategies of economic development of the nation where this study has been conducted too, the researcher believes that the need for fertilizer expansion will persist. A case in point here a recent speech of Ethiopia's prime minister emphasized that due to the high importance of inorganic fertilizer use, Ethiopia today is planning to build seven fertilizer industries within its territory. The supply side has been given emphasis;

however, in line with this, a critical assessment of the demand aspect is also of great importance.

The need to increase productivity of agriculture to keep pace with population to ensure adequate supply of food in the future is today's agenda in the Ethiopian economy. As a consequence of which, the government has embarked on a massive agricultural extension program since 1994/95 to promote the use of improved crop production technologies[3], a key component of which is chemical fertilizers. However, adoption and intensity of fertilizer application by small holders remained very low despite government efforts to promote its use (Fufa and Hassan, 2006). Diammonium Phosphate (DAP) and Urea are the two most important fertilizers that are widely promoted by the extension program of Ethiopia. Consumption of the said two fertilizers has dropped significantly between 1995 and 1997showing a slight increase of only 3% in 1999 (Ibid).

In spite of the Tigray's government efforts to expand fertilizer use among rural households, its use in the region is also still at its lower level in terms of adoption coverage and intensity of use. A case in point, Hagos and Holden, (2002) based on the information from individual households found out that about half (48.8%) of the households in Tigray region use fertilizer. It is therefore of critical importance for agricultural research and policy design to clearly understand the reasons behind the persistence of low adoption rate in the region. Lack of information on the characteristics of households that use fertilizer and those that do not is one of the important impediments for policy makers to design their policies to expand fertilizer use among rural households. Moreover, demand characteristics and constraints are not permanent and are volatile depending on the needs and perceptions of farmers to their micro environment at that particular point in time. Thus, the general objective of this paper is to analyse these household characteristics over time in order to have a better understanding of the constraints and opportunities to increasing fertilizer use. And the specific objectives which this study needs to address are:

[3] A technology is any idea, object or practice that is perceived as new by the members of a social system (Mahajan and Peterson, 1985)

- ✓ To identify factors that determine the likelihood of adoption of fertilizer by a household
- ✓ To investigate factors that influences the intensity of fertilizer use by households in the region.

Critically examining and addressing these specific research objectives will help policy makers to design their policies on how they can generate & disseminate fertilizer use in order to raise agricultural productivity and achieve food security throughout the Tigray region.

The paper is organized in to seven chapters. Chapter two reviews literatures which largely focus on concepts of adoption, methodology and empirical works from adoption studies. Chapter three describes the general background of the study area. In the fourth chapter, data & research methodologies of the study are explained. Chapter five presents descriptive analysis and chapter six deals with results and discussions of the study. Finally, Chapter seven winds up the paper by providing conclusions and policy implications.

2. LITERATURE REVIEW

2.1 Basic concepts of technologies adoption

Feder et al., (1985) defined adoption of new technology at the household level as the degree of use of a new technology in long-run equilibrium when the farmer has full information about the new technology. The adoption decision also involves the choice of how much resource; such as, land to be allocated to the new and the old technologies provided that the technology is not divisible; say mechanization and irrigation. When the technology is divisible such as improved seed, fertilizer, and herbicides; however, the decision process involves area allocations as well as level of use or rate of application.

From the above given concepts of adoption of new technology, the investigator of this study comprehends that the process of adoption decision includes the simultaneous choice of whether to adopt a technology or not and the intensity of its use. The intensity of use component indicates the degree of adoption. These two issues are therefore the center of attention for this study.

A distinction has been made between technologies that are divisible and that are not divisible with regard to the measurement of intensity of adoption. The intensity of adoption of divisible technologies can be measured at the individual level in a given period of time by the share of farm area under the new technology or quantity of input used per hectare in relation to the research recommendations (ibid). On the other hand, the extent of adoption of non-divisible agricultural technologies such as tractors and combine harvesters at the farm level at a given period of time is dichotomous (use or no use). The former is the main concern of this paper.

2.2 Why not Ethiopia has achieved the intended outcomes of technological adoption?

"Agricultural technologies have the potential to improve the livelihood of farmers in developing countries by increasing the productivity of land and labour. The success of the

Green Revolution in Asia in increasing production and income of farmers through the introduction of modern technologies and practices has been well documented. After the Green Revolution in Asia, there was great enthusiasm to repeat the Asian experience in SSA and substantial resources were channelled to agriculture over three decades" (Sanders et al., 1996 cited in Wubeneh, 2003).

As it is indicated above, technologies play an important role in economic development. Since policymakers paid little attention to the development of the peasant agriculture; however, agricultural technologies have not resulted in achieving the intended outcomes until the 1990s in the Ethiopian economy (Belay, 2003).

In brief, the researcher has noticed from his prior knowledge that in pre 1974 Ethiopia, the feudal tenure system and the neglect of small peasant agriculture were among the fundamental constraints towards the objective of achieving agricultural development. During the Derg[4] period (1974-91), though the previous archaic land tenure system was completely changed, emphasis was given to the establishment and consolidation of state farms and producers' cooperatives. Small peasant farms which comprised about 94% of the total farm land in Ethiopia were almost completely ignored. Among others; thus, the negligence of smallholder farmers led to a lesser achievement of the fruits of modern agricultural technologies adoption in the Ethiopian economy. It is therefore hoped that this paper contributes to the development of the peasant sector of the economy by assessing household and geographic factors that significantly enhance or constrain fertilizer adoption.

2.3 Technology adoption analyses: Current status and research gaps in Ethiopia

For millennia, Ethiopian farmers have been using traditional systems of fallowing, Crop rotations, manure and wood ash to maintain soil fertility and their crop yields. Thus, using chemical fertilizer is recent in Ethiopia. It started in the late 1960s along with the

[4] Provisional Military Administrative Council (PMAC)

launching of integrated agricultural programs and projects (EPA, 2003 cited in Edwards et al., 2010). Since then after, a number of institutions have been attempting to generate and disseminate improved agricultural technologies to smallholders.

Research conducted in the 1980s and onwards in Ethiopia assessed the status of agricultural technology adoption using descriptive statistics and found out that the rate of adoption of improved varieties, fertilizer, herbicide, and other agronomic practices were low. The amounts of fertilizer and herbicide applied by most farmers in Ethiopia were below the recommended levels (Hailu et al., 1992; Legesse et al., 1992; and Legesse, 1992 cited in Edwards et al., 2010).

Formal adoption studies using econometric models were carried out after the mid 1980. These studies provided information on the use of improved inputs including seed, fertilizer, herbicides, extent of adoption and factors that limit adoption decisions of smallholders in Ethiopia. Although these studies provided useful information on the rate of adoption and factors influencing adoption, the intensity of adoption was not adequately addressed. In general, the adoption studies had some limitations in their analyses and, thus, did not adequately explain farmers' adoption decisions. Some of these studies had methodological limitations, as they simply used a linear regression model to analyze the adoption behavior of farmers (Kebede et al., 1990); while others had data limitation, as they used intended (planned) adoption for some of sample farmers as the dependent variable. (Aklilu, 1980).

Moreover; as the researcher cited in the first chapter of this paper, it is indicated that few previous analyses look at the decision to use a new technology over multiple years of data. Consequently, the results obtained in most studies stand in isolation and cannot be shown to be consistent and robust over time. Thus, by utilizing two years (2001 and 2010) of panel data at household level, this paper is hoped to fill the existing gap.

2.4 Theoretical models

It is suggested that “a complete analytical frame work for investigating adoption processes at the farm level should include a model of the farmer’s decision making about the extent and intensity of use of the new technology at each point throughout the adoption process,” (Feder et al., 1985). In technology adoption studies, limited dependent variable models have been commonly used and these models assume that the decision maker; in this case the farmer’s objective in adopting the new technology is to maximize expected utility subject to some constraints (ibid).

In the case of categorical dependent variables (binomial or multinomial) qualitative choice models of adoption such as the logit and probit are usually specified. The difference between these two specifications is insignificant (Greene, 2003). These models are widely used to analyse situations where the choice problem is whether or not (0-1 value range) to adopt a new technology; however, the probit model has advantages over logit models in small samples (Fufa and Hassan, 2006).

Adoption of agricultural technologies is influenced by a number of interrelated components within the decision environment in which farmers operate. However, not all factors are equally important in different areas and for farmers with different socio-economic situations (ibid).

“Socio-economic conditions of farmers are the most cited factors influencing technology adoption. The variables most commonly included in this category are age, education, household size, landholding size, livestock ownership and other factors that indicate the wealth status of farmers. Farmers with bigger land holding size are assumed to have the ability to purchase improved technologies and the capacity to bear risk if the technology fails,” (Feder et al., 1985 cited in Fufa and Hassan, 2006).

2.5 Variables influencing fertilizer use

Empirical studies identify numerous variables as being important to household's decision to use fertilizer. Generally, the factors that affect a household's decision to use and not use fertilizer fall into three broad categories: market price, household level variables, and geographical level variables.

Market price and its effect on fertilizer adoption

Market price of fertilizer had a negative effect; as economic theory would suggest, on fertilizer use in Benin (Kherallah et al., 2001 cited in Knepper, 2002). This result suggested that household use of fertilizer decreased as its price increased and its use increased as price decreased. On the other hand, the corresponding variable for fertilizer use in their study in Malawi was not found to be significant.

Household factors determining the likelihood of fertilizer adoption

New technologies increase the seasonal demand for labor, so that adoption is less attractive for those with limited family labor or those operating in areas with less access to labor markets (Feder et al., 1985). Use of land and labor as separate variables is believed to capture the scale effects that might arise from having more of both in a single household. Thus, the researcher has used labor and farm size as separate explanatory variables in the model instead of the land/labor ratio.

Farm size can be positively related to adoption because larger farmers can experiment with new technologies on portion of land without severely risking their minimum subsistence food requirement. Accordingly, the probability of adoption may increase with farm size. Moreover, the potential benefits from adoption of new technologies are larger in absolute sense for large farmers (Zepeda, 1994). Some authors argue that the positive relationship may be explained by fixed transaction and information acquisition costs associated with the new technologies and that there may be a lower limit on the size of adopting farms such that farms smaller than a certain critical level will not adopt the new technology (Just et al., 1980 cited in Feder et al., 1985). Farm size is an indication of the level of economic resources available to farmers and thus probabilities of adopting improved varieties and fertilizer increase as this resource base increases (Polson and Spencer, 1991). On the contrary, some studies have found negative relationships between farm size and adoption. Van der Veen, (1970 cited in Feder et al., 1985) explained that small farms may exploit farm land more intensively. They have more labor available per unit of land and larger farmers have higher transaction costs to use hired labor.

Larger families would theoretically have more family members available to work on household's crop production as Croppenstedt and Demeke, (1996) indicated. However, it is not always the case that larger families positively affect new technology adoption. For instance, Sain and Martinez, (1999) pointed out that larger families would be less likely to use improved maize seeds as the increased financial strain of larger families led to budget constraints.

The gender of the head of household may influence the use of fertilizer in different ways. Male and female heads of households may have different levels of access to credit, market information, assets to transportation, technical knowledge and the like. On top of this, they may also vary on the types of crop they grow; consequently, their preferences for fertilizer use may significantly differ. However, often results from previous works show that the gender of the head of the household variable is insignificant. For example, Croppenstedt and Demeke, (1996) found gender to be insignificant in Ethiopia. Results from studies in Ghana among farming households also revealed the insignificance influence of gender on fertilizer use (Doss and Morris, 2001 cited in Knepper, 2002). On the other hand, Holden et al., (2008) reported that female-headed households were less likely to use chemical fertilizers on their farm plots in Ethiopia. They reasoned out that this may be due to the customary prohibition of women in undertaking oxen plowing in many places in the highlands of Ethiopia.

The head of the household in rural areas of Tigray region is the main decision maker in household activities. Consequently, the level of education of the household head is supposed to play role in adopting new technology. A case in point here Holden et al., (2008) found that more educated households were more likely to use chemical fertilizer in Ethiopia. It is indicated that this perhaps because education enhances the ability of individuals to utilize technical information associated with use of such modern inputs.

Interestingly enough, many studies have revealed different and contradictory results on the effect of the age of the head of the household on new technology adoption. For instance, Kaliba et al., (2000) found that older heads of households were more likely to use fertilizer in Tanzania. The reason for this result could be due to the fact that it is through increasing years of farming that higher level of education and experience achieved which in effect leads to a higher use of fertilizer. On the other hand; Sain and Martinez, (1999) reported the opposite effect for households in Guatemala on the use of improved maize seeds. Differently from the above results, the works of Croppenstedt and Demeke, (1996) on fertilizer use in Sub-Saharan Africa found age of the head of the household to be insignificant.

As to the theory of risk-averse peasant, peasant risk aversion inhibits the adoption of innovation which could improve the output and income of peasant farm families. Risk aversion declines as wealth or income increases. Higher income or wealthier farm households are better able to withstand the losses which might result from taking risky decision (Ellis, 1993). It is believed that off-farm income can have a positive impact on rural households' total income or wealth. When households income increase, their risk taking behavior also increase; this may lead to a higher probability of modern agricultural inputs use. On the other hand; if the household generates more income on the off-farm activities than do the farm activities, they may not spend more time on the farm so that the probability of new technology adoption on the farm sector may be reduced.

Regarding to off-farm activities as a secondary income source, Holden et al., (2008, p.231) revealed that compared to others; households with nonfarm employment were more likely to apply chemical fertilizers in Ethiopia. Likewise, income from off-farm employment has been obtained as the main factor which is influencing fertilizer adoption in Malawi (Green and Ng'ong'ola, 1993).

Asset ownership of households is another important factor which is supposed to determine households' level of fertilizer use. Asset ownership which is usually used as a proxy to explain the wealth status of rural households can be explained by different variables. However, often the number of oxen & livestock owned are used as a proxy of wealth status determinant in addition to farm size ownership. Accordingly; Croppenstedt and Demeke, (1996) used oxen ownership as a proxy for wealth and found it to be positively related to use of fertilizer in Ethiopia. On the other hand, Holden et al., (2008) indicated that ownership of livestock in Ethiopia was associated with a lower likelihood of using chemical fertilizers, perhaps because of the potential of applying manure obtainable from the livestock. Contrary to this, Holden and Lunduka, (2011) found that households with more livestock endowment were applying significantly more fertilizer on their plots, showing the importance of wealth for accessing fertilizers in Malawi.

