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ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
College of Development Studies



**MODERN AGRICULTURAL INPUT ADOPTION UNDER
 PRODUCTION RISK: *The Case of Fertilizer Application in
 Saesi Tsaeda-Emba Woreda, Eastern Zone of Tigray, Ethiopia***

BAHRE HAILESELASSIE GEBRE

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Ethiopia**

BY:

BAHRE HAILESELASSIE GEBRE

ADVISOR:

WORKENH NEGATU (PhD)

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Livelihood and Development*

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Title

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Tigray, Ethiopia.**

BY

Bahre H/Selassie Gebre

DEVELOPMENT STUDIES

APPROVED BY THE BOARD OF EXAMINERS:

SIGNATURE

Dr. Mulugeta Fescha

COLLEGE DEAN

Worknet Megatu

ADVISOR

Legesse Dadi (Sr.)

EXTERNAL EXAMINER

Getachew Yoseph

INTERNAL EXAMINAR

[Signature]

[Signature]

[Signature]

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ABSTRACT

Empirical studies give evidence that farming is a risky activity, especially under rain fed agriculture characterized by erratic rainfall. In such conditions, production risks (crop failure) arise mainly from uncertainties in climate, which is uncontrollable by farmers. Moreover, return on modern inputs such as fertilizer is unpredictable, because of exogenous variables such as weather, pests, and crop diseases. Consequently, production risk is one of the major constraints in the rain fed agriculture that can delay or avoid technology adoption. It has been argued that risk aversion makes farmers to avoid or hesitate to use modern agricultural inputs like fertilizer. However, empirical evidence on farmers risk aversion and fertilizer use is limited in Ethiopia. Most adoption studies have not explicitly addressed the issue in the country. The intention of the study was to examine if risk aversion has an adverse effect on fertilizer adoption and if risk aversion is associated with household's wealth status. To this end an empirical analysis was done using descriptive and econometric analysis in comparative fashion between adopters and non- adopters of fertilizer. Using the moments based approach it was tried empirically examine the relative risk premium related to fertilizer use among farmers. The findings showed that the farmers' exhibit absolute Arrow-Pratt risk aversion towards the use of fertilizer, i.e., risk aversion and fertilizer use was negatively related. The implication is that when considering promoting modern agricultural inputs such as fertilizer, it is important to assess the variance of income and its implications on risk preferences. Another notable finding was that credit access and extension service significantly influenced the likelihood of fertilizer adoption in the area. However, the problem was not a mere availability of fertilizer credit, but lack of financial capacity to purchase inputs as a key constraint to adoption and fear of repayment of credit if crop damage occurs, which is common feature of the study area. Thus, the input supply policy should be revised in the context of farmers' constraints.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Agriculture represents the main form of income for the majority of rural Ethiopians. Until other reliable and feasible options arise, it remains as main source of livelihood for rural population of Ethiopia. Thus, improving the production and productivity of the sector there by increasing incomes of more than 85% of the rural population remains as crucial goal in the country.

The performance of the Ethiopian economy highly depends on the performance of the agricultural sector. However, agriculture food production in the country is showing a declining trend. Despite the efforts made, the country has remained as food deficient let alone to produce surplus for structural transformation of the economy. Abeje (2007:227) stated as “Ethiopia is a food deficit country, with 3.5 to 26% of the population requiring food assistance in a given year”. A number of factors have contributed to this problem such as use of backward technology, drought, ineffective input and output markets, and ineffective extension services (Workneh, 2000).

Many scholars agree that soil fertility of the country especially in the high lands of it is depleted and food security will not occur unless agricultural activities are preceded by the adoption of new technologies such as fertilizer and high yielding varieties (e.g., Gezahegn and Mekonnen, 2007).

A number of studies show that farmers' decision making to adopt new technologies is affected by their attitude towards risk. There is also evidence that poor farmers are risk adverse. Risk bearing capacity of farmers is positively correlated with relative wealth (farm and non-farm income) they possess (Moscardi and de Janvry , 1997 ; Coady,1993). Poor households face a multitude of risks for which formal insurance and credit arrangements are limited or absent (Morduch, 1995; Dercon, 2005; Yesuf and Bluffstone, 2007). As a

result these households adopt risk sharing arrangements and consumption and income smoothing to cope these shocks (Morduch, 1995; Fafchamps 1999; Hoogeveen *et al.*, 2005; Anderman and Paxson, 1992).

One of these arrangements, for example, as noticed by Dercon (2004) is that poor households may opt for less risky agricultural investments which in turn result in low returns. Dercon and Christiansen (2007:2) stated, "Initially poorer agents revert to low yielding and lower risk portfolios, often absorbing to maintain asset levels".

Morduch (1995) stated that poor households take *ex ante precautionary* measure as first stage mitigating risk i.e. households can smooth income usually making conservative production or employment choices and diversifying economic activities. This implies relatively wealthier farmers engage in more risky portfolios but high yielding while smoothing their consumption. On the other hand, the relatively poorest households, "... are stuck with low return, low risk activities trapping them in to poverty even though their inherent risk preference may fundamentally the same" (Dercon and Christiaensen, 2007:2). The direction of causation, in this study, is that in poorer households risk induces poverty. i.e in the absence of formal insurance and other alternatives, households are obliged to engage in low riskier activities and investments making a trade-off to lower average income or return. In line with this, Morduch (1995) notes that consumption smoothing in low income countries and particularly in the rural poor is managed before shocks occur, for example "in season-to-season choices about cropping patterns or the intensity of input use." The over all argument is that there is an inherent linkage between wealth status of households and risk which reinforce each other especially in the poor rural households.

Various studies have given considerable attention on the importance of risk in analyzing farmers' behavior and agricultural sector development (Just and Pope, 1979; Moscardi and de Janvry, 1997; Feder, *et al.*, 1985). The extensive survey made by Feder, *et al.*, (1985) listed factors such as lack of credit, limited access to information, aversion to risk, inadequate farm size, farm tenure arrangements, insufficient human capital, absence of inputs and transportation problems as constraints to rapid technology adoption.

Moscardi and de Janvry (1997) have identified three classes of variables as determinants or attitudes towards risk namely the nature of the household, its income-generating opportunities and its access to public institutions. Here income-generating opportunities refer to the total land size under the household control and the level of off-farm income.

A growing body of literatures and empirical studies have given more emphasis on the effect of risk in influencing a farmer's decision to adopt a new technology. Risk-averse producers may decide to delay or avoid adoption of new technology (Sandmo, 1971). Whatever the sources of agricultural risk are, the central argument implies there is inherent link between risk and technology adoption.

1.2 Statement of the Problem

The adoption of improved agricultural inputs and techniques has been considered as a key route out of poverty in many developing countries. Understanding the determinants of technology adoption and of the diffusion process has long been a central theme in the development literature. Yet, agricultural innovations have often been adopted slowly and some aspects of the adoption process are still poorly understood. According to Feder *et al.*, (1985) factors that constrain for rapid adoption are mainly lack of credit, limited access to information, aversion to risk, inadequate farm size, farm tenure arrangements, insufficient human capital, absence inputs and transportation problems.

Researchers in Ethiopia have focused mainly on investigating socio-demographic factors influencing the adoption of modern technologies (Million, 2003; Chilot, *et al.*, 1996; Yohannes, *et al.*, 1990; Croppenstedt *et al.*, 1999; Workneh, 2000, Tenkir *et al.*, 2004; Lelisa and Mulat, 2002; Getahun *et al.*, 2006). However, theoretical and empirical works have given more emphasis on the effect of risk in influencing the adoption of modern technologies (Moscardi and de Janvry, 1997).

In this regard, a number of studies show that farmers' decision making is affected by their attitude towards risk. There is also evidence that poor farmers are risk averse. Risk bearing

LITERATURE REVIEW

Modeling household's decision to use a new technology is not an easy process. There is substantial variation in the methods and specifications of empirical studies of technology use. This section reviews some of the related works from previous studies. The types of models used in other empirical studies as well as the variables employed in similar studies will provide a foundation for this study.