Manure can increase yields by improving the soil organic matter content. It also improves the soil water holding capacity and thus increases efficiency in the use of inorganic fertilizer (Palm et al., 2001). With regard to this, Holden and Lunduka, (2011) found Manure and fertilizer to be used as complementary (not as substitutes) inputs in Malawi.

Transportation equipment or asset ownership also plays its own role in adopting fertilizer by rural households. Transportation equipment includes any transportation related asset such as ox carts, bicycles, Donkeys and wheelbarrows. Households owning transportation equipment would more likely use fertilizer since they would be in a better position to get it from the distribution center to the farmstead. In Tigray region; where this study has been conducted, often Donkeys are used as main transportation asset. Accordingly, the researcher has used donkey ownership as a proxy for access to transportation.

Geographical factors affecting the likelihood of fertilizer adoption

Plot distance can have its own impact on the likelihood of fertilizer adoption & the level of fertilizer use. For instance, Holden and Lunduka, (2011) stated that there was a tendency that more distant plots (further away from their homesteads) received less fertilizer.

Some of the earlier empirical research a priori assuming land fragmentation as an indicator of productive inefficiency (Bardhan, 1973 cited in Monchuk et al., 2010). On the other hand, opponents of land consolidation programs note the benefits of fragmented land holding to reduce risk and encouraging more diversified production. It has been suggested that fragmented land holdings allow producers to be more adaptive to certain circumstances but may more non-adaptive when factor prices and technology changes (McClosky, 1975 cited in Monchuk et al., 2010). In the end, the issue of whether or not land fragmentation negatively affects agricultural productivity is an empirical one (ibid). In relation to measurement of land fragmentation, many have been used the number of plots, which indeed reflects land fragmentation to a certain extent, but cannot capture the variation in average plot areas (Chen et al., 2009). In this study; however, since there is no as such skewed distribution of land in the study area, the researcher has used number of plots as a proxy for land fragmentation to see its effect on adoption of fertilizer.

Constraints of supply which may be explained by poor delivery time may act as an impediment to adopting fertilizer. Transportation cost which usually is associated with the supply constraint may also affect the likelihood of fertilizer adoption. Thus, the researcher has used market distance variable to handle these issues.

The data for this study is collected from Tigray region, Ethiopia which comprises four zones. And it is believed that soil types, quality and productivity, levels of infrastructure, rain fall patterns and the like may vary across zones within the region. Consequently, zone-level dummy variables are used to incorporate all of the omitted inter-zonal variations which are not specifically included in the models. Khanna, (2001) likewise used regional dummy variables to represent four states in his study on sequential adoption of site-specific technologies and its implications for Nitrogen productivity in four Midwestern states.

2.6 Hypotheses of the study

Based on the previous works that this study has reviewed, the researcher formulates the following hypotheses:

Hypothesis 1: Female-headed households do not have equal likelihood of participation in fertilizer adoption.

Hypothesis 2: Land fragmentation[5] leads to a higher probability of fertilizer adoption

Hypothesis 3: Access to market has significant positive effect on the likelihood of fertilizer adoption and degree of fertilizer adoption.

Hypothesis 4: The smaller is the farm size of the household, the higher is the intensity of fertilizer use.

[5] Adopted the concept of land fragmentation from Chen et al., 2009, I have used the number of plots as a proxy for land fragmentation.

3. GENERAL BACKGROUND OF THE STUDY AREA

3.1 Topography, Population, Rain Fall, Temperature, and Economic Conditions of Tigray Region, Ethiopia

Administratively, Ethiopia is divided into nine regional states and two city administrations, below which are zone and the 'Woredas', the latter of which can be taken as equivalent to districts. Woredas are made up of parishes called 'Tabias[6]' in Tigray and 'Kebeles' in other regions. Each Tabia or Kebele thus consists of several villages, though the villages are often not clearly delimited since the homesteads are usually scattered over the landscape (Edwards et al., 2010).

Tigray region is found in northern Ethiopia, bordered by Eritrea to the north, Sudan to the west, the Afar Region to the east, and the Amhara Region to the south. As to Wikipedia[7], the free encyclopaedia, based on the 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA), the Tigray region has an estimated total population of 4,314,456, of whom 2,124,853 are men and 2,189,603 women; urban inhabitants number 842,723 or 19.5% of the population. With an estimated area of 50,078.64 square kilometers, the region has an estimated density of 86.15 people per square kilometer. For the entire region, 985,654 households were counted which results in an average for the Region of 4.4 persons to a household, with urban households having on average 3.4 and rural households 4.6 people. On the same year, an annual population growth rate of 2.5 percent was reported for Tigray region (FDRE, 2008).

On the other hand, the average population density of the region was estimated 80 persons/km^2, with high concentrations in the Eastern, Southern and Central Zones where it is 131, 122 and 115 persons/km^2, respectively (CSA, 2002). From the above figures, it is evident that the population of Tigray has increased from a population density of 80 to 86.2

---

[6] According to Wikipedia; the free encyclopedia, Tabia is the smallest administrative unit of Ethiopia

[7] The information is obtained at: http://en.wikipedia.org/wiki/Tigray_Region , accessed on March 18/2011

people per square kilometre for the period 2002 through 2007 due to its higher population growth rate.

Average annual rain fall in Tigray is 800-1000 mm in the west and the high lands of the south dropping to 400 mm in the extreme east. In most parts, it averages between 400 and 600 mm/year (EMA, 1988 cited in Edwards et al., 2010). The precipitation occurs mostly during a short summer (end of June to mid-September) rainy season, often falling as intense storms (FAO, 1986; Hunting, 1976 cited in Edwards et al., 2010). High rainfall variability is one of the basic characteristics of the area; the Coefficient of Variation for annual rainfall is 28%, compared to 8% for Ethiopia on average (Belay, 1996 cited in Hagos and Holden, 2002).

Average temperature in the region is estimated to be 18^0C, but varies greatly with altitude. In the highlands of the region, during the months of November, December and January, the temperature drops to 5^0C. In the lowlands of Western Tigray, especially in areas around Humera, the average temperature increases from 28^0C to 40^0C during the summer (Hagos and Holden, 2002).

Figure 1 shows map[8] of Tigray region by zones where this study has conducted. As it is clearly seen from the Map, the region of Tigray comprises five zones named as Western, North Western, Central, Eastern and Southern Tigray.

---

[8] The map is obtained at: http://www.google.no/images?hl=no&q=Map+of+Tigray&rlz=1R2ADFA_enNO404&wrapid=tlif130044710999610&um=1&ie=UTF8&source=univ&sa=X&ei=6ECDTZi2MsjMtAav95CiAw&ved=0CG4QsAQ&biw=1276&bih=638 , accessed on March 18/2011

Figure 1: Map of Tigray by zones

The Tigrayan economy and society is characterized by the dominance of smallholder agriculture, where smallholder producers cultivate an average landholding of less than one hectare in a risky environment and heavily depend on natural factors. On the other hand, there is high population growth and involving high dependency ratios. The human capital resources in the region are poor in quality with low level of education and learned skills that have implications on agricultural productivity, food security and resources management (Ibid).

3.2 Fertilizer use in Tigray region

Hagos and Holden (2002) based on the information from individual households found out that about half (48.8%) of the households in the region use fertilizer. They also indicated that the most serious constraint faced by farmers for not using fertilizer is high fertilizer prices. Most farmers feel that the fertilizer prices are so high and they fear that this will contribute to their indebtedness. However, the researcher from his prior knowledge also realizes that though price of fertilizer affects households' preferences of fertilizer use; since the price of such inputs is highly controlled and uniform throughout the region, further investigation is needed on the household & geographic characteristics of users and non-users of fertilizer across the region for appropriate policy design & implementation.

In our data collection period throughout the region last summer (2009/10), we (Holden, the advisor of the researcher of this study and the researcher himself) have got an opportunity to visit and obtain some information from the Bureau of Agriculture and Rural Development (BoARD) of the region concerning trends of fertilizer use and price variations since 1998. Official data[9] show that; recently, use of fertilizer throughout the region has been increasing though price increases at an alarming rate. It is reported that the enhancement of fertilizer use across the agro ecological zones has resulted in boosting of agricultural productivity and production. In relation to supply, reports reveal that no more deficiency of supply compared to the existing demand. Supply is given according to the agro-ecology and personal interest of the farmers. This information has motivated and forced the researcher to raise a question and assess that given the price level, what factors then determine the likelihood of adoption of fertilizer and its intensity use among rural households of the region?

3.3 Major constraints of input use in Tigray region

The Bureau of Agriculture and Rural Development of Tigray region has identified the following major constrains; among others:

- ✓ Fertilizer consumption by households is not as expected
- ✓ High price of inputs

[9] The data is available in appendix 2

- ✓ Suppliers did not want to transport inputs to remote centers basically due to poor infrastructures; consequently, farmers use traditional (e.g. Donkey) as a means for input transportation.
- ✓ Shortage of storage
- ✓ Lack of closer supervision, monitoring and evaluation

Figure 2: Donkey serving as a means for fertilizer transportation in Tigray region

'Donkeys are the most common pack animal; owned by about one-third of households' (SAERP, 1997 cited in Hagos and Holden, 2002). In general, a short review of the general background of the region where this study has been conducted has helped the researcher to overview conditions of the study area regarding to problems that are linked with chemical fertilizer use and its expansion among rural households. It gives direction to suspect potential household & geographic characteristics that can affect the probability and intensity of fertilizer use in the region.

4. DATA SOURCES AND METHODOLOGY

In this section; data sources and sampling techniques, empirical models used for analysis and variable descriptions are presented.

4.1 Data sources and sampling techniques

The main data sources for this study comes from a stratified random sample of 16 communities[10] (with a simple random sample of 25 farm households from each community) from Tigray region in northern Ethiopia. "The stratified sampling of villages was based on agricultural potential, population pressure, access to irrigation, and market access," (Holden et al., 2008). The "Sixteen communities (tabias) were selected as a sub sample of the sample of 100 communities where IFPRI and ILRI/MUC planned to carry out a community survey in 1998/99" (Hagos and Holden, 2002).

The sampling method has used criteria such as the low land pastoral areas (less than 1500 m.a.s.l.) were excluded from the sample. The sample comprises Eastern, Southern, Central, and Western zones of the region. Based on that, four communities have been selected from each of the four zones. These zones reflect a significant variation in rain fall, agricultural potential, market access conditions and population density. In relation to market distance: markets that are far away (greater than 10 km) and closer markets (less than 10 km) are considered. With regard to population density: distinction has been made between high population density and a relatively low population density. Concerning irrigation projects: communities with and without irrigation projects are included (ibid).

IFPRI and ILRI stratified the highlands of Tigray in three strata: communities without irrigation projects; located far from markets (> 10 km), communities without irrigation projects; located close to markets (< 10 km), and communities with irrigation projects. Three communities out of the sample with irrigation projects have been selected. Among

[10] The names of the 16 selected communities and the number of households sampled from each communities is available in Appendix 3

communities far from markets, one with low population density and one with high population density from each zone have been strategically selected. In the Eastern and Western zones, one with high population density and one with low population density among villages close to markets were also selected. In the Southern zone, there has been only one distant from market and with irrigation project. The two other communities with irrigation projects were located in the Central zone, one with short distance to markets, and the other far from markets. The strategic sampling was used to increase the variation in rainfall, market access and population density and to ensure the inclusion of communities with irrigation projects (ibid).

In brief, this study uses both primary and secondary sources of data. The secondary data includes the 2001 household data collected from the rural households of Tigray region selected on the basis of the above explained sampling techniques by a research team from the Norwegian University of Life Sciences. The researcher also used price and fertilizer consumption information obtained from the Bureau of Agriculture and Rural Development of the Tigray region to descriptively inspect the price and consumption of fertilizer trends in the region.

The primary data has been collected for the year 2010 by the NOMA[11] students by distributing the same but with some modifications questioners[12] to the same households. Thus, this study is based on two years (2001 and 2010) panel data.

4.2 Empirical Models

In order to achieve the specified objectives and test the hypotheses set, this study has used econometric models of panel data regressions. On top of that, simple statistical tools such as graphs, averages, percentages and the like are used to descriptively explain findings that can substantiate the results of the econometric models.

[11] A collaborative Master Program of five partner universities: Mekelle University (Ethiopia), Hawassa university (Ethiopia), Bunda College of Agriculture (Malawi), Makerere University (Uganda), and Norwegian University of Life Sciences, UMB (Norway)

[12] A copy of the household questioner is available in Appendix 4

Model-1: Panel data Probit model

Limited dependent variable models have been widely used in fertilizer adoption studies. The decision maker (farmer) is assumed to maximize expected utility (expected profit) from adoption subject to land availability, and some other constraints (Feder et al., 1985).

Following Rahm and Huffman (1984), denote a technology index by t, where t is equal to 1 for the old technology and 2 for a new or different technology; moreover, a linear relationship is postulated for the i^{th} firm between the utility derived from the i^{th} technology and a vector of observed firm specific characteristics X_i (such as, farm size) and a zero mean random disturbance term e_i:

$$(1) \qquad U_{ti} = X_i \alpha_t + e_{ti}, \quad t = 1, 2; \quad i = 1 \ldots n.$$

Farm operators are assumed to choose the technology that gives them the largest utility. Thus, the i^{th} firm adopts the new technology if U_{2i} exceeds U_{1i}, and thus the qualitative variable D_i indexes the adoption decision:

$$(2) \qquad \boldsymbol{D_i = \begin{cases} 1 \; if \; U_{1i} < U_{2i}, new \; technology \; is \; adopted \\ 0 \; if \; U_{1i} \geq U_{2i}, old \; technology \; is \; continued \end{cases}}$$

The probability that D_i is equal to one can be expressed as a function of firm-specific characteristics:

$$(3) \quad P_i = P_r (D_i = 1) = P_r (U_{1i} < U_{2i})$$

$$= P_r (X_i\alpha_1 + e_{1i} < X_i\alpha_2 + e_{2i})$$

$$= P_r [e_{1i} - e_{2i} < X_i (\alpha_2 - \alpha_1)]$$

$$= P_r (\mu_i < X_i\beta) = F (X_i\beta)$$

Where; Pr (.) = a probability function

$\mu_{i} = e_{1i} - e_{2i}$ is a random disturbance term

$\beta = \alpha_2 - \alpha_1$ is a vector of parameters to be estimated

$F (X_i\beta)$ = is the cumulative distribution function for μ_i evaluated at $X_i\beta$.

The probability of the i^{th} firm adopting the new technology is thus the probability that the utility of the old technology is less than the utility of the new technology or the cumulative distribution function F evaluated at $X_i\beta$. And the exact distribution for F depends on the distribution of the random term $\mu_i = e_{1i} - e_{2i}$.

Depending on the assumption of the distribution of the error term, the specified model is to be estimated either using Probit or logit model. Assuming that the error term is normally distributed with mean zero and variance of 1, it takes a form of Probit model (Greene, 2003). Economists tend to favor the normality assumption for the disturbance term that is why the Probit model is more popular than logit in Econometrics (Wooldridge, 2009).

The researcher therefore has applied a probit model to achieve the first objective. The dependent variable; adopt, is specified as a function of both exogenous household (HH) and geographical (G) level variables that are reasonably supposed to enter into the model. Thus;

$$Adopt = f(HH, G)$$

Verbeek, (2004) has expressed random effect Probit model as:

$$Y_{it}{}^{*} = X_{it}\beta + U_{it}$$

$$Y_{it} = 1 \text{ if } Y_{it}{}^{*} > 0$$

$$Y_{it} = 0 \text{ if } Y_{it}{}^{*} \leq 0$$

Where; U_{it} is an error term with mean zero and unit variance, independent of $(X_{i1} \ldots X_{iT})$

$Y_{it}{}^{*}$ is unobservable latent variable = 1 if the farmer adopt fertilizer; 0 otherwise

X_{it} is the household and geographic explanatory variables

β is unknown regression parameters; and

The model has been specified with household random effect to control for unobserved heterogeneity. In terms of estimation method, Wooldridge, (2009) indicated that for estimating a limited dependent variable models, maximum likelihood methods are indispensable.

Model-II: Panel data Tobit Model

The second econometric analysis performed in this paper employs the quantity of fertilizer per hectare used as the dependent variable. According to Verbeek, (2004) when the dependent variable is zero for a substantial part of the population but positive for the remaining observation, the Tobit model is appropriate and most commonly used.

The intensity of use of fertilizer was analyzed by replacing the dependent dummy Variable given in the first model equation with the intensity of use of fertilizer in kg/ha. Fertilizer is measured by its weight. It is measured in units (kg) per unit of land (hectare) to examine intensity of fertilizer use. The model here also has been specified with household random effects to control for unobserved heterogeneity.

The Tobit model is a censored regression model. Observations on the Latent variable Y are missing (or censored) if $Y_{it}*$ is below a certain threshold level. One of the applications of the Tobit model is when the dependent variable (in our case quantity of fertilizer use per hectare) is zero for some individuals in the sample.

Verbeek, (2004) has given the random effect Tobit model in the form of:

$$Y_{it}* = X_{it}\beta + \alpha_i + \varepsilon_{it}$$

Where; $Y_{it} = Y_{it}*$ if $Y_{it}* > 0$

$Y_{it} = 0$ if $Y_{it}* \leq 0$

X_{it} = all the explanatory variables

β = regression unknown parameters

Y_{it}^* = latent variable

Finally, the models are estimated using the standard economic software, STATA version 10.

4.3 Variables Description and priori expectations

In light of the results of previous empirical research, this study has considered a number of explanatory variables in modeling the fertilizer adoption behaviour of farmers in the study area. The explanatory variables are broadly categorized as household and geographic characteristics. Under section 2.5 in chapter 2, detail explanations have been given based on results of study on the potential factors that are supposed to determine the likelihood of fertilizer adoption. Thus, the researcher simply and briefly lists the variables and suggests expected signs under this section.

Household Sex*:* dummy variable representing the sex of the head of the household; where, female = 1, male = 0. Although many previous works have indicated the insignificance influence of gender on fertilizer use, since females are customarily undermined in their economic and social participation in the study area, it is hypothesized that female headed households use less fertilizer than their counter part of male headed households.

Household Age: is the age of the head of the household in years. Though it is empirical question, age in the study area is hypothesized to have a negative coefficient showing that younger head of households will have a higher probability of using fertilizer.

Household educ.: dummy variable representing the education level of the head of the household. Where household heads that are literate= 1, otherwise 0**.** A positive relationship between fertilizer use and education of the head of the household is expected.

Adult Labour: Adult labour is the sum of female and male labours in the household aged between 15 and 64 years inclusive. No distinction is made between male and female labour, because unlike ploughing, inorganic fertilizer application does not require strong muscle power. Fertilizer is labour-using technology and it demands higher level of labour resource during peak seasons. It is therefore hypothesized that adult labour is positively related to adoption of fertilizer.

Household size: It refers to the total number of household members within the given household. It is believed that labour constraint affect household's ability and willingness to adopt and use a new technology (Feder et al., 1985). The larger is the family size, the more labour is expected within that household. Accordingly; though family size is an empirical question, it is hypothesized for this study that it positively affects household's fertilizer adoption.

Farm size: This is the total area cropped by the household in hectares. This includes plots the household owns & rents in to grow its crops. The relationship between farm size and adoption of agricultural technologies is an empirical question. However; for this study, a positive relationship between farm size and adoption is expected as larger farmers can experiment with new technologies on portion of land without severely risking their minimum subsistence food requirement.

Credit access: dummy variable representing availability of credit to households from credit institutions; where availability of credit = 1, & lack of credit = 0. A positive relationship is expected.

Off-farm income: includes earned none-farm activities and unearned (private transfer like remittance and government transfer). It is believed that off-farm income can have a positive impact on rural households' total income or wealth. When households income increase, their risk taking behavior also increase; this may lead to a higher probability of modern agricultural inputs use. Thus, a positive relation is expected.

Tropical livestock units: the total tropical livestock unit other than oxen owned by the household obtained by multiplying total number of animals with conversion factors. Though an empirical question, a negative relation is expected because of the potential of applying manure obtainable from the livestock.

Oxen: The number of oxen owned by the household. A positive relationship is expected.

C/W ratio: the proportion of total consumers available within the household divided by household labor (workforce). A higher consumer to worker ratio may imply higher level of dependency within the household and more spending for food items and less spending for fertilizer. Thus, a negative relation is expected.

Manure dummy: dummy variable taking the value 1 if applied; 0 other wise. Manure can increase yields by improving the soil organic matter content. It also improves the soil water holding capacity and thus increases efficiency in the use of inorganic fertilizer. Therefore, the availability and use of manure is hypothesized to be positively related to the adoption of fertilizer.

Trans. access: a dummy variable representing access to transportation equipment (asset). A donkey is used as a proxy for this purpose. 1 if owns; 0 otherwise. Households owning transportation equipment would be more likely to use fertilizer since they would be in a better position to get it from the distribution center to the farmstead. A positive relation is expected.

Plot number: the total number of plots which were used for cultivation by the household. Number of plots may be an implication of land fragmentation. Farmers who have more number of plots may be willing to adopt new technology on some of the plots taking the risk that may be embodied with the technology itself. Thus, a positive relation is expected.

Average plot distance: The average distance (in minutes of walk) of all plots under cultivation from home to each plot. It is expected that plot level factors influence adoption of fertilizer. The closer are the plots to the farmer's residence, the more likely is the farmer to use fertilizer. In other words, more intensive methods may be used on more accessible plots. Accordingly, a negative relation is expected.

Market distance: Distance from the village to the nearest market access (in minutes of walk) for which consumption goods, agricultural products and inputs can be bought & sold. The longer is the distance of the market, the lesser is the probability of buying and adopting fertilizer. Hence, a negative relation is expected.

Southern: zone dummy which represents 1 if Southern; 0 otherwise. A negative relation is expected

Eastern: zone dummy which represents 1 if Eastern; 0 otherwise. A negative relation is expected

Western: zone dummy which represents 1 if Western; 0 otherwise. A positive relation is expected

N.B: the Central zone serves as a baseline

Year 2010: this is year dummy variable which represents 1 if observation is in year 2010; 0 otherwise. Year 2001 serves as baseline. As time goes through, awareness of farmers about the importance of agricultural modern technology may increase. Hence, a significant effect is expected for the year 2010 dummy variable.

5. DESCRIPTIVE ANALYSIS

This section summarizes the results from the descriptive analysis. An attempt is given to recapitulate only important variables that can help as an important background for the econometric analysis which is dealt in the next section.

5.1 Secondary data descriptive analysis

In our survey of the year 2009/10 throughout Tigray region, the researcher of this study has gathered some important information from the Bureau of Agriculture and Rural Development of the region concerning fertilizer consumption and price trends. The obtained information is fed in to Stata version 10 and a brief summary is presented here in this sub section.

Table 1, figures 3 & 4 altogether indicate that total fertilizer consumption was declining from year to year in the period up to 2005 and reached a minimum of 81,697 quintals in the year 2005. This may be due to droughts, higher fertilizer prices, lesser efforts of extension workers and the like. However, since 2005 onwards, it is clearly seen that consumption of fertilizer; both Urea and DAP, has started to increase from year to year continuously and attained its maximum consumption of 175,968 quintals in 2009. It is also in this sub period that Ethiopia was said to be registering a double digit economic growth for a consecutive of five years.

As to the report of the 2007 Census results of the Central Statistical Agency of Ethiopia, the Tigray region has an estimated of 754,724 rural households. It therefore implies that, on average, a given household in the region consumes 23.3 kg of fertilizer in the year 2009 which is one of the lowest fertilizer consumption in the world. In general, fertilizer consumption in the region has increased on an average of 3.24% throughout the period under consideration; a big drop (-12.50%) was recorded between 2003 and 2004, and a maximum growth (24%) has attained in between 2006 and 2007. Thus, it can be concluded that though price of such an input has recently increased at an alarming rate, its consumption likewise has been also increased at regional level.

Table 1: Summary statistics of fertilizer consumption (in quintals) and growth rate trends in Tigray region for the period 1998 to 2009

Variables	Mean	Std. Dev.	Min	Max
Dap	67675.08	16533	49006	105688
Urea	50395.33	10860.72	32691	70280
Total fertilizer	118070.4	26632.24	81697	175968
% change of total fertilizer	3.24	14.78	-12.50	24

Source: computed based on the Data obtained from BoARD of Tigray region

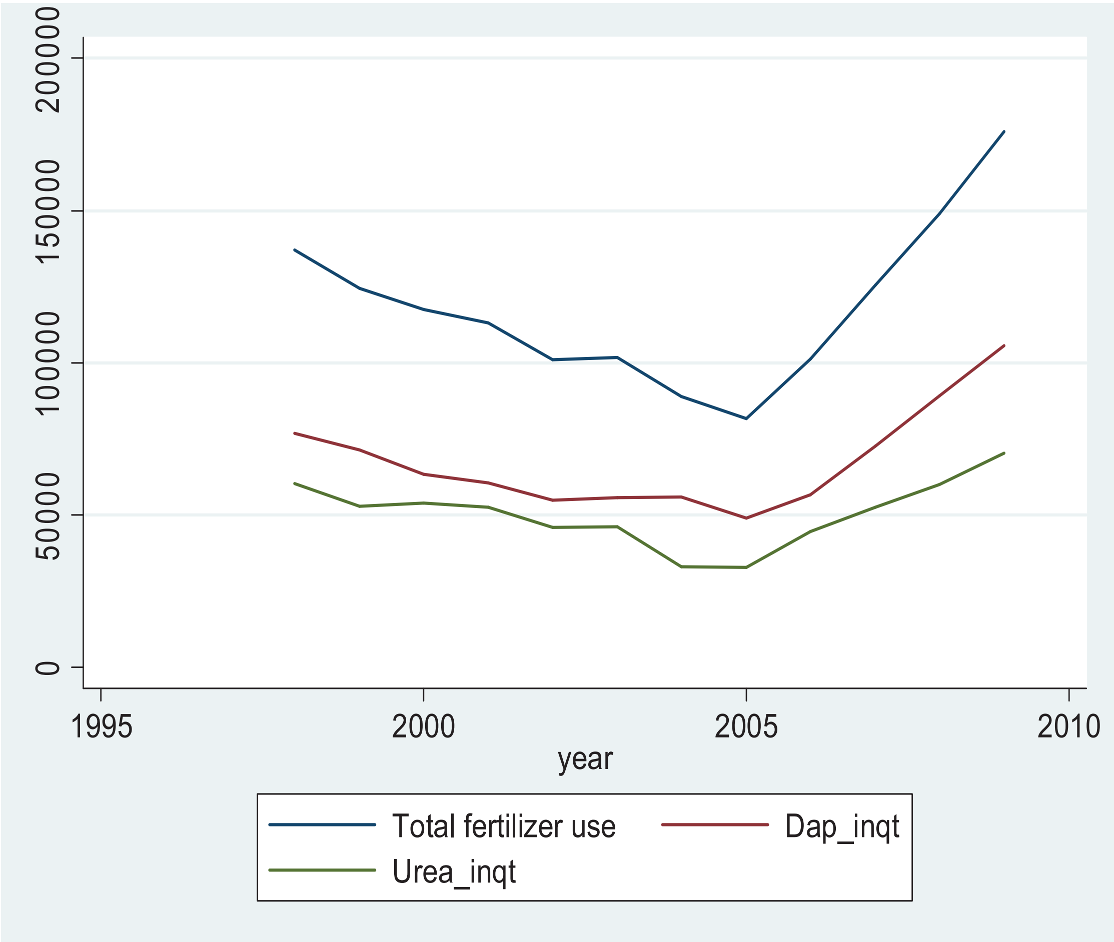


Figure 3: Yearly fertilizer distribution (in quintals) in Tigray region (1998 to 2009)
Source: Computed based on the data obtained from BoARD of Tigray region