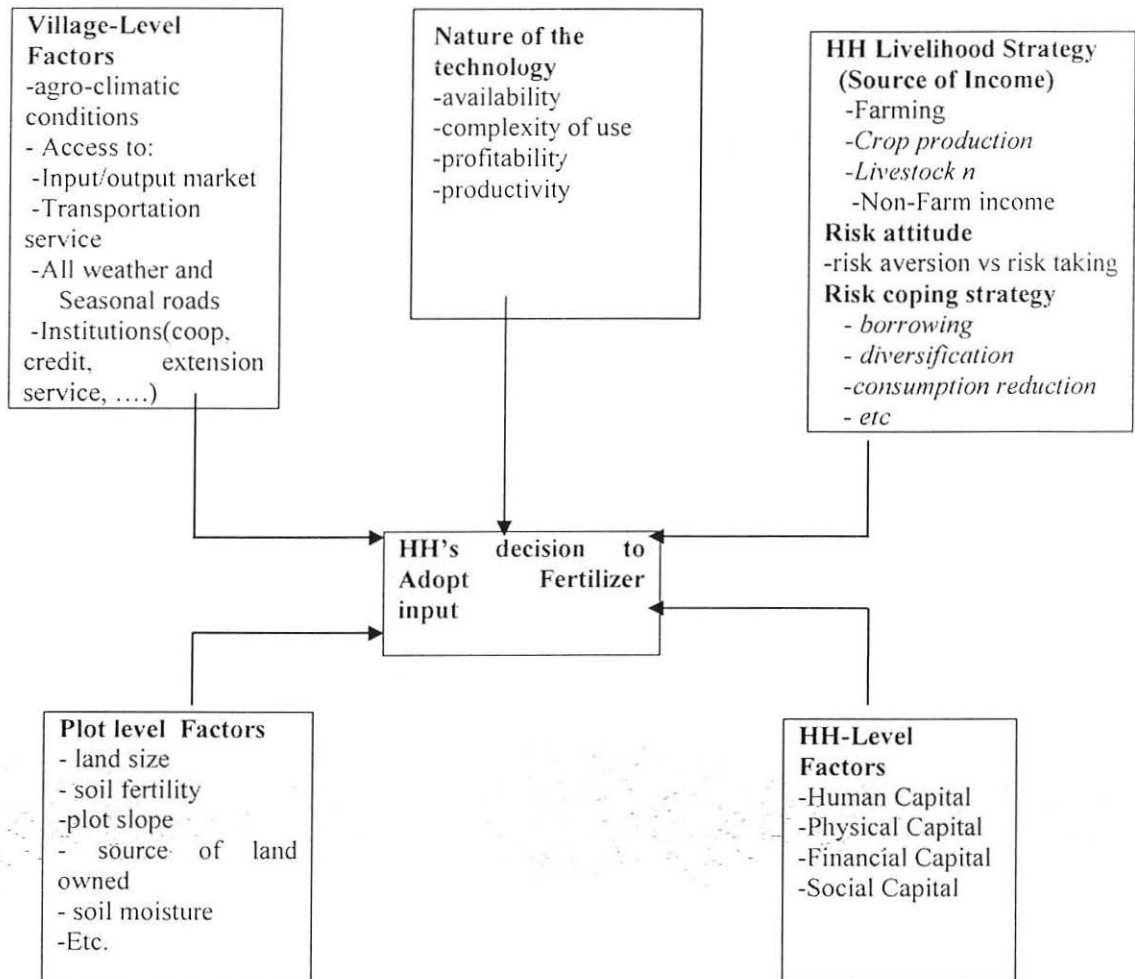
2.1 Theoretical Review

2.1.1 Conceptual Framework

In this section the theoretical and conceptual framework employed in the study is presented. As the schematic representation given below (fig. 1) shows the factors that influence adoption decision are multifaceted and complex. Thus, it is appropriate to set specific relationships for estimation and identify hypotheses that can be tested empirically.

The household factors, which could influence the farm household's decision on adoption modern agricultural input includes human capital (e.g. age, gender, educational status and training of household head, and household size), physical capital (e.g. land holding size and livestock endowment), social capital (e.g. membership in organization and/or associations, and contact with agricultural extension program), and financial capital (e.g. household's saving and access to credit). Moreover, the farm household's livelihood strategy, such as source of primary and/or secondary income of the household, will also have an impact on the farm household's decision to adopt modern input.

Figure-1: Schematic Presentation of the Relationships and Interdependence among the Various Factors That Affect Adoption of Fertilizer Input.



At individual household level, decision to adopt or not to adopt and to what extent could also be affected by plot-level factors, such as the size, slope, fertility, and means of ownership of the cultivable land. In addition to this, there are also village level factors, which could influence the farm household's investment decision, for instance, the level of annual average rainfall, the altitude of the village, population density, and access of the village to input/output market, transportation facility, and roads.

The characteristics of a particular modern agricultural input could also influence the decision to adopt the technology, as well as, the type of modern agricultural input to be adopted. These include its profitability, suitability to agro- ecology, complexity of use. On

the other hand, a farm household's decision to adopt modern agricultural input could have a direct influence on its livelihood strategies, which is manifested by the household's crop choice decision.

2.1.2 Research Hypotheses

As depicted in the above figure, the complexity of the interdependence among the different factors, made it difficult to take a separate examination of each factor under consideration. Hence, as hypothesized in various adoption studies this study wants to test the following major factors.

Household Livelihood Strategy (Source of Income)

- The impact of those households with both farming and non-farm livelihood strategies on input usage cannot be determined *apriori*.

Household Livelihood Risk Mitigation Strategy

- Poor farmers are risk averse than the rich, because they do not engage in more productive but riskier activities to smooth their minimum consumption level.
- Farmers risk aversion behavior inhibits the adoption of fertilizer

Household Human Capital:

- Younger farmers are expected to be relatively risk takers than older ones; thus, age is expected to have inverse relationship with use of fertilizer.
- Higher level of education and training are hypothesized to have positive association with risk- taking.
- Two opposing relationships are expected between risk-taking and family size. On the one hand, the larger the size of the family, the higher the subsistence consumption needs, and given a fixed land, the lower the willing of the farmer to assume risk. On the other hand, the household takes any options to achieve food security. Hence there will be positive association with adoption of fertilizer.
- Regarding sex of household head, female-headed households are expected to be less likely to adopt fertilizer.

Household Social Capital:

- The membership of household heads in organizations and/or associations (e.g. farmer's, women's, youth's associations, cooperative societies, etc.), is expected to have positive effect on adoption of fertilizer

Household Physical Capital:

- Household physical capital endowment – land and oxen—is expected to have positive relationship with its investment decision on fertilizer input.

Household Financial Capital:

- Household's endowment of financial capital (e.g. household saving and access to credit service), is obviously expected to have a positive relationship with a farm household's investment decision on modern agricultural input.

Access to market, transportation, roads and extension service:

- Access to market and transportation facilities is expected to increase use of fertilizer input
- The existence of relationship or contact between farm household head and agricultural extension programs will create a favorable environment for the household to easily access new innovations and technology interventions, as well as, expertise supports. Thus, household head contact with agricultural extension program is expected to have a positive impact on its decision to adopt fertilizer

Farmland factors:

- With respect to the influence of the characteristics of farm on the households input usage, households with farm size, suitable farm slope, and infertile plots are expected to increase use of fertilizer.

2.1.3 Defining Adoption of Technology

Feder et al. (1985) define technology adoption at farm-level (individual farmer) as " the degree of use of a new technology in long-run equilibrium when the farmer has full information about the new technology and its potential". The definition implies the intensity of use of a given technology as well as the length of time the given technology is adopted. But adoption can also be defined, as a binary decision to mean whether a given

individual used or did not use a given technology. This later definition will be used in this study.

2.2 Risk and Technology Adoption

2.2.1 Definition of Risk

The definition of risk is subjective, depending upon the nature or source of the risk and to what it is applied. As such there is no all-encompassing definition of risk (Greene, 2000). In this study some selective definitions are provided, which have particular relevance with the topic under consideration.

Risk is defined as

The probability of harmful consequences, expected losses(deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural and human-induced hazard and vulnerable conditions(www.unisdr.org/eng/library/lib-terminology-eng%20home.htm).

Smith (1999) defines risk as a decision expressed by a range or possible outcomes with attached probabilities. When there is a range of possible outcomes but no assumed probabilities, there is only uncertainty.

Another definition of risk to mean deviation from expected results is given as follows:

The chance of happening that will have an impact upon objectives. Risk can have both positive (upside risk) and negative (downside risk) consequences. For investments it is the chance that an investment's actual return will be different than expected- both higher and lower than expected (www.nzsuperfund.co.nz/index.asp).

Chicken & Posner (1998) as cited in Greene(2000) define risk as

$$\text{Risk} = \text{Hazard} \times \text{Exposure}$$

In this definition hazard is to mean “.. the way in which a thing or situation can cause harm,” and exposure as “.. the extent to which the likely recipient of the harm can be influenced by the hazard”. Harm is taken to imply injury, damage, loss of performance and finances, whilst exposure imbues the notions of frequency and probability (Greene, 1998:17). In this case expertise to anticipate and deal with risk is based upon ones experiences and the ability to learn from those experiences on certain hazards .i.e. risk perception.

2.2.2 Risk Categories

Morduch(1991, 1997), Fafchamps(1999) have identified the following risk categories:

- High and low frequency risk: high frequency risk factors are those with high mean rate of occurrence of shock and low frequency risk factors are those with low mean rate of occurrence like locust attack.
- Low intensity and high intensity risks which implies how seriously a risk factor affects the individual irrespective its frequency.
- Auto-correlated and non-stationary risk: if a risk occurrence or exposure to one type of risk results in other risk, it is auto-correlated. For instance, if malnutrition reduces the resistance and exposes to common diseases or crop failure may lead to malnutrition, in turn raises vulnerability to other risk factors it is said to be auto-correlated risk. On the other hand if certain risks have permanent damage- such as death and incurable diseases- such risk is non-stationary.
- Collective and idiosyncratic risk: Collective risk refers to risk factors that affect a group or community such as droughts, epidemics, and warfare, and idiosyncratic risk factors are those that affect isolated individuals, such as illness, unemployment, or accident.

2.2.3 Measuring Risk Aversion

Measure of risk aversion defined by Young (1979) as (... the amount of an individual will willingly pay to avoid participation in a fair bet, or risk premium". In other words the "risk premium for a risky action is the difference between its expected monetary value and certainty equivalent"(Ibid). Here the certainty equivalent of a risky action is the certain outcome that yields an identical level of utility.

Various studies in the area indicate risk aversion can be represented by the von Neumann-Morgenstern(vNM)¹ expected utility function (e.g., Mahmud and Bluffstone, 2007; Nigisti et al, 2007). Specifically, the second derivative of this utility function contains important information regarding the risk aversion of a decision maker. Nigisti et al,(2007 citing Mas-Colell et al., 1995) wrote vNM work provides the ground to use the expected utility model by a rational decision maker. This model views decision making under risk as a choice between alternatives. Under the framework of Expected Utility (EU) model, decision makers are assumed to have a preference ordering defined over the probability distributions for which the axioms of the EU model hold².