At the early stages of introduction of a new technology, only few farmers get information about the potential economic benefits of the technology and hence the adoption speed is slow. Moreover, even if farmers get enough information about the potential economic benefits of the technology at the early stage, most farmers fear the possible risks associated with the new technology and hence do not opt to adopt. However, in subsequent time periods potential adopters acquire more information about the benefits of the technology and the degree of riskiness associated with it. Another explanation could be also that grain prices increased from 2005 and made it more profitable to buy fertilizer as well as more costly not to meet the household food requirement from own production. Then adoption accelerates until it reaches an inflection point after which it increases gradually at a decreasing rate and begins to level off, ultimately reaching an upper ceiling. The dip in 2008-2010 may be associated with the financial crises and a fall in price of grain. This idea is revealed in figure 4:

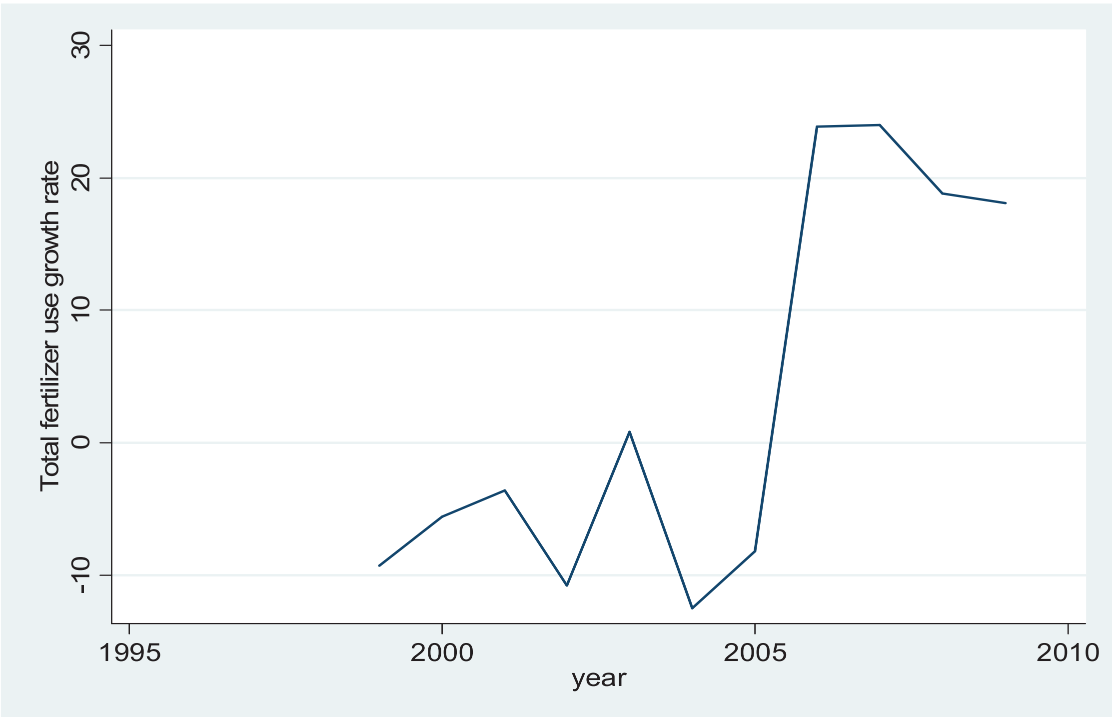


Figure 4: Annual fertilizer use growth rate in Tigray region for the period 1998 to 2009

Source: Computed based on the data obtained from BoARD of Tigray region

It is indicated in table 2 that a recent increase in fertilizer use has been associated with a rapid increment in nominal price in the region which is basically interlinked with the unstable operating conditions in the global pricing environment. Price of DAP has increased from 265.75 birr to 792.9 birr per quintal in 2002 and 2009, respectively. Likewise, price of Urea has increased from 212.25 birr per quintal in 2002 to 663.2 birr per quintal in 2009. The average price of total fertilizer per quintal for the period of 2002 to 2009 was 374.62 birr.

Table 2: Summary statistics of average fertilizer price (birr per qt.) trends in Tigray region for the period 2002 to 2009

Variables	Mean	Std. Dev.	Min	Max
Average DAP price	400.91	181.73	265.75	792.9
Average Urea price	348.33	152.86	212.25	663.2
Average total price	374.62	166.97	239	728.05

Source: computed from the data obtained from BoARD of Tigray region

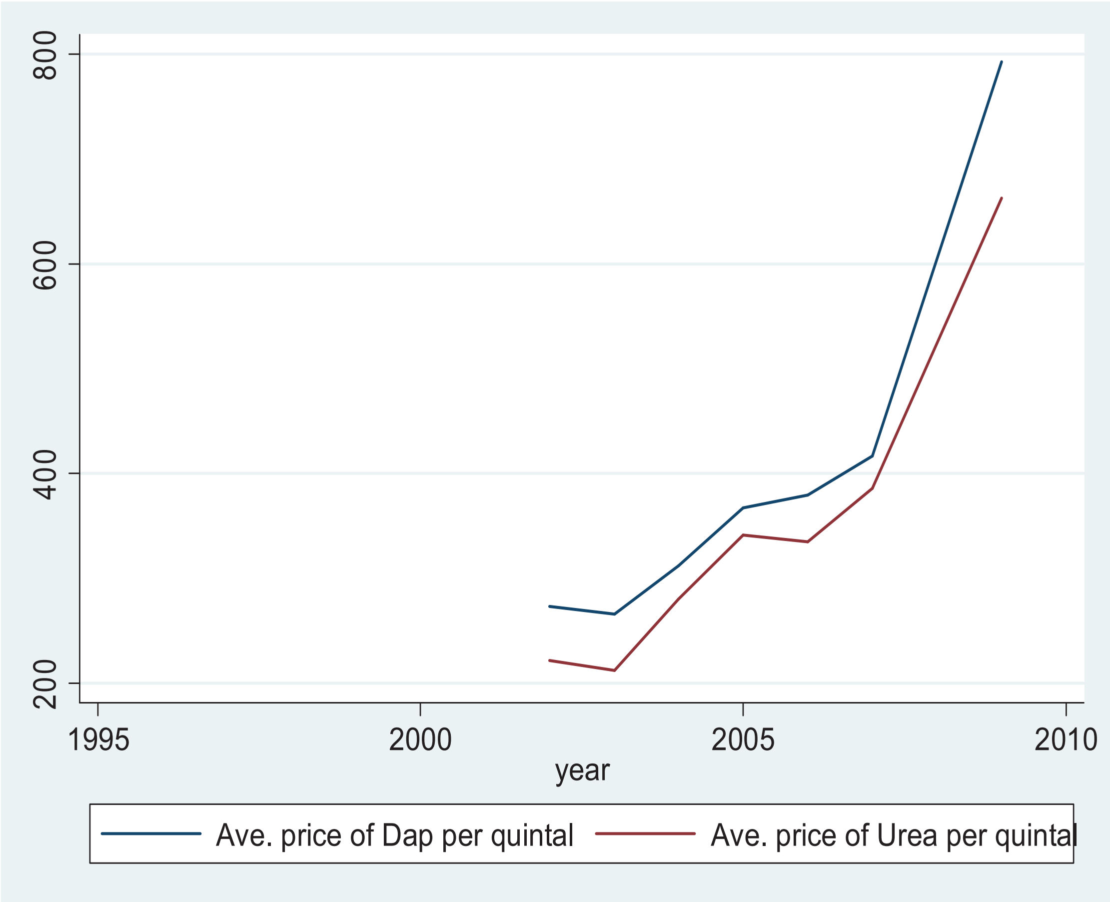


Figure 5: Average nominal prices of Dap & Urea trend in Tigray region for the period 2002 to 2009

Source: Computed from the data obtained from BoARD of Tigray region

Figure 6 discloses that the percentage change in average price in the year 2003 was -3.16; however, the price has been changed by 23.8, 19.6, 0.9, and 12.45 percent in 2004, 2005, 2006 and 2007, respectively. A remarkable change (81.3%) in price has been observed between the years of 2007 and 2009 as indicated in the figure. This is basically associated with increment in world fertilizer prices.

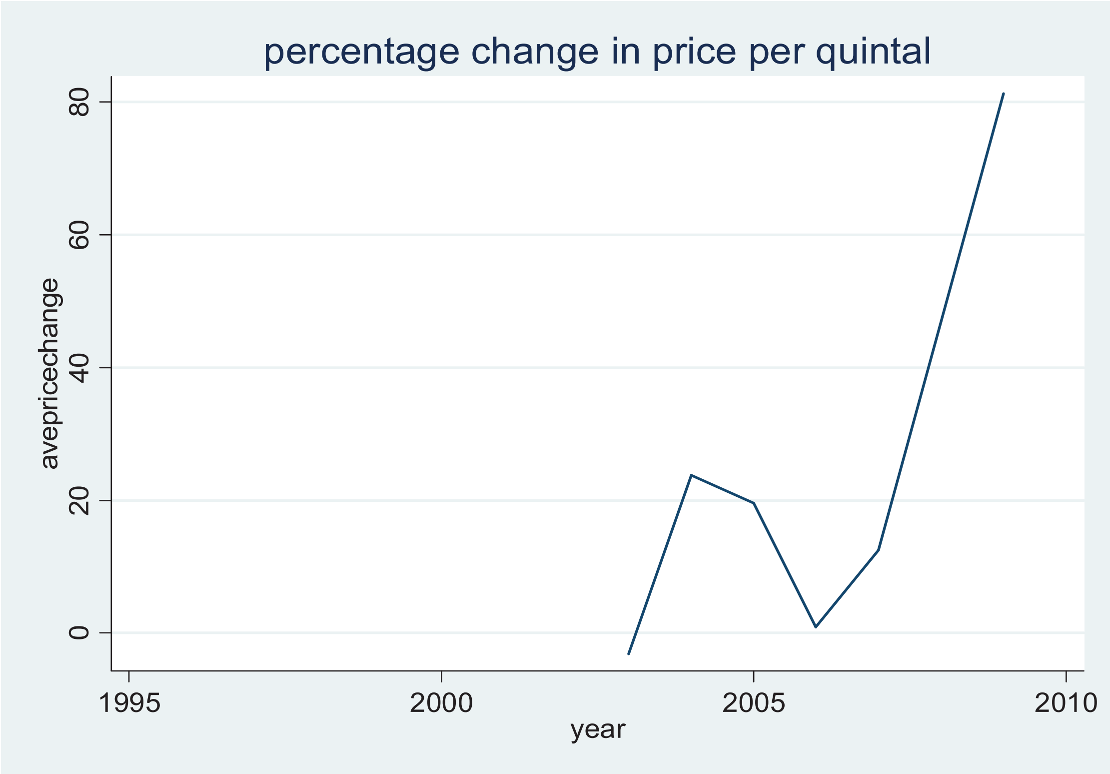


Figure 6: percentage change in price per quintal of fertilizer
Source: computed from the data obtained from BoARD of Tigray region

5.2 primary data descriptive analysis

This study uses a balanced panel data of the years 2001 and 2010. Accordingly, only 307 households of the last survey (2010) have been found appropriate to be balanced with the previous households. The researcher has therefore used a total of 614 observations in this analysis. These observations are 110, 168, 174 and 162 from Southern, Eastern, Central and Western zones of Tigray region, respectively.

5.2.1 Characteristics of respondents

Out of the 614 observations used in this study, 146 (23.78%) are female headed households while the remaining 468 (76.22%) are male headed households. Whilst 407 (66.29%) of the observations adopted fertilizer, 207 (33.71%) were non-adopters.

It is also observed that only 195 (31.76%) of the observations able to write and read while majority of them, i.e., 419 (68.24%) are illiterate. Though 337 (54.89%) of the observations have access to credit, yet 277 (45.11%) have lacked access to credit from formal institutions as it is shown in table 3.

Table 3: Sex composition, adoption rate, educational status and credit access situations of households for 2001 and 2010

Variables	Freq.	Percent	Cum.
Household sex			
Male headed	468	76.22	76.22
Female headed	146	23.78	100.00
Total	614	100.00	
Adopt			
Use fertilizer	407	66.29	66.29
No use fertilizer	207	33.71	100.00
Total	614	100.00	
Household educ.			
Illiterate	419	68.24	68.24
literate	195	31.76	100.00
Total	614	100.00	
Credit access			
No	277	45.11	45.11
Yes	337	54.89	100.00
Total	614	100.00	

Source: computed from NOMA data

If we critically see adoption level within the same sex of household heads, we found that out of the 146 observations of female headed households, only 76 observations (52.05%) use fertilizer. On the other hand, from the total of 468 observations of male headed households, it is observed that majority of them; i.e., 331observations (70.73%) used fertilizer while only 137 observations (29.27%) did not use fertilizer. It therefore seems reasonable to conclude that female headed households were less adopter not only from the total sample, but also within their group too. The mean difference between male headed and female headed adopters was obtained statically significant at 0.1% levels of significance. Table 4 has depicted this fact:

Table 4: Percentage of adopters and non-adopters within the same sex of household heads for the years 2001 and 2010

Description	Freq.	Percent	Cum.
Male headed			
Use fertilizer	331	70.73	70.73
Not use fertilizer	137	29.27	100.00
Total	468	100.00	
Female headed			
Use fertilizer	76	52.05	52.05
Not use fertilizer	70	47.95	100.00
Total	146	100.00	

Source: computed from NOMA data

It is believed that economic agents; in this case, farmers resist to accept and adopt a new technology at its early stage. However, as time goes through, learning skills and experiences enable them to become willing and open to accept and practice the technology at the grass roots level. Accordingly, the descriptive statistics indicates that in the year 2001, out of the 307 household samples, 197 (64.17%) used fertilizer while the remaining 110 (35.83%) did not practice at all. On the other hand, data of the year 2010 demonstrates that from the total of 307 samples of the same households, 210 (68.40%) used fertilizer while only 97 (31.60%) of the sample did not use the technology under consideration. The researcher therefore deduced that an increment of only 4.23% (68.40% - 64.17%) in adoption has been observed from year 2001 to 2010. It was tested using the t-test and found that this mean difference was insignificant at any standard levels of significance. This fact is shown in table 5:

Table 5: Comparison of adoption rate by year

Description	Freq.	Percent	Cum.
2001			
Use fertilizer	197	64.17	64.17
Not use fertilizer	110	35.83	100.00
Total	307	100.00	
2010			
Use fertilizer	210	68.40	68.40
Not use fertilizer	97	31.60	100.00
Total	307	100.00	

Source: computed from NOMA data

Data about the age of the household heads shows that 54 year is the average age. The maximum is 100 and the minimum is 18. The average household size for the sample of 307 in this study was 5.49 which range from a minimum of 1 to a maximum of 12 members in a household. On average, households had 2.97 adult labor ranging from a highly labor constrained which comprises zero labor to a highly labor endowed households with a maximum of 8 adult labors. Households had averagely a consumer worker ratio of 2.03 with a minimum of 1 and a maximum of 7 as it is revealed in table 6.