As to Mahmud and Bluffstone(2007)

In empirical studies, the three most commonly used measures of risk aversion are absolute risk aversion, relative risk aversion and partial risk aversion. Absolute risk aversion traces the behavior of an individual toward risk when his/her wealth rises and the prospect remains the same. Partial risk aversion examines behavior when the prospect changes, but wealth remains the same. Relative risk aversion looks at

¹ This convention recognizes these authors' pioneering contribution to the development of the expected utility model in vNM(1944),

² Expected utility (EU) theory rests on a set of axiomatic principles of rational choice:

- Ordering: individuals are willing to state preferences across all pairs of alternatives, and these preferences are transitive, in other words, having once preferred A to B, and B to C, they do not then prefer C to A;
- Continuity: there are no kinks in indifference curves.
- Independence: for any three prospects A, B and C, if A is preferred to B then an x per cent probability of A combined with a (1-x) per cent probability of C will always be preferred to an x per cent probability of B combined with a (1-x) per cent probability of C, whatever the probability x may be; in other words, once third options are introduced, they do not, however they are presented, alter the structure of an individual's preference between any two basic options (Moesly and Verschoor, 2005).

behavior when both the initial wealth and the level of the prospect rise proportionally.

Since Pratt (1964), the most commonly accepted characteristic of people's attitude toward risk has been Decreasing Absolute Risk Aversion (DARA). DARA implies that people are averse to risk and that their aversion decreases as wealth or income increases (Binici *et al.*, 2003).

DARA implies that a person will be more willing to accept a risky prospect as wealth increases. Increasing Relative Risk Aversion (IRRA) indicates that a person's willingness to accept a risky prospect declines when both the outcome and wealth increase proportionally. IPRA implies a decrease in the willingness to take a gamble as the scale of the prospect increases (*ibid*).

Empirical studies in technology adoption and risk observe that risky returns in agriculture occur because if the yields or prices or both are uncertain (Dillon, 1977 as cited in Simtowe, 2006). These uncertainties may arise from the influence of exogenous variables whose levels are unknown. If the probability distribution of a return relative to the uncontrolled variables can only be specified conditional on controlled variables, the choice and level of controlled variables will influence the distribution of the return. Therefore in such a case, the choice and levels of controlled inputs should allow for risk effects. For instance weather variation is beyond the control of farmers, but the level of risk (e.g., from crop failure) can be minimized by the farmers decision on agricultural investments.

Binici *et al.*, (2003) stated that empirical estimation of risk attitude starts with specification of a utility function that relates an individual's well being and his/her income or wealth. It implies the risk attitude of an individual produces can be represented by the shape of the utility function.

An individual is said to be risk neutral if the utility of the expected value is equal to the expected utility. In such cases the individual is said to have a linear utility function. An individual is said to be risk averse if his or her vNM utility function is strictly concave, thus if the utility of the expected value is greater than the expected utility. Similarly an

individual is said to be a risk lover if his or her vNM utility function is strictly convex (Takayama, 1993 as cited in Simtowe, 2006).

The most commonly used utility functions when assessing risk preferences are the negative exponential, power, expo-power and cubic functions (Binici et al., 2003). The basic assumption of an economic agents utility function is a positive slope over the entire range of payoffs. Based on this assumption risk attitude of farmers can be mathematically stated as $u'(w) > 0$, where $u'(w) >$ is the first derivative of the utility function with respect to w , which is usually either income or wealth. The second derivative of a utility function, or the change in marginal utility as the level of income or wealth increases, is a commonly used measure of risk aversion. Its sign is used to classify a decision maker's attitude toward risk. Specifically, $u''(w) < 0$ implies risk aversion, $u''(w) = 0$ implies risk neutral, and $u''(w) > 0$ implies risk preference (taking), where $u''(w)$ denotes the second derivative of the utility function with respect to wealth or income (Mahmud and Bluffstone, 2007).

Utility generally is measured on an ordinal scale. However, the problem in estimating risk attitude using utility function is the difficulty of transforming the ordinal scale into a quantitative measure of risk aversion. In several applied studies (e.g., Koundouri, et al, 2006, Groom, et al, 2006), the transformation process is anonymously done by linear transformation of a utility function using Taylor's Expansion Theorem. This measure is known as the coefficient of absolute risk aversion, or Arrow-Pratt (AP) measure of risk aversion coefficient. This coefficient is mathematically represented as $A(w) = -u''(w)/u'(w)$. $AR(w)$ can be interpreted as the change in marginal utility per a unit of change in the wealth or income of the individual. It is positive if the individual is averse to risk, zero if the individual is indifferent to risk, and negative if the individual prefers risk.

Given that farming is a business activity subject to risky events such as drought, especially in rain fed agriculture accompanied by erratic and unreliable rain fall like that of Ethiopia, an important factor in understanding the behavior and managerial decisions of farmers is their attitude toward risk. For example, the more risk averse a farmer, the more likely he or she is to make managerial decisions that emphasize the goal of reducing variation in income rather than the goal of maximizing income.

This study has employed the econometric approach as developed by Antle (1983 and 1987), using cross-sectional data for the researcher has believed to be relatively correct to explain the behavior of farmers' decision to use or not use fertilizer from their actual farm practices.

2.3. Risk Management Strategies

In analyzing risk and its implication on adoption of modern agricultural inputs (e.g., fertilizer) it is imperative to look on how the rural poor cope with risks. Two broad risk mitigating namely risk management and risk coping, which are also known as *ex ante* and *ex post* strategies respectively (Anderman and Paxson, 1992).

2.3.1. Ex ante Strategies: Reducing Exposure to Shocks

1. Consumption Smoothing

One way to reduce exposure to shocks is via "consumption smoothing". It means by engaging in activities and techniques of production that smooth income rather than maximizing profit (Morduch 1995), or that keeps income variation minimum (Fafchaps, 1999). Dercon and Christeinsen(2007) also state that to avoid such income variation rural households engage in less risky technologies and inputs including high varieties and fertilizer. However, one adverse effect of this strategy is that it may hinder technology adoption by farmers that raise the mean and variance of income (Feder *et al.*, 1985). This implies the risk aversion behavior of farmers.

This argument is not different from the exemplary work of Sandamo(1971) on risk and technology adoption in the absence of insurance. He argues that poor households are risk averse with out perfect insurance so that they use less input and under invest in production unlike the classical profit maximization principle. However, Sandamo's argument is not free of critiques. For instance recent works like that of Fafchamps(1999) argue poorer households will produce more and use more input as a way out of poverty and ensuring food security. Implicitly, this means the poor households are not risk averse as Sandamo

assumes. Recent findings of Fitsum and Holden (2004) are in support of Fafchamps argument.

2. *Selecting and Modifying the Environment*

This strategy refers to resettlements to areas with better rainfall, less exposure to disease such as malaria, better natural resource or better peace and security to reduce risk.

According to Fafchamps(1999), it is probably due to this reason that the East African highlands are more densely populated than other parts of Africa: malaria risk is lower at high altitudes. He also indicated the condition is so much true that Ethiopian populations severely affected by the 1984 famine vigorously resisted their relocation from the drought prone northern highlands to wet southern lowlands for fear of morbidity and mortality from exposure to malaria and other diseases⁴.

3. *Specialization*

Another way to reduce exposure to risk is for individuals to adopt production techniques that are resistant to pests, droughts, and other environmental risk factors. This implies specialization may serve as main income smoothing technique to reduce exposure to shocks.

4. *Diversification*

In contrary to specialization, usually risk coping is achieved via portfolio diversification. Rural inhabitants often seek to minimize their exposure to risk by diversifying their portfolio of income generating activities. Hogeveen *et al.*(2005) elaborated risk management in terms of moment of risk occurrence. The ex ante measure (before risk occurs) is done as prevention of risk from risk occurring. Household crop and job diversification and strategic migration are typical examples. Strategies to reduce the impact of risk- risk mitigation strategies- are also in this category.

⁴ "This is hardly surprising given that many of the resettled people were weakened by malnutrition and that a cholera epidemic was rampant among them. It is estimated that, of the one million people forcibly relocated in the wake of the 1984 Ethiopian famine, between 50,000 and 100,000 died within a year"(Fafchamps, 1999:7).

As noted by Fafchamps(1999) in areas with less extreme climatic conditions, for instance, farmers often plant different crops, or several varieties of the same crop to obtain a more stable output. Intercropping, that is, planting several crops in the same field is often partially justified by risk considerations as well or diversification is done via combining farm and non-farm activities within a single household. Similarly temporary migration to better area can also be seen as part of a diversification strategy.

5. *Self-sufficiency*

Another important dimension of risk is food security. Like anyone, rural households worry about being able to feed themselves. When markets are absent or not reliable, it becomes optimal for them to grow their own food self-sufficiency then becomes the natural route toward food security. It has been shown elsewhere that even when food markets exist, imperfect market integration may nevertheless generate enough food price volatility so as to provoke households to produce their own food.

2.3.2. *Ex post* Strategies: Saving and Liquidating Assets

If the *ex ante* strategies are no effective other options are adopted by poor households, i.e., *ex post*, that is, measures taken after shocks have been realized(Morduch, 1990; Fafchamps 1999; Hoogeveen *et al.*, 2005; Anderman and Paxson,1992) have identified the following major *ex post* strategies.

1. *Liquidating productive assets*

For an individual hit by an overwhelming shock, one obvious way to handle the situation is to liquidate productive assets in order to buy food, pay the rent, or take a child to the doctor. Asset liquidation, however, is likely to have a negative impact on future earnings. Households forced to sell their land, for instance, are likely to experience a permanent fall in income. Distress sale of productive assets are options to cope risk but a way to buy time in the hope that things will improve: with luck, future shocks will be better and the household will be able to purchase its assets back. This is, however, largely wishful

thinking: on average, there is no reason for things to improve. Households who sell productive assets are more likely to face difficulties meeting their consumption needs in the future, and thus more likely to sell assets again (Fafchamps, 1999).

2. Reducing Consumption to Keep Productive Assets

Liquidating productive assets to deal with shocks can be extremely damaging to one's long run welfare. For instance, selling farm oxen or seed may have severe and permanent negative consequence on the household's future production and food security. Consequently, it is perhaps not too surprising to find that poor rural dwellers often prefer to reduce their consumption rather than liquidating productive assets.

Household's desire to protect their assets is not, however, always possible if households do not have access to other ways of sharing risk. As the work of Zimmerman and Carter(2003) demonstrates, distress sales will occur even if households correctly anticipate that they will not be able to buy their assets back because of the negative correlation between shocks and asset prices. This is because survival, even at a lower level of utility, is always better than starvation.

3. Precautionary Saving

Saving is one way by which households can protect themselves against the damaging consequences of distress sales to productive assets without having to reduce consumption: in anticipation of future shocks, households may build up liquid reserves that can be sold or consumed in times of need. In the literature this practice is commonly referred to as "precautionary saving". The liquid assets that are accumulated in this manner by poor rural dwellers include food stocks, gold and jewelry, cash, and, provided a bank is close by, and deposits on savings.

4. Borrowing

We have seen that asset accumulation can serve to smooth consumption. Faced with a sufficiently long series of bad income and shocks, individuals will nevertheless run out of assets and will no longer be able to absorb shocks by liquidating assets. One conceivable

way out of this difficulty is to let households' asset position become negative, that is, to let households borrow. However, credit constraints are unavoidable if credit contracts are strict, that is, if creditors insist on repayment under any circumstance.

2.4 Review of Empirical Literature

A substantial amount of studies on adoption and its determinants have showed that poor people are risk averse and their production is characterized by high degree of uncertainty (Dercon and Christensen 2007). Feder and Umali (1990) in reviewing factors that affect technology adoption underline risk preference as key determinant of most agricultural innovations.

Coady(1993) in analyzing the use and intensity of fertilizer use in Pakistan found that credit access is positively correlated with farm size, but intensity(level of use) of fertilizer decreases with farm size. This implies although larger farms have higher level of non-stochastic wealth which, in the presence of decreasing absolute risk aversion, has the effect of increasing fertilizer intensity with farm size, the presence of increasing relative risk aversion means the net relationship between farm size and fertilizer intensity is negative.

An empirical analysis of demand for fertilizer in Ethiopia by Croppenstedt *et al.*,(1999) report that credit as major constraint to fertilizer adoption. In addition they indicate that land size and education coefficients are positively correlated with use for fertilizer. Dercon and Christensen(2007) has examined the impact of risk on the adoption of fertilizer in Ethiopia. They report fertilizer application rates, though found to be profitable in raising the mean income, are significantly lower due to downside risk aversion in its consumption.

However, a recent study by Fitsum and Holden(2004) show that risk preference has no significant effect on households decision to adopt fertilizer. To the contrary, the decision to adopt fertilizer has positive association with risk aversion. The explanation provided for their findings is that risk adverse households may opt to use fertilizer as way out of disaster level income and their motive to ensure food security. Their results show factors such as

access to market, working capital and asset holdings are major determinants of fertilizer in northern Ethiopia.

A recent work by Dercon and Christensen (2007) tries to link risk, fertilizer adoption and poverty. In their analysis they incorporated high yielding varieties and fertilizer as risk input with an assumption of these inputs affect both the mean and variance of yield. They also pointed out that “Fertilizer use in Ethiopia has remained limited despite concerted efforts by the government to promote its adoption through improved extension services and access to credit” (Dercon and Christensen 2007:3). Several factors are mentioned as primary reasons.

Lelissa and Mulat (2002) examined the determinants of adoption and intensity of fertilizer in Ejere District. They reported cash (credit), land tenure, oxen, age and manure as significant factors to fertilizer adoption. They suggest government action to mitigate these constraints could improve the adoption and intensity of fertilizer use. However, no thing is said about the risk preference of the farmers in this study.

Another study by Beyene (2000) has analyzed the efficacy of agricultural technology among farmers with different resource endowment. His results show that resource rich farmers (such as large family size, oxen size, and family size) were relatively better to adopt improved agricultural technology than poor farmers. However, this study has also failed to consider the impact of risk perception on technology adoption among the different wealth groups.

Tenkir *et al* (2004) tried to link the role of extension service on technology adoption and diffusion. The findings report that farmers become reluctant to adopt fertilizer for fear of strict enforcement of repayment of loans after they experienced pervasive drought as occurred in 2002.

Formal input credit (short term or seasonal credit) is common in Ethiopia, for example as provided by regional governments without collateral (Dercon and christensen, 2007). However, it is not without default of repayment. For instance, about 20 percent of the sample farmers failed to repay fertilizer credit mainly due to crop failure and they were

exposed to severe penalties such as imprisonment or sell of livestock or other fixed assets or food items (Tenkir *et al.*, 2004). The implication is that risk of crop failure in the absence of insurance hinders technology adoption such as fertilizer. Another important implication of this finding is that unlike many other findings, even in the presence of wide spread credit access fertilizer adoption may be constrained by risk avoidance with out crop insurance.

The important point to be noticed here is that, is fertilizer perceived by farmers as a risk increasing or risk reducing input?. Inputs could be perceived as risky if knowledge about the new technology is limited, which raises uncertainty and this uncertainty declines a farmers become familiar with the new technology (Hiebert and Dean 1974). In the empirical analysis by Dercon and Christensen (2007) they provide evidence that fertilizer results in more risk yields due to the associated costs and absence of crop insurance. Hence, fertilizer use rates are significantly lower due to downside risk version. There findings also suggested there is a link between downside consumption risk and modern agricultural input adoption. As a result the poorer households reduce adoption of profitable input as means of protecting themselves against risk.

Another exemplary study is done recently by Fistum and Hoden (2004). They analyze linkage among farmers risk preference, the use and intensity of use of fertilizer and food security. Unlike many other adoption studies in Ethiopia, the basic hypothesis of the study was that both risk and risk aversion may encourage farm households, to use fertilizer as a means of achieving food security. It seems similar to that of Fafchamps (1999) and Hoogeveen et al (2005). They report risk preference rates as highly significant variable and positive association with fertilizer use. It implies households risk aversion and use of fertilizer has positive association.

These findings seem contrary the safety first model developed by Moscardi and de Janvry (1977), which is pointed out high risk aversion (premium) as a cause for low fertilizer use in Puebla, Mexico.

The safety principle is adhered as increasing relative risk aversion behavior. It is exhibited when the farmer attempts to minimize the probability of falling below some fixed “disaster” level of wealth. In the safety model the decision maker presumed to be interested in maximizing is expected value of his investment subject to some probability constraint on going below the disastrous level of wealth (Sadoulet and de Janvry, 1995).

Existing evidence is consistent with the idea that relative risk aversion is decreasing for low-income households. The famous work by Rosenzweig and Binswagner (1993) report that Indian farmers are in general risk-averse, but the wealthier they are, the less their investment portfolios are affected by increasing weather risk. Similarly, using survey data from U.S, Barsky et al (1997 as cited Sadoulet and de Janvry, 1995) report that RRA tends, to increase slightly from the first to the third wealth quantities and decreases slightly from the third to the fifth quantities.

Recent evidence from Ethiopia supports DARA hypothesis (Mahmud and Bluffstone, 2007). They stated that “After initial successes have convinced farmers that technologies are viable (i.e. after they had some good luck) risk aversion declines.” Their findings have also shown that risk aversion differs between the relatively poor and wealthy households, i.e, the more wealthier the farm households the more they will be willing to engage in more riskier activities for higher returns.

Assuming a farmer whose income is uncertain, his welfare function will serve to measure the welfare cost of risk. This leads to theory of behavior under risk that farmers maximize their welfare as a function of profit. Farmers’ welfare can also be measured by the expected utility of income. The difference between the expected utility of random income and the utility of sure income is a measure of the cost of risk in terms of the welfare of the farmer, which is also known as the certainty equivalent of income. Similarly the difference between the certainty equality and the sure income gives the average income that the farmer is reality to give up to exchange random income for sure income, which is also known as the risk premium (Saduolet and de Janvry, 1995).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research Design

Kumar(1996) states that cross-sectional , or ‘status study’ is simple and the most commonly used design in social sciences. According to him this design is best to study the prevalence phenomenon, situation, attitude or issues, by taking a cross-section of the population. Such survey methods could be adapted to collect generalizable information from almost any known human population.

Technology adoption is a process than an event. Farmers’ decision may change over time and hence there is a tendency of moving in and out of adoption. Accordingly, determinants also change over time. Because of such very nature of the subject, attitudes of farmers towards risk and technology adoption can be also best studied by having a panel of observations in a longitudinal study design. However, longitudinal study design often requires taking repeated measurements, which has cost and time implications. Because of the time and cost involved and for it suffers from attrition, panel conditioning changes in the measuring procedures and absence of guidelines particularly with respect to time interval, it is a relatively little used design in social research (Dooley, 1995).

For a thesis work like this, which is supposed to be completed in limited period , cross sectional study design is the most appropriate one. Hence, this research employed cross sectional research design.

3.2 Sample Size and Sampling Techniques

Despite to the critics of error in generalization and prediction, Dooley (1995:124) pointed out that “[s]ocial science has come to depend on sample surveys because the alternatives to them are either a census (that is, a survey of everyone in the population) or no information at all. Social scientists regard census as impractical since only national governments have the resources to contact everyone and the legal mandate to require that everyone

cooperate". Kumar (1996) also pointed out that sampling usually enable a researcher to reduce costs, reduce manpower requirements, and save time.

For the above practical reasons, this study uses a sample survey. To achieve the research objectives, data was collected from a sample of 120 household heads using a survey questionnaire. The data was collected from two *Tabias*(peasant associations) in *Saesi Tsaeda Eamba Woreda*, Eastern Zone of Tigray. The Woreda was selected purposively from based on the researcher's past experience. The *Tabias* were selected using multi-stage sampling method. The total *Tabias* in the selected Woreda were clustered into relatively fertilizer users and completely non-users in consultation with the Woreda Agriculture and Rural Development Office. As a result six *tabias* were found to be relatively sound for this study. These *Tabias* were further stratified into two strata based on their agricultural potential in consultation with the aforementioned Office. Next, two *tabias* were randomly selected from each stratum; namely *Welwalo* representing the relatively better potential *tabias* and *Imbasemena* representing the relatively low agricultural potential *tabias* of the Woreda.