Table 6: Age, household size, adult labor and consumer worker ratio composition for the years 2001 and 2010

Variables	Mean	Std. Dev.	Min	Max
Household age	54.04	14.22	18	100
Household size	5.49	2.29	1	12
Adult labor	2.97	1.50	0	8
Consumer worker ratio	2.03	0.89	1	7

Source: computed from NOMA data

5.2.2 Farm size, number of plots per farm, market distance and average plot distance from homesteads for the years 2001 and 2010 by zone

Data on farm size demonstrates that the average farm size is smallest (0.76 ha) in the Central zone and largest (1.34) in the Eastern zone. The variation in farm size is also smallest in the Central zone as it is implied by the standard deviation. The overall average farm size of the four zones was 1.14 ha. The data on average number of plots per farm for the different zones indicate that the degree of land fragmentation is largest (5.31) in the Eastern zone and lowest (4.07) in the Western zone. The overall average number of plots per farm of the four zones was 4.76 with a standard deviation of 2.36.

The average distance to market for all the zones in the region was 126.01 minutes of walk. While households living in the Eastern zone are relatively accessible to market (117.68 minutes of walk), dwellers of the Western zone are highly constrained to market access as it is revealed by the longest minutes of walk (143.43). Households were also asked the walking distance for all the plots from their homesteads. Accordingly, while plots in the Southern zone are very distant, plots in the Central zone are nearer to homesteads. The overall average plot distance for the four zones was 23.59 minutes of walk as it is indicated in table 7.

Table 7: Average farm size, number of plots per farm, distance to market and average plot distance from homestead for the years 2001 and 2010 by zone

	Zone				
Variables	**Eastern**	**Central**	**Western**	**Southern**	**All**
Average farm size	1.34	0.76	1.28	1.26	1.14
	(1.28)	(0.54)	(0.77)	(0.71)	(0.91)
No. of plots per farm	5.31	5.14	4.07	4.30	4.76
	(2.79)	(2.16)	(1.92)	(2.20)	(2.36)
Market distance	117.68	118.22	143.43	125.41	126.01
	(83.21)	(90.30)	(86.05)	(94.03)	(88.44)
Average plot distance	26.58	16.25	24.87	28.74	23.59
	(27.47)	(10.62)	(27.25)	(13.06)	(22.04)

Note: 1) Numbers in parenthesis are standard deviations
2) Farm size is measured in hectares
3) Market distance and plot distance are measured in minutes of walking
Source: computed from NOMA data

5.2.3 Fertilizer and Manure use

Information on fertilizer use illustrates that the overall average fertilizer (both Urea and DAP) use per household and per hectare in the region was 40.18 kg and 46.33 kg, respectively. Likewise, the overall average manure use per household and per hectare in the region was found to be 623.76 kg and 878.48 kg, respectively. While households living in the Western zone used more fertilizer, fertilizer use in the Eastern zone is very low. Moreover, it is indicated that the intensity of fertilizer use was higher in the Central zone and lower in the Eastern zone of the region. While manure use per household and per hectare is highest in the Central zone, it is low in the Eastern and Southern zone, respectively as it is shown in table 8.

Table 8: Fertilizer and manure use (in kg) per household and per hectare for all households for the years 2001 and 2010 by zone

Variables	Zone				
	Eastern	Central	Western	Southern	All
Average fertilizer use Per household	27.08	41.21	57.64	32.86	40.18
Average fertilizer use Per hectare	27.46	65.49	56.90	29.27	46.33
Average manure use Per household	295.34	1004.27	629.04	515.69	623.76
Average manure use Per hectare	514.50	1782.02	575.03	452.04	878.48

Source: computed from NOMA data

In order to know whether intensity of fertilizer use by rural households increase or decrease with time, the researcher attempts to descriptively analyse average use of total fertilizer by households and fertilizer use per hectare of land for the year 2001 and 2010. Consequently, it is noticed that use of fertilizer per household, on average, has increased from 35.85 kg to 44.51 kg in 2001 and 2010, respectively. Likewise, fertilize use per hectare of land, on average, has increased from 40.99 kg to 51.68 kg in 2001 and 2010, respectively as it is shown in table 9.

Table 9: Average fertilizer use (in kg) per household and per hectare for all households and plots by year

Year	Description	Mean
2001	Fertilizer use per household	35.85
	Fertilizer use per hectare	40.99
2010	Fertilizer use per household	44.51
	Fertilizer use per hectare	51.68

Source: computed from NOMA data

5.2.4 Off-farm income, oxen and livestock holdings by zone

Livestock in general and oxen holdings in particular are important wealth indicators in the region. Moreover, Oxen are a very important input that farmers use in the production system. Off farm income which is an income generated by a household working off the farm also serves as a means of surviving of life when the income from the on farm activities couldn't be as expected. Accordingly, data on off farm income indicates that the overall yearly average income of the households in the study area was 2114.07 ETB[13]. Average maximum (3852.36) and minimum (983.59) off farm income was found in the Southern and western zones of the region, respectively.

On the other hand, information regarding to oxen and livestock holdings shows that on average, all households owns almost one (0.90) ox and 3.04 tropical livestock units. Averagely, a maximum (3.98) of and minimum (2.23) of tropical livestock unit was found in the Western and Central zones, respectively as it is shown in table 10.

Table 10: Average off farm income, oxen and Tropical livestock unit holdings for the years 2001 and 2010 by zone

	Zone				
Variables	**Eastern**	**Central**	**Western**	**Southern**	**All**
Off farm income	2014.12	2164.18	983.59	3852.36	2114.07
Oxen holding	0.80	0.78	1.07	1.00	0.90
Tropical livestock units	3.01	2.23	3.98	2.99	3.04

Source: computed from NOMA data

5.2.5 Donkey ownership

Donkeys are the most common pack animal which rural households of the region use. Accordingly, we interlink donkey ownership as access to transport in our model. The descriptive statistics shows that 257 (41.86%) of the observations own at least one donkey

[13] Ethiopian Birr (currency of Ethiopia)

while the remaining 357 (58.14%) observations constrained with donkey ownership as it is shown in table 11.

Table 11: Donkey ownership of rural households for the years 2001 and 2010

Variables	Freq.	Percent	Cum.
Donkey ownership			
Own at least one donkey	257	41.86	41.86
Do not own donkey	357	58.14	100.00
Total	614	100.00	

Source: computed from NOMA data

So far, emphasis has been given simply to describe basic variables of the panel data. One of the researcher's basic hypotheses; however, is to test if female headed households have equal likelihood of participation in fertilizer adoption. It is therefore essential to descriptively see the basic variables which determine the likelihood of fertilizer adoption by sex category.

Just looking at table 12, one can deduce that female headed households on average seem to be characterised by a relatively younger age, smaller household size, with a lesser adult labour endowment, lower consumer-worker ratio, lower quantities of fertilizer use, smaller farm size, lower use of fertilizer per hectare, lower use of quantities of manure & manure per hectare, and smaller number of plots as compared to their counterpart of male headed households. Moreover, it seems that they are also characterised by a lesser income from off farm activities and lower oxen and livestock holdings. Regarding to market distance, it is visualized that female headed households are on average far from a market as compared to male headed households. The only main variable which seems equal for both households is average plot distance from homesteads.

The researcher has tried to test using the t-test whether the seemingly mean differences of these basic variables between female headed & male headed households are significant enough at standard significance levels. This is possible whenever the variables are normally distributed and have equal variance for both households. One of the methods that help us to know whether a variable is normally distributed is to know its skewness. Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution is symmetric if it looks the same to the left and right of the centre point. The skewness for a normal distribution is zero and any symmetric data should have skewness near zero. Negative values for the skewness indicate data that are skewed left and positive values for the skewness indicate data that are skewed right. In addition to this, a value of 6 or larger on Kurtosis indicates a large departure from Normality.

Table 12: Summary of basic variables for the years 2001 and 2010 by household sex

	Female headed households		Male headed households	
Variables	**Mean**	**Std. Dev**	**Mean**	**Std. Dev**
Household age	51.14	14.78	54.95	13.94
Household size	3.80	1.89	6.01	2.15
Adult labour	2.25	1.29	3.20	1.49
C/w ratio	1.88	0.97	2.08	0.856
Fertilizer use	24.18	31.11	45.17	50.42
Farm size	0.89	0.85	1.22	0.918
Fertilizer use per ha	38.3	55.47	48.83	56.54
Manure	294.45	1093.90	726.50	2018.98
Manure use per ha	752.74	3711.03	917.71	3377.40
Plot number	3.81	1.89	5.05	2.41
Plot distance	23.56	24.34	23.60	21.30
Off farm income	1898.52	3262.69	2181.32	3524.07
Oxen	0.45	0.63	1.04	0.83
Livestock	1.33	1.99	3.57	3.29
Market distance	134.66	88.11	123.31	88.46

Source: computed from NOMA data

Based on the above ideas, the researcher has checked the Skewness and the Kurtosis of each of the basic variables for both female headed & male headed households. Accordingly, while household age, household size, adult labour, oxen holdings and market distance are normally distributed, the remaining ones are abnormally distributed.

The t-test on household age, household size, adult labour, and oxen holdings rejects the null hypothesis which states that the mean differences of the variables under consideration for the two household categories is not significantly different from zero at 5% level of significance. Likewise, the t-test on the mean differences of market distance for the two groups rejects the null hypothesis at 10% level of significance. It therefore implies that the difference is statistically significant at the specified significance levels. However, since we simultaneously don't control other variables, it is hardly possible to take a perfect conclusion from these descriptive analyses.

6. RESULTS AND DISCUSSIONS

This section presents and discusses results obtained from multivariate econometric analysis. The researcher has given attention to address the two specific objectives and to test the four hypotheses. The first objective is to identify & single out the most influential factors that determine the likelihood of fertilizer adoption where as the second objective is to investigate factors that influence the intensity of fertilizer use by rural households. The researcher has used random effect probit model & random effect tobit model to attempt the first & the second objectives, respectively.

6.1 Estimated results of panel probit models on the likelihood of fertilizer adoption

Adoption of fertilizer is influenced by a number of interrelated variables within the decision environment in which rural households operate. A simple correlation coefficient matrix has also been run to check whether there exists multicollinearity problem or not. Studenmund (2006) has put a rule of thumb that multicollinearity is a serious problem when the correlation coefficient becomes 0.8 or above. Accordingly, no serious problem was noticed.

Table 13: Estimated results of panel probit models on the likelihood of fertilizer adoption

Explanatory variables	Coefficients		
	All	**Female headed**	**Male headed**
Household sex	-0.187		
	(0.17)		
Household age	0.004	-0.062	0.029
	(0.03)	(0.06)	(0.03)
Age2	-0.000	0.001	-0.000
	(0.00)	(0.00)	(0.00)
Household educ.	0.340**	0.546	0.343**
	(0.15)	(0.53)	(0.16)
Household size	-0.081	0.084	-0.143*
	(0.07)	(0.21)	(0.08)
Adult labour	0.252**	0.445	0.255*
	(0.12)	(0.33)	(0.13)
C/W ratio	0.133	-0.048	0.225
	(0.13)	(0.30)	(0.16)

Farm size	-0.144*	-0.351*	-0.069
	(0.08)	(0.21)	(0.10)
Manure dummy	0.163	-0.148	0.179
	(0.14)	(0.32)	(0.16)
Plot number	0.131****	0.137	0.124***
	(0.04)	(0.09)	(0.04)
Average plot distance	-0.006**	-0.003	-0.007*
	(0.00)	(0.01)	(0.00)
Oxen	0.165*	0.538*	0.073
	(0.10)	(0.30)	(0.11)
Tropical livestock units	0.042	0.178	0.028
	(0.03)	(0.12)	(0.03)
Trans. access	-0.167	-0.335	-0.175
	(0.16)	(0.51)	(0.17)
Market distance	-0.002**	0.000	-0.002***
	(0.00)	(0.00)	(0.00)
Southern	-0.829****	-1.214**	-0.837****
	(0.20)	(0.53)	(0.23)
Eastern	-0.633****	-0.382	-0.778****
	(0.17)	(0.34)	(0.21)
Western	0.264	0.210	0.295
	(0.20)	(0.36)	(0.24)
Year 2010	0.048	0.571*	-0.027
	(0.15)	(0.32)	(0.18)
Constant	-0.187	-0.405	-0.376
	(0.81)	(1.62)	(1.01)
Prob > chi2	0.000	0.001	0.000
Number of obs.	614	146	468

Note: Dependent variable=1 if fertilizer used, =0 otherwise. Numbers in parenthesis are std. errors *:10%, **:5%, ***:1%, ****:0.1%

Table 13 presents the results of the panel probit models for all of the households, female headed households & male headed households. It is indicated in the second column of the results table that variables like education of the head of the household, adult labour of the household, farm size, number of plots, average plot distance from homesteads, oxen ownership, market distance, Southern and Eastern zone dummies significantly determine the likelihood of adoption of fertilizer at a standard level of significance. Moreover, the null hypothesis that all parameters associated with covariates are zero is rejected at 0.1% level of significance as it is indicated by the prob. > chi2 value. Thus, the model's goodness of fit is statistically acceptable to explain the relation between the probability of fertilizer adoption and the set of explanatory variables.

It is believed that education plays an important role by helping decision makers to think critically and use information sources efficiently. Producers with more education are more accessible to and be aware of more sources of information and more efficient in practicing and evaluating innovations as compared to their counterpart of uneducated producers. Education was found to be positively and significantly correlated with the likelihood of fertilizer adoption at 5% level of significance. This result fits with the findings of Holden et al., (2008) in Ethiopia.