In general the two *Tabias* are characterized by: mainly cereal producers; highly degraded land which requires fertilizers to increase production and productivity. Thirdly, they are characterized by chronic food unsecured. Fourthly, they enjoy relatively better rain fall thus, adoption of fertilizer is recommended by the government. And lastly, the two *Tabias* comprises relatively proportional adopters and non-adopters of chemical fertilizer which helps to compare the risk preferences of households.

In this study households are the units of analysis. The household survey was conducted on a total of 120 households. The sampling frame for the study was a complete list of households in the two PAs, obtained from respective *Tabias* Administrations. Survey sampling has two goals: providing unbiased samples and sample estimates with the smallest sampling error. The solution to the problem of bias and sampling error is probability sampling (Dooley, 1995). Accordingly, the method of sampling applied to select the sample households was probability sampling. The sample size of each PA was decided based on proportional sampling technique and adopters and non-adopter

households were represented proportionally. Lastly, selection of the households for the survey was based on systematic random sampling.

3.3 Source of Data and Instruments

Farmers' decision making under risk is complex, multidimensional and an outcome of multitude of causes, neither quantitative nor qualitative methods alone could capture the salient features in a comprehensive way. However, the method used in this study is to analyze the behaviors of farmers quantitatively. Thus for the purpose of attaining objectives of the research and testing the stated research hypotheses, quantitative data were used.

The data for the study was collected both from primary and secondary sources. The main source of primary data was the household survey. Structured questionnaire was used to collect information on socio-demographic characteristics input use and cropping pattern at plot level, resource endowment, and types of shocks the sample households' face and their risk coping strategies are few to mention.

Secondary data source used for the study includes published and unpublished materials, donor and government agency reports and project documents.

3.4 Method of Data Analysis

The study heavily depends on quantitative method of data analysis. The study used descriptive statistics (averages, cross-tabulation, percentages, etc.) as well as econometric models (OLS and Binary Logistic Regressions). In the descriptive analysis statistical tests (t-test and chi-square test) were used to show significance of variables variation. To this end, the study employed version 12 of the Statistical Package for Social Science (SPSS) and STATA version 9.

Previous adoptions of new technology studies have utilized a variety of econometric models. Production functions have been used to examine adoption and levels of fertilizer

use. Feder *et al.* (1985) present additional studies that analyzed the use of fertilizer or other new technologies utilizing similar ordinary least squares (OLS) methods. A newer method in this area of study is to incorporate a Bayesian learning model. Applied to a household's decision to adopt fertilizer, the assumption behind this model is that the household will try the new technology, in small trials or on specific fields for instance, to see whether or not its performance, in output or return on investment criteria, meets their expectations. The household may perform trials, watch neighbors' performance, or gain information from extension workers before more widely adopting or entirely rejecting the use of the new input (Feder *et al.* 1985).

Many adoption studies also utilized maximum likelihood estimation techniques. Among the more commonly used estimation techniques are tobit, logit and probit. These models are more appropriate than OLS for analyzing the decision to use a new technology (Feder *et al.* 1985). Because of the underlying specifications of these maximum likelihood models, they have a more discrete range of values. The dependent variable takes the values zero and one in the case of the logit and probit models

As previously described, the decision to adopt fertilizer in this study will be modeled as a binary decision: a household either uses or does not use fertilizer.

In situations such as this when the dependent variable is a discrete dummy variable (adopter = 1; non-adopter = 0), linear estimation is inappropriate for at least three reasons (Green 1993, Wooldridge 2000). First, the error term cannot be normally distributed since it can take only two values. Second, the error is heteroskedastic because it can be shown that the variance of the error term is not constant. Third, the estimated probabilities generated via a linear estimation would not necessarily lie between zero and one. Probabilities greater than one or less than zero are not acceptable; e.g. the use of fertilizer can not be predicted with over one hundred percent certainty.

For the reasons outlined above, estimating a binary response model typically utilizes maximum likelihood estimation (MLE) techniques (Wooldridge 2000). Appropriate MLE models include the logit or probit model. The difference between these techniques is

insignificant (Green 1993). The current study utilizes a logit model to analyze the factors influencing the adoption of chemical fertilizer in the study area. This model is specified in section 3.5.2 to follow.

3.5 Model Specification

3.5.1 Model Used to Estimate Risk Aversion

To estimate the risk attitude of farmers Antle(1983) has developed a flexible moment based approach. This approach can be specified following Koudouri *et.al.*,(2006) and Groom *et al.*, (2006), as follows:

For simplicity let us consider a risk-averse farmer who produces a single crop with output q . Let p denote the output price, $f(\cdot)$ is the production function which is assumed to be continuous and twice differentiable, f is the fertilizer input, x_0 is the vector of other inputs and r is the vector of input prices.

Applying fertilizer in the production of q is considered to be an important input. Assuming that inputs are chosen to maximize the expected utility of profit $EU(\pi)$. The total profit of a farm activity can be expressed as:

$$\pi = \sum_{i=1}^n pf(f, x_0) - r_f f - r x_0 \quad [1]$$

The von Neumann-Morgenstern(vNM)⁵ utility function $U(\cdot)$ represents risk preferences of a farmer. The farmer's utility maximization problem is:

$$\text{Max}_{xof} EU(\pi) = \text{Max}_{xof} \sum_{i=1}^n pf(f, x_0) - r_f f - r x_0 \quad [2]$$

Allowing for risk aversion and assuming the cost of private risk bearing to be R , then the farmer's problem is to maximize the certainty equivalent of profit given as:

$$EU(\pi) = U[E(\pi) - R], \quad [3]$$

⁵ vNM utility function is also known as expected utility function

The term is proportional and has an opposite sign to the marginal risk premium with respect to fertilizer specified in equation 6.

Econometric Estimation of Risk Attitudes

In general the approaches used to elicit individual risk attitudes can be categorized into an experimental and econometric approaches. The former approach is based on hypothetical questions on risk alternatives or risky games with or without real payments; the latter is based on individuals actual behaviors(Wik and Holden 1998; Nigisti et al., 2007).

In using the econometric approach the works of Moscardi and de Janvry(1977), Antle(1983) and (1987), Pope and Just(1991) are prominent foundations. This study adopts the works of Antle: a flexible approach which estimates not only mean output as a function of inputs but also the variance and higher moments as a function of inputs.

Antle (1987) proposes a moment based approach to estimate risk-attitude parameters of a population of producer. We assume that a farmer maximizes a function of moments of the profit distribution. We firstly estimate the risk-premium of each farmer associated with the use of fertilizer which is later incorporated as one explanatory variable with other farmers characteristics using a logit model as specified in the next section. Following this approach, the farmer's program becomes:

$$\text{Max } E[U(\pi)] = [f(\mu_1(X), \mu_2(X), \mu_3(X), \dots, \mu_m(x))] \quad [7]$$

where $\mu_j, j=1,2,\dots, m$ is the m^{th} moment of profit.

The first order condition of the program is approximated by the following Taylor Expansion, in matrix form. The Taylor series approximation is used to approximate a non-linear function by transforming into linear function (Gugarati 2007). Taylor theorem states that any arbitrary function $f(x)$ that continuous and has continuous n^{th} -order derivative can be approximated around a point $x = x_0$ (in this study x_0 is mean profit of fertilizer use).

Following the Taylor's expansion, one can derive the marginal contribution of input j to the expected profit from equation (7) as follows:

$$\frac{\partial U_1(X)}{\partial X_j} = \theta_{1j} + \theta_{2j} \frac{\partial u_2(X)}{\partial X_j} + \theta_{3j} \frac{\partial u_3(X)}{\partial X_j} + \dots + \theta_{mj} \frac{\partial u_m(X)}{\partial X_j} + u_j \quad [8]$$

The analysis will be made input by input⁶ to capture the effect that each input contributes differently to the moments of profit distribution (Groom et al., 2006). The expected result from the analysis is that both inputs increase the mean profit, but for variance (second moment of profit), inputs can be risk-increasing or risk decreasing.

From equation(8), the marginal contribution on input j to the expected profit is given by

$\frac{\partial u_1(X)}{\partial X_j}$. This can be written as a linear combination of the marginal contributions of input

j to -the other moments such as variance ($\frac{\partial u_2(X)}{\partial X_j}$) and skewness($\frac{\partial u_3(X)}{\partial X_j}$).

(Groom *et al.*, 2006). A nice feature of this model is that the parameters θ_{2j} and θ_{3j} are directly interpretable as Arrow-Pratt and down-side risk aversion coefficients respectively (Groom et al., 2006, Koundouri *et al.*, 2006).

The Arrow-Pratt (AP) absolute risk aversion coefficient is defined by:

$$AP_j = \frac{-E(U''(\pi))}{E(U'(\pi))} = \frac{\partial F(X) / \partial \mu_2(X)}{\partial F(X) / \partial \mu_1(X)} = 2\theta_{2j} \quad [9]$$

A positive AP coefficient means that the farmer is risk -averse. Down -side (DS) risk aversion is measured by

$$DS_j = \frac{-E(U'''(\pi))}{E(U''(\pi))} = \frac{\partial F(X) / \partial \mu_3(X)}{\partial F(X) / \partial \mu_1(X)} = -6\theta_{3j} \quad [10]$$

According to (Groom *et al.*, 2006) “[a] positive DS coefficient means that the farmer is averse to down-side risk, where Downside-risk aversion can be thought of as a preference for disaster avoidance”. The further stated that “Downside-risk is concerned with symmetric (skewed) statistical distribution of profit and in particular aversion to disastrous events. Usually the higher moments have less influence on the dependent variable, as such

⁶ Fertilizer input will be considered here as it is important factor inputs in the study area.

this analysis will concentrate of the first three moments (i.e., mean, variance and skewness) (Koundouri *et al.*,2006).

The AP_j and DS_j can be used to estimate the risk premium, RP. Assuming the farmer is concerned by the first three moments of profit distribution only, the RP is computed as:

$$RP_j = \mu_2 RP_j /2 - \mu_3 DS_j /6 \text{ for } j. \quad [11]$$

where μ_2 and μ_3 are , respectively a measure of the second- and third-order moments of the distribution as stated above. “ $RP_j > 0$ may mean that the farmer is characterized by a positive willingness to pay to be insured against the risk associated with the use of input j” (Koundouri et, al.,2006). The risk premium derived from the process is used as an explanatory variable in the adoption model later on.

3.5.2 Model Used to Estimate Determinant of Fertilizer Adoption (the Logistic Regression Model)

Gujarati (2007) and Kennedy (1996) pointed out that in logistic regression model, we directly estimate the probability of an event occurring. For the case of a single independent variable, in our case the decision to adopt (1=if yes and 0= otherwise)⁷, the logistic regression model can be written as:

$$\text{Prob (event)} = \frac{e^{B_0 + B_1 X}}{1 + e^{B_0 + B_1 X}} \quad [12]$$

Or equivalently,

$$\text{Prob (event)} = \frac{1}{1 + e^{-B_0 + B_1 X}} \quad [13]$$

Where, B_0 and B_1 are coefficients to be estimated from data

X is the independent variable

⁷ The explanatory variables of the independent variable and the expected signs of their respective coefficients are deined et the end of this section(Table 3.1).

e is the base of the natural logarithms.

For more than one independent variable the model of using fertilizer can be written as

$$\text{Prob (use)} = \frac{e^Z}{1 + e^Z} \quad [14]$$

Or equivalently,

$$\text{Prob (not use)} = \frac{1}{1 + e^{-Z}} \quad [15]$$

Where, Z is the linear combination of independent variables written as

$$Z = B_0 + B_1X_1 + B_2X_2 + \dots + B_pX_p \quad [16]$$

Equation (14) represents the logistic distribution function. It varies from 0 to 1 as z varies from positive infinity to negative infinity.

The probability of not using fertilizer by a household is estimated as:

Prob (not use) = 1 - Prob (use); Let the probability of use be denoted by P_i

$$\text{Thus, } 1 - P_i = \frac{1}{1 + e^Z} \quad [17]$$

$$\text{Therefore, } \frac{P_i}{1 - P_i} = \frac{1 + e^Z}{1 + e^{-Z}} = e^{Z_i} \quad [18]$$

Now the expression on the left side implies the odds ratio in favor of using fertilizer. This means the probability that a farmer will use fertilizer to the probability that he will not use.

Taking logarithm of equation(18) give:

$$\text{Log}(e^{Z_i}) = Z_i = B_0 + B_1Z_1 + \dots + B_pZ_p \quad [19]$$

From equation (19), the logistic coefficients can be interpreted as the change in the log odds associated with a unit change in the independent variable. Since it is easier to think of odds rather than log odds, the above equation can be re-written in terms of odds as:

$$\frac{\text{Prob (use)}}{\text{Prob (no use)}} = e^{B_0 + B_1 Z_1 + \dots + B_p Z_p} \quad [20]$$

The interpretation of equation(20) is as follows. e raised to the power B_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If B_i is positive, the factor will be greater than 1, which means that the odds are increased. If B_i is negative, the factor will be less than 1, which means that the odds are decreased. When B_i is zero, the factor equals 1, which leaves the odds unchanged. For further clarity of interpretation partial derivatives of the adoption model coefficients (not specified here) were also estimated.

Table3.1: Variables Definitions Used in the Regression Analyses

Explanatory Variables	Definition
HH Characteristics	
Age(-)	Age of the household head in years.
Sexdmy(+)	sex of respondent: male= 1, Else=0
Matrital(-)	Marital status of HH head: married=1, Else=0
HHeduc(+)	Education status of HH head 1=literate, 0= otherwise
Training(+).	Last year's HH training on modern input, yes=1, Else=0
Membership(+)	Membership status of HH head in organization; Yes=1, Else=0
Hhsize(+/-)	Total number of household members .
off_farm(+/-)	Sum of last year's off-income income in Birr.
Noxen(+)	Number of oxen owed by the HH.
Credit(+)	Credit access of HH; Yes=1, Else=0
Extension(+)	Number of ext. visits
Q2(+)	Arrow-Pratt risk coefficient
Q3(-)	Downside risk coefficient
Landdmy (+)	HH land ownership in timad; \geq mean= 1, Else=0
risk_gro- 1(-)	the HH is in the risk averse group; Yes=1, Else=0
Irisk_gro- 2(-)	the HH is in the risk taker group; Yes=1, Else=0
Plot Characteristics	
lsize_timad(+)	size of cultivated area in timad.
slop_cat((-)	slope category of majority of HH land; flat and mid slope=1, Else=0
soil_ferti(+)	soil fertility category of majority of HH land; infertile=1, Else=0
sour_land (-)	source of majority of land; government and inherited =0, Else=1
manure_use(-)	amount of manure or compost use in Birr
<p><i>Note:</i></p> <ul style="list-style-type: none"> • <i>Dependent variable- decision to adopt</i> • <i>signs (+/-), in braces indicate the expected sign of coefficients of the specified variable to fertilizer adoption.</i> 	

CHAPTER FOUR

AREA DESCRIPTION

4.1 Tigray Region

The region is situated in the northern part of Ethiopia and covers an approximate area of 54,000 square kilometers with a total population of 4,449,000. Geographically, the regional state lies roughly between 12° 15'-14° 57' North latitudes to 36° 27'-39° 59' East longitudes. The Afar region bounds Tigray to the East, the Sudan to the west, Eritrea to the North, and Amhara region to the South (Tigray Regional State, 2007 as cited in Tewelde, 2007).

Both population and livestock population are believed to be beyond the carrying capacity of the land. Most of the cultivable land (64%) is planted. The average yield is around 0.6 tons/ha significantly below the national average for grain yields of between 0.8 and 1.3 tons/ha . The area suffers from serious land degradation and soil loss and from highly unreliable and erratic rainfall (Croppenstedt *et al.*, (1999).

Like any other regions of the country, agriculture is the mainstay of the region's economy. Agriculture is characterized by mixed (crop-livestock) farming system. It contributes about 57% to regional GDP. Rain fed crop production accounts for about 85% of the population's livelihood. Livestock rearing under mixed farmers system also contributes about 17% to the regional GDP. The major crops of the region are sorghum, *Teff*, barley, finger millet(dagusa), wheat, and maize accounting for 26%, 16%, 12%, 11%, and 7% of the total area(BoFED⁸, 2004 as cited in Girmay, 2006).

Fistum and Hoden(2004:16) state that " Agriculture production in the region is highly risky not only because of the recurrent drought and adverse weather conditions but also due to deteriorating land quality owing to land degradation". The study also pointed out

⁸ Represents Bureau of Finance and Economic Development

that access to infrastructure and institutions, such as market for inputs and outputs, road and transport, storage facilities; etc in the region is limited.