It is apparent that some new technologies are relatively labour saving and others are labour using. For those labour using technologies just like fertilizer adoption, labour availability plays major role in adoption. The result indicates that the likelihood of fertilizer adoption is positively and significantly related with adult labour at 5% level of significance. This result matches with the findings of Feder et al., (1985). They deduced that new technologies increase the seasonal demand for labor, so that adoption is less attractive for those with limited family labor or those operating in areas with less access to labor markets.

Interestingly enough, the variable farm size has negative and significant impact on the outcome variable at 10% significance level. This result agrees with the findings of Van der Veen, (1970). The possible reason for this may be the fact that small farms exploit farm land more intensively vis-à-vis large farms. Thus, the probability of adoption for small farms becomes higher as compared to large farms.

One of the researcher's hypotheses was to test if land fragmentation leads to a higher probability of fertilizer adoption. The number of plots which a farmer used has been considered as a proxy to land fragmentation and found positively and significantly interrelated with the outcome variable at 0.1% significance level. This may be due to the fact that fragmented land holdings allow producers to be more adaptive to certain circumstances such as adoption of new technology. This result goes in line with the findings of McClosky, (1975).

Average plots of distance have been considered in the model to see if the distance from peasants' residence (homesteads) to their plots had an impact on the likelihood of adoption of the technology under consideration. Accordingly; as expected, it is found that plot distance negatively and significantly affected the outcome variable at 5% level of significance. Holden and Lunduka, (2011) also concluded that there was a tendency that more distant plots (further away from their homesteads) received less fertilizer in Malawi.

Economists usually use asset ownership as a proxy to explain the wealth status of rural households. Oxen ownership, which is one of the indicators of wealth status of rural households, was found in this study positively and significantly affecting the likelihood of fertilizer adoption at 10% level of significance. Croppenstedt and Demeke, (1996) also used oxen ownership as a proxy for wealth and found it to be positively related to use of fertilizer in Ethiopia.

It is believed that constraints of supply which may be explained by poor delivery time may act as an impediment to adopting fertilizer. Transportation cost which usually is associated with the supply constraint may also affect the likelihood of fertilizer adoption. Accordingly, the researcher has incorporated market distance variable to consider such phenomenon and found negatively and significantly affecting the probability of fertilizer adoption at 5% level of significance. This proves the hypothesis that access to market has significant positive effect on the likelihood of adoption. In other words, lack of access to market negatively affects adoption.

As the data for this study was collected from different zones, it is supposed that soil types, quality and productivity, levels of infrastructure, rain fall patterns, temperature and other variables may vary across zones within the region. Consequently, zone-level dummy variables are used to incorporate all of the omitted inter-zonal variations which are not specifically included in the model. The results indicate that households living in the Southern and Eastern zones were less likely to apply fertilizer on their plots as compared to households living in the Central zone of the region at 0.1% level of significance. However, there is no significant difference in applying fertilizer between households living in the Western and Central zones.

It was hypothesized that female headed households had less probability of fertilizer adoption vis-à-vis male headed households. However, the estimated coefficient on the variable household sex verified that though it seems that female headed households had less likelihood of adoption as it is revealed by the negative coefficient, its difference is not statistically significant at any standard significance level. It is therefore quite deducible that female headed households are equally participating in adoption of fertilizer in the region.

The researcher further checked if the different variables which are incorporated in the model equally explain the likelihood of adoption for male headed & female headed households. A random effect probit model was run for each household group separately and different estimates with different significance level have been obtained for each household head categories as it is indicated in table 13 above.

Interestingly enough, while farm size and oxen holdings had significant impact on the probability of fertilizer adoption by the female headed households' category at 10% level of significance, neither of them had a strong impact on the probability of fertilizer adoption by male headed households. The reason for this may be associated with the fact that in the rural areas of Tigray region, it is not uncommon to consider female headed households owning oxen as rich households which may not be necessarily true to male headed households. The wealth of male headed households may be explained by other variables such as financial strength beyond oxen holdings unlike to female headed households. In relation to farm size, in general, female headed households were characterized by smaller farm size as compared to male headed households as it has been descriptively explained in the previous section. Thus, females with smaller farm size may not have other options than to intensively use their plots by adopting fertilizer; which means intensity of fertilizer use & probability of adoption altogether may be increased.

Coming to the regional dummies, female headed households living in Southern zone were found to be less adopter compared to female headed households living in the Central zone. The reason may be as it was analyzed in the descriptive analysis section; households living in the Southern zone on average own large farm size, smaller number of plots, they reside far away from market access and their plot distances were also very far as compared to households living in the Central zone. Of course, other uncontrolled variables such as soil quality, rain fall pattern, temperature and other geographical differences may also play their own roles.

Interestingly, the year dummy for female headed households was found to be positive and significant at 10% significance level, which means female headed households become more adopter in the year 2010 as compared to the year 2001. Among others, this may be due to the fact that governments of developing countries, in the last few years, have given priorities to female headed households in economic, social, and political activities. For instance, in the region where this study has been conducted, females recently have access to credit that can enable them buy & apply fertilizer on their plots.

Coming to the male headed households category, household head education level, adult labor, the number of plots which the household used, average plot distance from homesteads, market distance, Southern and Eastern zone dummies strongly (with expected signs) affected the outcome variable at standard significance levels may be for reasons that the researcher has already discussed in the above few paragraphs. One new variable that becomes influential for male headed households is household size. It negatively and significantly affected the outcome variable at 10% level of significance. The reason for this may be that increased financial strain of larger families led to budget constraints that prohibit them from buying & applying fertilizer on their plots. This result agrees with the findings of Sain and Martinez, (1999).

The researcher has also tried to check results of regressions by incorporating other variables such as credit access and off-farm income. Incorporation of these variables in the model does not bring significant changes on the results of the final model. However, since these variables by their nature are endogenous and no appropriate instruments were found, they are excluded in the final model.

6.2 Estimated results of panel Tobit models on intensity of fertilizer use

The results of the Tobit model reported in table 14 show that almost all of the variables which are included in the model have the expected signs. The researcher has used fertilizer (in kg) per hectare as a measure of intensity of fertilizer use by rural households in the study area. Many reasons that could be linked with the significant variables have been already explained in discussing the first model. An attempt is therefore given here only to identify and overview influential factors that are associated with the intensity of fertilizer use by all households, female headed households and male headed households.

Table 14: Estimated results of panel Tobit models on intensity of fertilizer use per hectare

Explanatory variables	Coefficients		
	All	Female head	Male headed
Household sex	-10.460		
	(8.47)		
Household age	-0.037	-4.849	0.707
	(1.43)	(3.41)	(1.67)
Age2	-0.005	0.045	-0.012
	(0.01)	(0.03)	(0.01)
Household educ.	16.733**	13.421	17.049**
	(6.98)	(27.84)	(6.98)
Household size	0.361	1.057	-2.558
	(3.33)	(10.25)	(3.48)
Adult labour	1.031	16.072	3.387

	(5.23)	(15.79)	(5.57)
C/W ratio	-1.579	-12.793	6.700
	(6.46)	(16.20)	(7.13)
Farm size	-24.855****	-36.750***	-22.012****
	(4.11)	(12.82)	(4.34)
Manure kg/ha	-0.003***	-0.006	-0.003***
	(0.00)	(0.00)	(0.00)
Plot number	5.530****	6.990	4.849***
	(1.55)	(4.78)	(1.61)
Plot distance	-0.345**	-0.166	-0.341**
	(0.15)	(0.32)	(0.17)
Oxen	8.895**	27.341*	5.014
	(4.29)	(14.43)	(4.42)
Livestock	1.874	4.089	1.153
	(1.24)	(4.99)	(1.25)
Trans access	1.286	-8.623	2.595
	(7.27)	(24.76)	(7.43)
Market distance	-0.050	0.160*	-0.108***
	(0.04)	(0.09)	(0.04)
Southern	-45.559****	-91.896***	-39.024****
	(10.40)	(30.05)	(10.70)
Eastern	-42.184****	-44.843**	-45.129****
	(8.86)	(19.21)	(9.54)
Western	2.330	-16.820	7.180
	(9.20)	(19.47)	(9.99)
Year 2010	18.421***	40.645**	14.617**
	(6.40)	(16.45)	(7.12)
Constant	54.926	90.981	44.909
	(41.47)	(91.42)	(47.89)
Prob > chi2	0.000	0.000	0.000
Number of obs.	614	146	468
	207 left-censored	70 left-censored	137 left-censored
	407 uncensored	76 uncensored	331 uncensored
	0 right-censored	0 right-censored	0 right-censored

Note: numbers in parenthesis are std. errors *:10%, **:5%, ***:1%, ****:0.1%

Results from the model indicated that variables that considerably explained the intensity of fertilizer use were household education, farm size, manure use, plot number, plot distance, oxen holdings, Southern zone, Eastern zone and year dummy. Educated farmers use more fertilizer per hectare compared to uneducated farmers at 5% level of significance. One of the hypotheses which this study needed to test was if farm size and intensity of fertilizer use were inversely related. The result verified that farmers with smaller farm size used more amount of fertilizer per hectare compared to farmers with larger farm size.

Manure use was negatively and significantly correlated with fertilizer application at 1% significance level which implies that these two inputs were used as substitutes of each other in Tigray region, just not as complements. The number of plots a farmer cultivated also strongly and positively affected the amount of fertilizer used by the farmers which indicates that the more number of plots a farmer had, the higher was the amount of fertilizer applied per hectare of land. On the other hand, it is revealed that plots that are far away from homesteads got smaller amount of fertilizer as compared to plots that are nearer to the homesteads. The more oxen a farmer owns, the higher was the application of fertilizer on their plots at a standard level of significance.

The results also showed that households living in the Southern and Eastern zones applied smaller amount of fertilizer per hectare of land contrasted with households living in the Central zone. Interestingly, though year dummy had insignificant impact on the likelihood of fertilizer adoption of all farmers, it positively and significantly affected intensity of fertilizer use. This implies that households applied more amount of fertilizer on their plots in the year 2010 contrasted with the year 2001. The reason for this may be that households show improvements in their social and economic scenarios so that they may be able to buy more amount of fertilizer and apply more of it on their plots. The regional government & extension workers effort may also play its own role for this positive outcome; among others of course.

7. CONCLUSIONS AND POLICY IMPLICATIONS

This study has investigated influential factors which determine the probability of fertilizer adoption and intensity of fertilizer use in Tigray region, Ethiopia. A panel data of 2001 and 2010 with a sample of 307 households and a total observation of 614 has been employed in the analysis.

Today, there is a general consensus that fertilizer is considered as one of the most important inputs for the achievement of increased agricultural production and productivity in Ethiopia, which is one of the Sub Saharan Africa countries. Econometric results has verified that though intensity of fertilizer use increased significantly over the last decade, increments in the proportion of households who adopt fertilizer has remained insignificant considering all of the households in the sample. Econometric analysis, supported by the descriptive analysis too, has shown that education level of the head of the household, adult labour, farm size, the number of plots that a household used, average plot distance from homesteads, oxen holdings, and market distance altogether had significant impact in determining the likelihood of fertilizer adoption in the region under consideration. Moreover, the results have proved that households living in the Southern and Eastern zones had less likelihood of adopting fertilizer compared to households living in the Central zone.

Regarding to intensity use, the above mentioned variables have generally remained significant except that adult labour and market distance had become insignificant with this issue concerning all of the households in the sample. However, manure use and year dummy were found to be significant unlike to the likelihood of adoption for the whole sample. In addition to this, it is found that the variables that determine the probability of adoption and intensity of fertilizer use a little bit vary for male headed households and female headed households. More explanation regarding to this has been given in the results and discussions part of the paper.

Intensity of fertilizer use though increased has still remained far below the recommended rate of 100 kg/ha. The descriptive analysis has clearly shown that the percentage of adopters has increased by 4.27% only within the last ten years; likewise, intensity of use has increased by 10.69 kg/ha only though significant. Therefore, the researcher recommends that even though efforts by the government has resulted in accelerating the proportion of households that made use of inorganic fertilizer, still a lot of efforts is expected and needed from the government. The national government along with the regional government should do a big push investment on the educational sector, expanding of infrastructural facilities, creating market activities, and building institutions. Within the region itself, a special assessment and treatment is needed for households living in the Southern and Eastern zones for reasons that they became less adopters as compared to households living in the Central zone of the region.

REFERENCES

Adugna, T. 2010. Ethiopia's agriculture sector policy and investment framework (PIF) 2010/11-2019/20. Director, Planning and Programming Directorate of MOA. Addis Ababa, Ethiopia.

Aklilu, B. 1980. The Diffusion of Fertilizer in Ethiopia: Pattern, Determinants, and Implications. *The Journal of Developing Areas*, 387-399.

Belay, K. 2003. Agricultural extension in Ethiopia: the case of participatory demonstration and training extension system. *Journal of social development in Africa,* 18, 49-84.

Chen, Z., Huffman, W. E. & Rozelle, S. 2009. Farm technology and technical efficiency: Evidence from four regions in China. *China Economic Review,* 20, 153-161.

Croppenstedt, A., Demeke, M. & Economies, C. F. T. S. O. A. 1996. *Determinants of adoption and levels of demand for fertiliser for cereal growing farmers in Ethiopia*, CSAE Pub.

CSA (Central Statistical Authority). 2002. Ethiopia, Statistical Abstract 2002. Addis Ababa, Ethiopia.

Edwards, S., Gebre Egziabher, T., Araya, H. 2010. Successes and Challenges in Ecological Agriculture: Experiences from Tigray, Ethiopia. FAO, Rome.

Ellis, F. 1993. *Peasant economics: farm households and agrarian development*, Cambridge Univ Pr.

FDRE (Federal Democratic Republic of Ethiopia). 2008. Population Census Commission 2008. Summary and statistical report of the 2007 population and housing census: Population size by age and sex. Addis Ababa, Ethiopia.

Feder, G., Just, R. E. & Zilberman, D. 1985. Adoption of agricultural innovations in developing countries: A survey. *Economic Development and Cultural Change,* 33, 255-298.

Fufa, B. & Hassan, R. M. 2006. Determinants of fertilizer use on maize in Eastern Ethiopia: A weighted endogenous sampling analysis of the extent and intensity of adoption. *Agrekon,* 45.