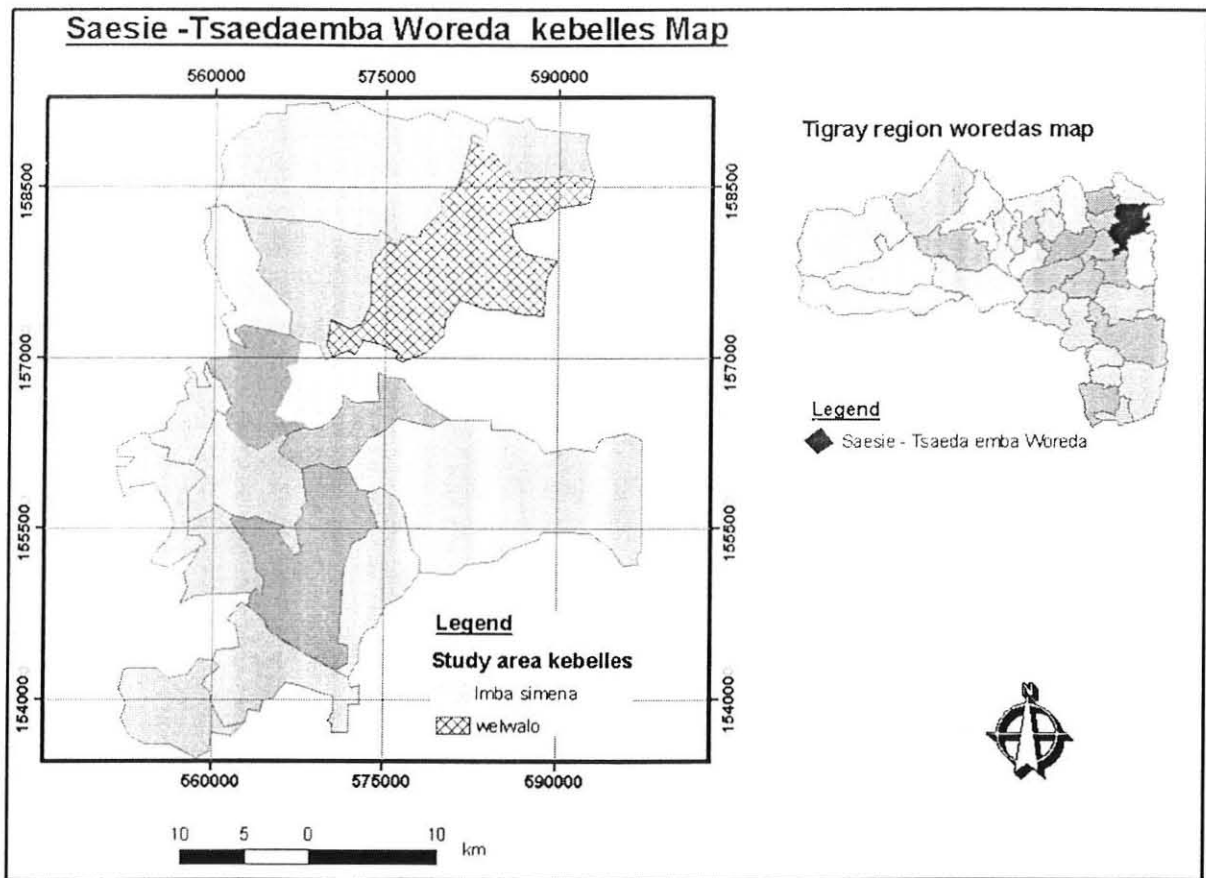
4.2 Study Woreda

The study area, Saesi Tsaeda Emba Wereda is located in Northeastern part of the Eastern Zone of Tigray Region, with an area of 94,000 hectares, of which 19,365.75 hectares is arable land. About 98% of the area lies on midland, 1 % Highland and 1% lowland. The average annual rainfall of the Woreda ranges from 500mm to 900mm. As to Berhanu and Pender(2006) areas that receive annual rainfall of less than 1000 mm are categorized as low rainfall areas. According to this classification, the Tigray highlands were all categorized as low rainfall since the maximum annual rainfall in the region was below 1000 mm. Accordingly, the study Woreda is generally characterized by low rain fall. In addition the agricultural potential of the area is the poorest due to poor soils and high land degradation in addition to the low annual rainfall.

The total population of the Saesie Tsaeda Emba Wereda is estimated to be 132,000; and agriculture is the mainstay for 90% of the total population. There are 24 Tabias⁹ in the Wereda, of which two of them are Uraban Tabias: Freweini(the Woreda Town) and Edagahamus. The main crops grown in the area include barley, vetch, chickpea, wheat, flux, teff, millet, maize, sorghum, field pea, beans and lentils(Tewlde, 2007).

According to the Woreda Agriculture Office(2007), the area is severely deforested and prone frequent rain failure. It is also characterized by densely populated with 0.68 hectare average landholdings, where residents cultivate on steep mountain sides in search of additional cultivable land. Berhanu and Pender(2006) indicated in Tigray, the average area of a community in the high population density areas was 40 km², compared with an average area of 106 km² in the low population density areas. The woreda population density is believed to be higher than the regional average.

⁹ *Tabia* is the lowest administrative unit in Tigray usually comprising of four to five villages.



It is chronically food insecure area, where the major food crops cultivated are wheat barley and maize. Almost all households in the Woreda are net food buyers. The productive safety net programs supplements to households' food intake. And *Beles*(cactus) is consumed in summer season in the area.

4.3 The Study Tabias

The case study Tabias have been selected from two adjacent Tabias in the Wereda: namely, Welwalo and Imbasmena. The method of selection was specified in section 3.2.

Welwalo is one of the 24 Tabias in Saesie Tsaeda-Emba Wereda. The Tabia is situated about 10 km. east of the small town of Edagahamus, on a mid-highland plateau at an altitude of 2200m.a.l. The Tabia located on the escarpments of Afar Region from east. With regard to the accessibility, public transport passes through the two tabias along the standardized rural gravel road. There is rural market, electric power and other social

institutions at the Tabia center. The total population in the Welwalo is about 2,861. The average land-ownership is 0.67 ha per household. There is no irrigation site and around 30% of the Tabia farmers are categorized fertilizer users. It has relatively better agricultural potential than Imbasemena Tabia..

Imbasemena is the second Tabia selected for this study. The total population of the Tabia is about 5,879. The Tabia located at an altitude of 2000-2006 mts. a.l. and is located around 7 km, away from the small town of Edagahamus. The average land-ownership is 0.54 ha per household. Other factors are more or less similar to Welwalo except its lower agricultural potential.

which are around 30kms away from the sample Tabias. Three variables of particular interest with regard to access to institutions were membership of the farmer to any organization/association and access to extension and training service. The survey result is presented in tables 5.3 and 5.4.

Table 5.3: Access to Institutions by Type of Respondents

Household type	Membership to any association.*		Formal training about modern input**	
	No	Yes	No	Yes
Adopter	1 (1.7)	59 (93.3)	13 (22.4)	47 (75.8)
Non-adopter	4 (6.7)	56 (98.3)	45 (77.6)	15 (24.2)
Total	5 (4.2)	115 (95.8)	58 (48.3)	62 (51.7)

* $\chi^2 = 1.878$; Asymp. Sig. (2-sided) = 0.171

** $\chi^2 = 35.5$; Asymp. Sig. (2-sided) = 0.000

Note: numbers in braces indicate percentages.

Source: Survey data, 2008.

Household heads who are member of groups or associations were assumed to have better access to direct or indirect assistance in agriculture. For example, membership in farmers' association may give many advantages like price information, better access to inputs, and credit. Such network may also play an important role in obtaining oxen, fertilizer, and seed credit during cropping seasons. To examine the social capital effect on fertilizer adoption a variable membership was included in both descriptive and econometric analyses.

The survey result on farmers' membership in associations shows that almost all adopters were members in farmers associations and only 6.7% of the non-adopters were not member in any organization. The difference is not statistically significant. Usually farmers in the study area were members of farmers', youth or women's association or/and co-operative groups, for political, social or economic reasons. However, problems

cited by farmers were that the associations have no relevant service, and they charge high membership fee. Thus, the variable may not have significant impact on fertilizer adoption.

Farmers training and visit by extension agents were assumed to have positive association with adoption of modern inputs. Training was given to 75.8% of adopters and to 24.2% of non-adopters. Training service received by adopters is by far larger than received by non-adopters. This difference is also significant at 1 percent level. It implies that knowledge of adopter on the application of fertilizer is higher than non-adopters. It also indicates the variable had influenced use of fertilizer in the area.

Table 5.4: Number of Visits per year by Extension Agents in 2007/08 Cropping Season.

Number of visits		Respondents category		Total
		non-adopter	adopter	
1	Number	13	4	17
	%	21.7	6.7	14.2
2	Number	10	10	20
	%	16.7	16.7	16.7
3	Number	37	45	82
	%	61.7	75.0	68.3
4 to5	Number	0	1	1
	%	.0%	1.7	.8
Total	Number	60	60	120
	%	100.0	100.0	100.0
$\chi^2= 6.55.$ Asymp. Sig. (2-sided)= 0.088				

Source: Survey data, 2008.

The number of visits by extension agents per year was also skewed towards adopters. On average farmers were visited 2.6 times by extension agents last year. But the numbers of visits more than 3 times was higher for adopters (69%) than non-adopters (61.7%). And the difference is statistically significant at 10 percent level, indicating extension visit could have influenced fertilizer adoption.

Table 5.5: Average Visits of farmers by Extension Agent in 2007/08 Cropping Season.

Type of respondents		# of visits
Non- adopters	Mean	2.4
	Std. Deviation	.83
Adopters	Mean	2.7
	Std. Deviation	.66
Total	Mean	2.6
	Std. Deviation	.76

Source: Survey data, 2008.

The result of the study implies extension service plays important role in decision to adopt fertilizer in the study area. If this is the case it is important to conduct further research so as to examine the determinants of extension service variation between respondents.

Access to Credit and Fertilizer Adoption

Many empirical studies usually give emphasis to the impact of credit on technology adoption. Because the lack of such access may constrain farmers from adopting technologies that require initial investments. To examine the effect of the variable in the study area, this study has tried to examine whether credit is available for which the farmer is eligible by asking whether or not the farmer used or has access credit to finance cost of fertilizer.

Table 5.6 shows that the condition of credit access to households, which enables them to purchase modern agricultural input like fertilizer. Farmers were asked, if they had taken fertilizer credit from formal institutions in the 2007/08 cropping season. Accordingly, 56.7% of the total respondents replied “No”. Of which, 70.6% of them were non-adopters while adopters were only 29.4%. The difference is significant at 1 percent level. The interpretation is that households that used fertilizer were more likely to have better credit access than households that do not use fertilizer.

Table 5.6: Household Fertilizer Credit Status in 2007/08 Cropping Season

access to credit to purchase fertilizer		respondents category		
		non-adopter	adopter	Total
No	Number	48	20	68
	%	80.0	33.3	56.7
Yes	Number	12	40	52
	%	20.0	66.7	43.3
Total	Number	60	60	120
	%	100.0	100.0	100.0
$\chi^2=26.6$		Asymp. Sig. (2-sided) = 0.00		

Source: survey data, 2008.

The caveat of interpreting this result is that farmers who did not take credit may not necessarily mean they had no access or fertilizer is not available in the area. This means credit use may not clearly distinguish between farmers who chose not to use available credit and farmers who did not have access to credit. For instance, farmers may not take credit if it is not affordable, or if they perceived it is associated with some risks, though there is access (availability). This means rationale farmers will use credit if it is profitable. Profitability in turn depends on the cost of credit and the potential returns on investment (which is uncertain). Thus, examination of supply and demand factors for credit is important to determine whether or not credit market failures constitute important constraints to technology adoption, which remains open for further research.

To examine the reason(s) that constrains farmers from taking fertilizer credit, they were also asked to mention the most important reasons. The mostly quoted reasons are given in the table 5.7.

Table 5.7: Major Constraints in Taking Credit for Fertilizer (in cash or kind)

Problems		respondents category		Total
		non-adopter	adopter	
lack of access	Number	40	32	72
	%	66.7	53.3	60
fear of crop failure	Number	18	12	30
	%	30	20	25
	Number	2	16	18
not needed	%	3.3	26.7	15
Total	Number	60	60	120
	%	100.0	100.0	100.0

$\chi^2=17.68$; Asymp. Sig. (2-sided)= .000

Source: survey data, 2008.