Gebremedhin, B., Hoekstra, D. & Tegegne, A. 2006. Improving the competitiveness of agricultural input markets in Ethiopia: experiences since 1991.

Green, D. A. G. & Ng'ong'ola, D. 1993. Factors Affecting Fertilizer Adoption in Less Developed Countries: an application of multivariate logistic analysis in Malawi. *Journal of Agricultural Economics,* 44**,** 99-109.

Greene, W. H. & Zhang, C. 2003. *Econometric analysis*, Prentice hall Upper Saddle River, NJ.

Hagos, F., and Holden, S. 2002. Incentices for Conservation in Tigray, Ethiopia: Findings from a Household Survey. Department of Economics and Social Sciences, Agricultural University of Norway. (Revised paper).

Holden, S. T., Otsuka, K., & Place, F. M. 2008. The Emergence of Land Market in Africa: Impacts on Poverty, Equity, and Efficiency. Washington DC, Resource For the Future (RFF) publisher.

Holden, S. & Lunduka, R. (2011). Do Fertilizer Subsidies Crowd Out Organic Manures? The Case of Malawi. Department of Economics and Resource Management. Norwegian University of Life Sciences, As, Norway.

Kaliba, A. R. M., Verkuijl, H. & Mwangi, W. 2000. Factors affecting adoption of improved maize seeds and use of inorganic fertilizer for maize production in the intermediate and lowland zones of Tanzania. *Journal of Agricultural and Applied Economics,* 32**,** 35-48.

Kebede, Y., Gunjal, K. & Coffin, G. 1990. Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga district Shoa province. *Agricultural Economics,* 4**,** 27-43.

Khanna, M. 2001. Sequential adoption of site-specific technologies and its implications for nitrogen productivity: A double selectivity model. *American Journal of Agricultural Economics,* 83**,** 35-51.

Knepper, E. T. 2002. *Factors Affecting the Use of Fertilizer by Small-and Medium-sized Farming Households in Zambia, 1997 to 2000.* Michigan State University.

Lindner, R., Fischer, A. & Pardey, P. 1979. The time to adoption* 1. *Economics Letters,* 2**,** 187-190.

Mahajan, V. & Peterson, R. A. 1985. *Models for innovation diffusion*, Sage Publications, Inc.

Monchuk, D., Deininger, K. W. & Nagarajan, H. Year. Does Land Fragmentation Reduce Efficiency: Micro Evidence from India? *In*, 2010. Agricultural and Applied Economics Association> 2010 Annual Meeting, July 25-27, Association.

Palm, C. A., Gachengo, C. N., Delve, R. J., Cadisch, G. & Giller, K. E. 2001. Organic inputs for soil fertility management in tropical agroecosystems: application of an organic resource database. *Agriculture, ecosystems & environment,* 83**,** 27-42.

Polson, R. A. & Spencer, D. S. C. 1991. The technology adoption process in subsistence agriculture: the case of cassava in southwestern Nigeria. *Agricultural Systems,* 36**,** 65-78.

Rahm, M. R. & Huffman, W. E. 1984. The adoption of reduced tillage: The role of human capital and other variables. *American Journal of Agricultural Economics,* 66**,** 405-413.

Sain, G. & Martinez, J. 1999. *Adoption and use of improved maize by small-scale farmers in Southeast Guatemala*, CIMMYT.

Stoorvogel, J. & Smaling, E. 1990. Assessment of soil nutrient depletion in Sub-Saharan Africa: 1983-2000, Winand Staring Centre.

Studenmund, A. H. 2011. Using econometrics: A practical guide.

Tobin, J. 1958. Estimation of relationships for limited dependent variables. *Econometrica: Journal of the Econometric Society***,** 24-36.

Verbeek, M. 2004. *A guide to modern econometrics*, Wiley.

Wooldridge, J. M. 2009. *Introductory econometrics: A modern approach*, South-Western Pub.

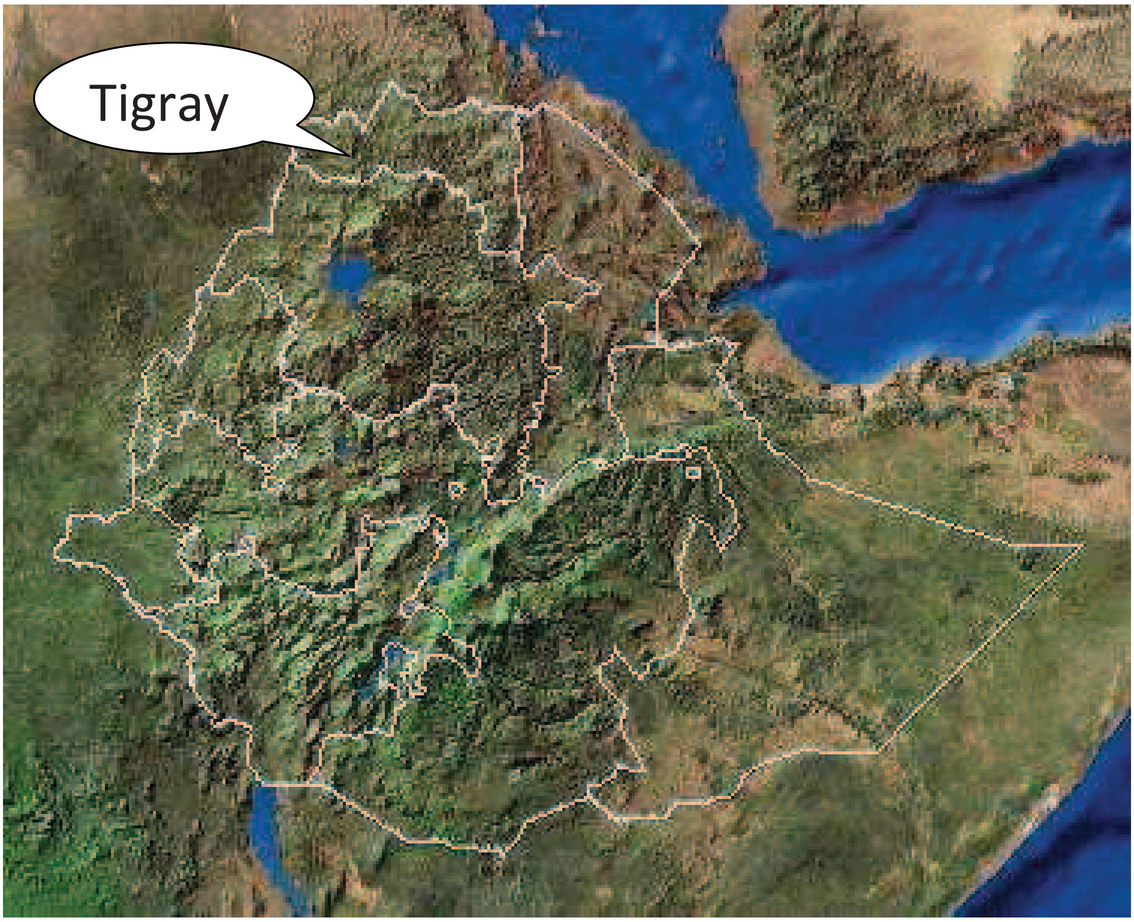
Wubeneh, N. 2003. Farm-level adoption of new Sorghum technologies in Tigray region, Ethiopia.

Yamano, T. & Arai, A. 2010. Fertilizer Policies, Price, and Application in East Africa. *GRIPS Discussion Papers*: 10-24.

Zepeda, L. 1994. Simultaneity of technology adoption and productivity. *Journal of Agricultural and Resource Economics,* 19, 46-57.

APPENDICES

Appendix 1: Map of Ethiopia showing the location of Tigray region



Appendix 2: Fertilizer consumption and average price trends in Tigray region for the period 1998 to 2009

Year	Dap (qt)	Urea (qt)	Total(qt)	Average price of Dap per qt	Average price of Urea per qt
1998	76886	60214	137100	-	-
1999	71441	52924	124365	-	-
2000	63444	53921	117365	-	-
2001	60635	52544	113179	-	-
2002	54996	45912	100908	272.75	221
2003	55649	46080	101729	265.75	212.25
2004	55879	33093	88972	312	280
2005	49006	32691	81697	366.75	341
2006	56687	44502	101189	379.25	334.85
2007	72773	52654	125427	417	386
2008	89017	59929	148946	-	-
2009	105688	70280	175968	792.9	663.2

Appendix 3: Zones, Communities and Number of Sample Households

Zone	Community (Tabia) name	Number of sample households
Southern	Hintalo	25
Southern	Samre	25
Southern	Mai Alem	25
Southern	Mahbere Genet	25
Eastern	Hagere Selam	25
Eastern	Kihen	25
Eastern	Genfel	25
Eastern	Emba Asmena	25
Central	Seret	25
Central	Debdebo	25
Central	Mai Keyahti	25
Central	Adi Selam	25
Western	Hadegti	25
Western	Tseada Ambera	25
Western	Mai Adrasha	25
Western	Adi Menabir	25
Total		**400**

Appendix 4: QUESTIONNAIRE

Household Questioner

MASTERS PROGRAM: 2010 NOMA FELLOWS NORWEGIAN UNIVERSITY OF LIFE SCIENCES IN COLLABORATION WITH MEKELLE UNIVERSITY HOUSEHOLD QUESTIONNAIRE		
The information collected will be used for research purposes. It will be treated as confidential and will not be used by tax authorities or others to assess the need for food aid or other assistance.		
Zone		
Woreda		
Tabia		
Kushet		
Household ID		
Name of household head		
Distance to woreda town (walking minutes)		
Distance to local market (walking minutes)		
Distance to primary school (walking minutes)		
Distance to secondary school (walking minutes)		
Distance to all weather road (walking minutes)		
Distance to transporatation service (walking minutes)		
Distance to health center (walking minutes)		
Distance to grain mill		
Distance to nursery site		
Distance to protected water source(walking minutes)		
Distance to tap water(walking minutes)		
Enumerators:		**Dates interviewed**
First interview:		
Second interview:		
Third interview:		

HOUSEHOLD NAME:________________________________ HH id:________________

Farm household survey: Household Expenditures

Expenditure on farm inputs EC 1994-95

Item	Quantity	Own prod.	Purchased	Price	Unit	Tot. Expend.	Where bought	source of cash
Seed, teff								
Seed, wheat								
Seed,maize								
Seed, barley								
Seed, sorghum								
Seed, chickpea								
Seed, Millet								
Seed, Fava bean								
Seed, pea								
Seed, Latyrus								
Seed, others								
Seed, vegetables								
Seed, Pepper								
Other tree seedling.								
Fertilizer: Urea								
Fertilizer: DAP								
Herbicide								
Pesticide								
Tools/equipment								
Manure								
Hired oxen								
Animal salt								
Animal medicine								
Animals bought								
Animal feed:								
Grass								

crop residue (hay stover, etc.)								
Unit: 1) kg; 2) Shember; 3)Minilik; 4) mishe; 5)others. Specify								
Where bought: 1: from neighbour, 2: within kushet, 3: local market, 4: woreda market, 5: trader visiting village								
Source of cash: 1: ownsavings, 2:formal credit, 3:informal credit,4:sale of own production, 5:sale of assets,6: other specify.								
Have you obtained credit to pay for farm inputs or for farm investments? 1) YES, 0) NO. A69 If yes, give details for the 3 last years:								
Source	Year	Purpose		Amount	Repayment conditions			
					Frequency	Duration	Interest	completed
Have **you over the last 3 years received credit for** Nonagricultural investments								

If **you want, are you able to obtain credit for**	Yes/No	Source	Max amount	Interest rate	Duration	Comment	
a. Investment							
in farm inputs							
in oxen purchase							
in other business							
b. Consumption							
c. Family events							
						Yes=1	No=0
If you have already received credit for some purpose, are you able to obtain more loans before paying back what you have already obtained? Yes\no							
Are you member of a credit association?							
If yes, do you prefer to get credit on individual basis?							
Has any member in your credit group defaulted?							
If yes, what were the consequences?							
Does any one in the HH save/put money in any of the following?							
DECSI							
Equb							
Edir							

Nearby Bank		
At home		
Others,specify		

HOUSEHOLD NAME:________________					HH id:________						
Farm household survey: Household Consumption Expenditures (last year)											
Commodity	Quantity			Quantity	Where	Per	Price	Unit	Own prod. Cons. Value	Cash Consump. Expenditure	Total Value of Consumption
	Own Prod	Free food	FFW	Bought	bought		Birr				
Teff											
Wheat											
Barley											
Maize											
Sorghum											
Millet											
Faba Bean											
Latyrus											
Chick Pea											
Pea											
Linseed											
Lentile											
other, specify											
Fruites											
Banana											
Mango											
Papaya											
Avocado											
Guava											
Vegetables											
Pepper											

Cabbage											
Onion											
Potato											
Tomato											
Other vegetables											
Garlic											
Coffee											
Spices											
Quantity: Number of units. Per: 1:week, 2:month, 3:season,4: year.											
Unit: 1:Kg, 2:pieces, 3:sheets,4:litre, 5:bags, 6:bundles 7:others, specify etc.											
Total expenditure: Includes value of own production. Cash expenditure: On purchased quantity											
Own production: Market value (Birr) of own production.											
Where bought: 1: from neighbour, 2: within Tabia 3: local market, 4: distant market, 5: trader visiting village											

Farm household survey: Household Consumption Expenditures (continued)

Commodity	Quantity Own Prod	Free food	FFW	Quantity Bought	Where bought	Per	Price Birr	Unit	Own prod. Cons. Value	Cash Consump. Expenditure	Total Value of Consumption
Beef											
Sheep											
Goat											
Chicken											
Eggs											
Milk											
Butter											
Sugar											
Cooking oil											
Salt											
Tea											
Clothing											
Shoes											
Blanket/bedsheet											
Umbrella											