- Note:
1. Lack of access for this particular case proxies lack of formal access to credit, high interest rate, untimely supply, need of collateral and the like.
 2. Fear of crop failure represents the farmer believes fertilizer is accessible but does not take credit fear of failure to repay if crop failure occurs. It indicates risk aversion behavior of farmers.

The two important reasons for not taking fertilizer credit were lack of access (60%) followed by fear of crop failure (30%). When we look at the intra-group variation, as expected, lack of access and risk aversion problems are higher in non-adopters than adopters. And the difference is also significant at less than one percent level. In general, credit constraint is relatively severe for non-adopters. The result is lower than Fitsum and Holden (2004) reported in the region. As per the same authors around 68% of their sample households had no access to formal credit.

Table 5.8: Source of Credit for Fertilizer

source	Dedebit ¹⁰	ext. program	relatives	coop	Total
Number	1	4	3	28	40
%	2.5	10	7.5	70.5	100

Source: Survey data, 2008.

¹⁰ Dedebit (Dedebit Credit and Saving Institution) is a formal microfinance institution in Tigray Region.

With regard source of credit, the major source of credit in the area was cooperatives. Around 71% of those who took fertilizer credit in 2007/08 obtained it from cooperatives.

Out of 60 fertilizer users 16(26.7%) did not take credit or not needed in the 2007/08 cropping season (Table 5.7). This means they used own money to finance fertilizer input. One possible reason may be they were less affected by liquidity constraint because they relatively earned better farm and off-farm income (Table 5.10).

Table 5.9: Saving Status and Type of Saving by Respondents' Category

Respondents category		Type of saving			Total
		No saving	cash or crops	fixed assets or live stock	
Non-adopter	Number	31	3	26	60
	%	67.4	75.0	37.1	50.0
	% of Total	25.8	2.5	21.7	50.0
Adopter	Number	15	1	44	60
	%	32.6	25.0	62.9	50.0
	% of Total	12.5	.8	36.7	50.0
Total	Number	46	4	70	120
	%	100.0	100.0	100.0	100.0
	% of Total	38.3	3.3	58.3	100.0

$\chi^2 = 11.194$

Asymp. Sig. (2-sided) = .004

Source: survey data, 2008.

With regard to saving status of respondents, as shown in Table 5.9, 38.3% of the total respondents had no saving habit. Of which, 67.4% were non-adopters. And 73.3% of the savers in terms of livestock and fixed were adopters against 21.7% non-adopters. The difference is significant at 1% level. This implies the variable may have positive association with adoption of fertilizer.

Household Economic Factors

Wealth of house holds was estimated using farm and off-farm income as proxy variables. And the major economic indicators are presented in Table 5.10.

Table 5.10: Economic Indicators of Respondents*

Household category	land holding size in ha	farm income (in Birr)	% of total income	annual off farm income(in Birr)	% of total income	% difference	total annual income (in Birr)
Non-adopters	0.49	496.50	31.37	1,086.00	68.63	37.26	1,582.50
Adopters	0.78	1,122.42	36.20	1,978.20	84.77	48.57	3,100.62
Total	0.64	809.46	34.57	1,532.10	65.43	30.86	2,341.56
P-value	0.001	0.00		0.001			0.00

*all variables are significant at 1 percent level.

Source: survey data, 2008.

The average farm income (estimated at market price) of sample households was 809.46 Birr. In addition to this low income, there is also significant variation in income of the two groups. The mean farm income of adopters and non-adopters is Birr 1, 122.42 and 496.5 respectively. The farm income of adopters was more than double to that of non-users of fertilizer. Two possible reasons for this variation, as expected, could be due to either the relatively larger farm size adopters possess (Table 5.10) or increased production and productivity of agriculture due to fertilizer use.

Engaging in off-farm income activities has got a lion's share in generating household annual income. Non-adopters and adopters generate 68.63% and 84.77% of their total annual income from off-farm activities respectively. The off-farm income of both non-adopters and adopters is larger than their respective farm income by 37.26 and 48.57%. This clearly implies farm income is extremely low and the farmers cannot rely on agriculture as means of their livelihood. The low annual farm income has forced all sample households to engage in off-farm activities.

Unexpectedly, the average annual off-farm income of adopters is also by far larger than non-adopters. As can be shown from the Table 5.10, the annual income of adopters is almost double to that of non-adopters. Keeping other things constant, the liquidity constraint of non-adopters is more severe than that of adopters.

As stated before, the off-farm income is almost double to that of farm income, though with high standard deviation. This clearly implies farm income is extremely low and the farmers cannot rely on agriculture. The low annual farm income has probably forced all sample households to engage in off-farm activities. Household's survival depends on the ability to generate off-farm income so as to smooth their consumption as means of risk management.

Three major reasons were identified as reasons for the result. Firstly, the Woreda is characterized as chronic food insecure and almost all households in the sample Tabias are included in safety net programs, which was considered as major source of off-farm income in the area. Secondly, due to relative good road network and proximity to nearest urban centers, members of household have good opportunity to engage as daily laborers. Another strategic reason to rely on non-farm activities is almost 100% of the farm households have never become food secured every year even at times of good reason. The implication is that farmers are discouraged to rely on farming, which in turn may result farmer's to under invest on their farmlands.

Oxen Ownership and Adoption of Fertilizer

As can be shown from the Table 4.9, 32.5% of the total respondents have no oxen. The remaining 48.3%, 17.5% and 1.67% owned 1, 2 and 3 oxen respectively. When we look the variation between the two groups, none of the non-adopters of fertilizer owned more than two oxen. The mean oxen owned by the adopters was one and the mean for non adopters was 0.58 (one oxen for two households). The difference was significant at less than 1 percent level.

Table 5.11: Oxen Ownership Status of Respondents

Respondents category	Number of oxen owned in 2007/08 cropping season				Total
	0	1	2	≥ 3	
Non-adopters	29	27	4	0	60
%	74.36	46.55	19.05	0.00	50.00
Adopters	10	31	17	2	60
%	25.64	53.45	80.95	100.00	50.00
Total	39	58	21	2	120
% row	32.50	48.33	17.50	1.67	100.00

t= -4.79; Sig. (2-tailed)= 0.000

Source: Survey data, 2008.

This implies fertilizer use was significantly influenced by oxen ownership. The result is higher than similar studies. For instance, Hailu, *et.al*, (1990) reported that 27% of their sample farmers had no oxen and 57% of them had no enough oxen. The same authors indicated that farmers owning two or more oxen cultivated larger farms than farmers owned less than two. The difference was significant at 1% level. Another study by Lelissa and Mulat(2003) reported similar problem. The authors showed 45.5% of their sample had shortage of oxen.

5.2 Plot Level Factors and Fertilizer Adoption

As shown in Table 5.10, the average land holding size was 0.64 hectare, which is lower than the region's average (1.09ha). But the intra-group land size variation shows adopters had relatively larger land holding than non-adopters. Taking the average hectare of the sample households as benchmark, 85% of the non-adopters own less than the average against only 46.7% adopters. This means 64.6% of those who owned less than 0.64 hectare were from non-adopters. The variation is also statistically significant at 1 percent level, indicating the variable could have influenced fertilizer adoption in the area.

With regard to slope category of plots, households were asked to categorize the slope of majority of their plots into steep, gentle slope, and flat. Accordingly, majority of their land (89.2%) was categorized as flat and moderately sloped, indicating suitable for

fertilization. But the percentages of flat and moderately sloped plots were slightly higher in adopters than non-adopters. This intra-group variation is also significant at 1 percent level (Table 5 .12). It implies slope of plots is inversely related with adoption of fertilizer holding other factors constant.

Table 5.12: Slope Category of Majority Farm Land by Respondents Category

Slope type		respondents category		Total
		Non adopter	Adopter	
Steep	Number	7	6	13
	%	11.7	10.0	10.8
Moderate slope	Number	16	32	48
	%	26.7	53.3	40.0
Flat	%	61.7	36.7	49.2
Total	Number	60	60	120
	%	100.0%	100.0%	100.0%

$\chi^2 = 3.07$ Asymp. Sig. (2-sided) = .010

Source: survey data, 2008.

Similarly, farmers were asked to categorize majority of their plots based on fertility into three: fertile, medium, and infertile. Accordingly, 61.7% of the total respondents categorized their plots as infertile, and 59.5% of which were from adopters of fertilizer. It implies soil fertility and adoption of fertilizer seems to associate inversely. But the difference is not significant at 10 percent level. In general, we can conclude plot slope was not significant factor for adoption decision in the area.

Table 5.13: Average Soil Fertility of Farm Land by Respondents Category

Average soil fertility of farm land		respondents category		Total
		non-adopter	adopter	
Fertile	Number	7	4	11
	%	11.7	6.7	9.2
Medium	Number	20	14	34
	%	33.3	23.3	28.3
Infertile	Number	33	41	74
	%	55.0	68.3	61.7
Total	Number	60	60	120
	%	100.0	100.0	100.0

$\chi^2 = 3.74$ Asymp. Sig. (2-sided) = 0.29

Source: Survey data, 2008.

Another plot level factor analyzed in this study was means (source) of majority of land ownership: the state or inherited, rented or crop sharing.

Table 5.14: Source of Majority of Farmland by Respondents Category

Source of majority of farmland		respondents category		Total
		Non-adopter	adopter	
The state	Number	55	35	90
	%	91.7	58.3	75.0
Inherited	Number	4	2	6
	%	6.7	3.3	5.0
Crop sharing	Number	0	23	23
	%	.0	38.3	19.2
Others (rented, common land, etc.)	Number	1	0	1
	%	1.7	.0	.8