Soap/Wash.p.											
Fuelwood											
Kerosene											
Batteries											
Mobile phone											
Radio											
Corrugated iron											
Furniture											
Travel/Transport											
School fees											
School books etc.											
Health/Medicine											
Income tax											
Land tax											
Religious contribution											
Ceremonies											
Jewelry											
House rent											
House construction											
Cigarettes/Tobacco											
Electricity											
Wood materials											
Leisure (drinks, candies, lotteries etc.)											
Quantity: Number of units. Per: 1:week, 2:month, 3: season ,4: year.											
Unit: 1:Kg, 2:pieces, 3:sheets,4:litre, 5:bags, 6:bundles 7:others, specify etc.											
Total expenditure: Includes value of own production. Cash expenditure: On purchased quantity											
Own production: Market value (Birr) of own production.											
Where bought: 1: from neighbour, 2: within Tabia 3: local market, 4: distant market, 5: trader											

visiting village		

HOUSEHOLD NAME:__________________________					HH id:____________									
Farm household survey: Crop Selling Activities														
Crop	**Kushet**				**Local market**					**Woreda market:**				
	Qty	Price/ unit	Month sold	Income	Qt y	Price/ unit	Where ?	Mont h sold	Incom e	Qty	Price/ unit	Where ?	Mont h sold	Incom e
Teff														
Wheat														
Barley														
Maize														
Sorghum														
Millet														
Oats														
Faba Bean														
Latyrus														
Chick pea														
Lentile														
Linseed														
Pea														
Pepper														
Potato														
Tomato														
Banana														
Mango														
Papaya														
Avocado														
Guava														
Pepper														
Cabbage														
Onion														
Carrot														
Tomato														
Garlic														

Coffee														
Eucalyptu s														
Means of transport to the different markets:							Local market:			Distant market:				
Frequency of visit to the different markets:				(Per month)			Local market:			Distant market:				

HOUSEHOLD NAME:______________________________					HH id:_______________					
Farm household **survey: Livestock Production Activities**										
Animal type	Stock	Stock	Stock	Born during	Died during	Slaughtered	Bought	Sold during	Months in	Milk per
	2 years ago	1 year ago	Current	EC 2001/02	EC 2001/02	EC 2001/02	EC 2001/02	EC 2001/02	milking (2001/02)	day (EC2001/02)
Cattle										
Milking cow										
Other cows										
Oxen										
Heifer										
Bulls										
Calves										
Sheep										
Goats										
Horses										
Mules										
Donkeys										
Camel										
Chicken										
Bee hives										
Source of cash to buy the livestock										

Farm household survey: Livestock Selling Activities EC 2001-02														
Animal/	**Village Market**				**Local Market**					**Distant market**				
Product	Qty	Price/ unit	When sold	Income	Qty	Price/ unit	Where	When sold	Income	Qty	Price/ unit	Where	When sold	Income
Cattle														
Milking cow														
Other cows														
Oxen														
Heifer														
Bulls														
Calves														
Sheep														
Goats														
Horses														
Mules														
Donkeys														
Chicken														
Butter														
Milk														
Meat														
Eggs														
Skins														
Animal dung														
Honey/Wax														
Reasons for selling livestock last year?														
1	To cover food expense						4	To cover land tax						
2	To cover clothing and schooling expenses						5	Others. Specify						
3	For wedding and other social expenses													

Farm household survey: Livestock Selling Activities EC 2001-02														
Animal/	**Village**				**Local Market**					**Distant market**				
Product	Qty	Price/ unit	When sold	Income	Qty	Price/ unit	Where	When sold	Income	Qty	Price/ unit	Where	When sold	Income
Cattle														
Milking cow														
Other cows														
Oxen														
Heifer														
Bulls														
Calves														
Sheep														
Goats														
Horses														
Mules														
Donkeys														
Chicken														
Butter														
Milk														
Meat														
Eggs														
Skins														
Animal dung														
Honey/Wax														
Reasons for selling livestock last year?														
1	To cover food expense													
2	To cover clothing and schooling expenses													
3	For wedding and other social expenses													
4	To cover land tax													
5	Others. Specify													

Farm household survey: Other Sources of Income 2001 -02 E.C)

Source	Input quantity	Input costs	Who earned	Where /to whom	When/Period	Quantity	Price/Wage	Income	Years of Experienc e
Hiring out oxen									
Hire out labour									
Labour exchange									
Assistance received									
Assistance given									
Rent out land									
Employment									
Cash support									
Migrant income									
Remittance Income									
Assistance from relatives									
Government Transfers									
Gifts									
Sale of firewood									
Sale of Handicraft									
Sale of beverages									
Petty trade									
Grain mill									
Other business/services									

Source	Number of months/ yr worked	how many person in the hh	Who earned (hh member id)	Input quantity (toal labor mandays)	Outoput Quantity (food in kg or days of work) per year		price/wage (price of wheat per kg or daily payment rate of CFW		Total income
					unit	quantity	unit	price	
Food for Work									
Food Aid									
Cash for Work									
OFSP(Other Food Security Program)									
Employment: permanent job locally, Hire out labour: temporary job locally, Migrant income: temporary job outside community member by household Remittance income: Money sent by relatives permanently living elsewhere									

What durable commodities and implements does the household have?									
Household Assets	Number now	Year bought	Number bought	Price	Current value	Need replacement (# of years)		Implements Owned 1998 EC	Source of cash
		Latest	last year						
Farm inplements									
Plough									
Donkeycart/ horsecart									
Plough parts									
Hoe									
Sickle									
Hammer									
Ax									
Spade									
Wheelbarrow									
Other production									

assets:									
Irrigation equipment									
Irrigation well									
Irrigation pump									
Pond									
Assets									
Furniture									
Radio/cassetplayer									
Wrestwatch									
Bicycle									
Stove									
House with iron roof									
Hut									
Kitchen house									
toilet*									
Jewelry									
Mobile phone									
Source of cash: 1:Sale of output, 2:Remittances, 3:Credit, 4:Sale of food from FFW, 5:Sale of livestock, 6:Savings, 7:Others, specify									
*Whether the household has toilet or not should be verified by the interviwer									

Plot Level Questionnaire

Household Name:	Interviewer:	GPS Coordinates for home of household:	Altitude (masl)
Household Id. No.:	Date of Interview:	1.	
Kushet:	Tabia:	2.	

Does the household have a land certificate? 1=Yes 0= No If yes, Year (EC) of receiving the certificate:__________
Land certificate information (copy information from land certificate), If no, why no certificate? 1=Did not collect it, 2=No land at that time, 3=Too small land, 4=Land was not registered, 5=Tabia did not give me, 6=Lost it, 7=Other, specify

Registration number on certificate:___________
Full name (owner):______________________________Sex of owner: ______________
Is owner current head of household? Yes No If no, relationship between listed owner and hhhead: HHhead is…………………

Family size when land was allocated:____________ The time when the last land allocation was made: ___________________
The number of plots allocated: ___________

Plot No.	The name of the place where the plot is located	Distance (minutes)	Soil depth of the plot (Deep=1, medium =2, or shallow= 3)	Plot size in Tsimdi	Measure dplot size in Tsimdi	The plot is Adjacent to…..	GPS Coordi -nates	Alti- tude (Ele va- tion)	Origin of plots	Who decide on plots	Who work on plots
						E: _______N: _____ W: _______S: ______					
						E: ________N: _____ W: _______S: ______					
						E: ________N: ____ W: _______S: _____					

Origin of plots: 1. Husband/Husband's family, 2. Wife's family, 3. Government, 4. Tabia, 5. Others, specify….
Who decide on plots (make production and investment decisions): 1.Husband/male head, 2.Wife, 3.Joint husband/wife, 4.Female head, 5.Son, 6.Other, specify:
Who work on plots: 1.Husband/male head, 2. Whole family, 3.Joint husband/wife, 4.Female head, 5.Wife, 6.Son, 7. Others, specify:

Does the household have plots that are not listed on the certificate? Yes = 1 No = 0
If yes, list the plots

Plot No.	The name of the place where the plot is located	Distance (minutes)	Soil depth of the plot (Deep=1, medium=2, or shallow=3)	Plot size in Tsimdi	Measuredplot size in Tsimdi	GPS Coordi-nates	Alti-tude (Eleva-tion)	Origin of plots	Who decide on plots	Who work on plots

Origin of plots: 1. Husband/Husband's family, 2. Wife's family, 3. Government., 4. Tabia, 5. Other, specify….
Who decide on plots (make production and investment decisions): 1.Husband/male head, 2.Wife, 3.Joint husband/wife, 4.Female head, 5.Son, 6.Other, specify:
Who work on plots: 1.Husband/male head, 2. Whole family, 3.Joint husband/wife, 4.Female head, 5.Wife, 6.Son, 7.
Other, specify:

Cross/check information with plot level data from our earlier survey rounds:
NB! Fill plot number continuing from plot numbers on previous page and use carefully the same plot numbers and order of plots in the following pages.

Household Name:	Household Id. No.:	Interviewer:

Land rental and partners in rental market
Have you rented in or out land during the last year? Yes=1 No=0 If no, skip this page.
NB! Keep plot number the same as in land certificate and the following list of plots

Plot No.	Plot Name	Tenure status	Rented-in plot		Rented-out plot		Reasons for renting out	If the plot is transacted, details about rental partners				
			2000 1=yes 0=no	2001 1=yes 0=no	2000 1=yes 0=no	2001 1=yes 0=no		Name	Relationship	Kushet	How long has the contract partnership lasted?	Where rental partner lives

Tenure status: 1.Own land with certificate, 2.Own land without certificate, 3.Rented in, 4.Transferred, 5.Inherited, 6. Other,specify:
Reasons for renting out: 1= lack of labour, 2= lack of oxen, 3= unable to rent oxen, 4=lack of cash, 5= credit obligation, 6=other, specify…,
Relationship: 1=husband's close relative, 2=wife's close relative, 3=distant relative, 4=ex-husband/ex-wife, , 5= non-relative, 6=Son/Daughter, 7=other, specify,
Where rental partner lives: 1= within the kushet, 2= within the tabia, 3= A closer tabia, 3= distant tabia, 4= other, specify.
How long: How many years has the contract partnership lasted

Household Name:	Household Id. No.:	Interviewer:

Land characteristics
! Keep plot number the same as in land certificate and the following list of plots

Plot No.	Plot Name	Irrigated? 1=yes, 0=no	Soil Type	Soil Depth	Slope	Land quality	Weed infestation	Susceptibility to erosion	Degree of soil erosion /degradation
Codes: a) Soil type: 1. Baekel, 2. Walka, 3. Hutsa, 4. Mekeyih, Soil depth: 1.Shallow, 2. Medium, 3. Deep									
Slope: 1. Meda, 2. Tedafat (foothill), 3. Daget (midhill), 4. Gedel (steep hill)									
Land quality: 1. Poor, 2. Medium, 3. Good, Weed infestation: 1. High, 2. Medium, 3. Low									
Susceptability to erosion: 1. High, 2. Medium, 3. Low, 4. None Degree of degradation: 1. Highly degraded, 2. Degraded, 3. Moderately degraded, 4. No degradation									

Number of Visits to Plot (May 2001 – May 2002)

Plot No.	Plot Name	Land preparation		Planting		Manuring /Fertilization		Weeding		Inspecting/ (scaring birds)		Harvesting		Threshing		If landlord, monitoring visit		Total No. of visits	No. of Sole visits
		No.	Who	No.	Who	No.	Who	No.	Who	No.	Who	No.	Who	No.	Who	No.	Who		

No: Number of Visits
Who: Persons visited the plot: 1= Husband, 2= Wife/female head, 3= Husband and wife, 4= Husband and Son,
5= Others, specify __

Land market participation
Fill in if household has participated in the land rental market (including sharecropping in or out) during the last year.

! Keep plot number the same as in land certificate and the following list of plots

Household No.:	Interviewer:	
HH name	Data of Interview:	
Kushet:	Woreda:	
Tabia:	Zone:	Who decides

2006 plot no	Plot Name	Land rental markets								Byproducts, who get them?			Responsibilities					
		Contract	Type	Duration	If duration>3 yrs, specify	Payment	Advance payment	Paid when	Cost-sharing arrangement	Crop residues	Manure	Grasing	New SWC	Maintain SWC	Pay land tax	Contract type	Crop choice	Share rate/ Rent

Contract: 1. Fixed rent (cash), 2. Fixed rent (Kind), 3. Sharecropping (output only), 4. Cost sharing, 5. Output sharing after deduction of (cash) input costs,
6.Other, specify: Type: 1. Oral without witness, 2. Oral with witness, 3. Written and unreported. 4. Written and reported to tabia.

Duration: 1. 1 year, 2- 2 years, 3. 3 years, 4. >3 years, specify……………., 5. Open ended.
Payment: Fixed rent: cash amount, Sharecropping: Share of output to the landlord (Code: 1. 50%, 2. 33%, 3. 25%, other, specify:……………………
Advance payment: Cash amount in sharecropping contracts.
Paid when: 1. Before cultivation, 2. After harvest, 3. Other, specify:…………………..
Costsharing arrangement: 1. Landlord pays fertilizer and seed, 2. Landlord and tenant share cash input costs, 3. Other, specify:……………………………
Byproducts, who gets them/Responsibilities/Who decides: 1.Landlord, 2.Tenant, 3.Shared, 4. Open
Crop choice: 1. Landlord, 2. Tenant, 3. Follow follwing crop rotation system (specify): ………………..

Crop production and input use

Plot no.	Sub-plot	Sea-son	Plot Name	Crop grown	Area planted	crop output Kg	Seeds		Manure in Kg	Urea in Kg	Dap in Kg	Herb and pesticide Birr	Number of labor man days					Oxen
							Type	Kg					Plow-ing	Weed-ing	Harvest-ing	Thresh-ing	hired labor	

Season: 1=Meher (rainy season, 2=Dry season 1 (irrigated land), 3=Dry season 2 (irrigated land)
Crops grown: C1. Barley, C2. Wheat, C3. Teff, C4. Maize, C5. Millet, C6. Sorghum, C7. Field pea, C8. Bean, C9. Linseed, C10. Lentil, C11. Hanfets
Vegetables: V1. Onion, V2. Potato, V3. Tomato, V4. Letus, V5. Cabbage, V6. Carrot, V7. Pepper, V8. Others
Perennials:P1. Orange, P2. Banana, P3. Eucalyptus. P4. Guava, P5. Papaya, P6. Coffee, P7. Others, Specify…………..
Seed type: 1. Improved, 2. Local, 3. Others, specify
Oxen: 1. Own oxen, 2. Shared oxen, 3. Oxen exchange with labour, 4. Borrowed oxen, 5. Rented oxen for cash, 6. Other, specify: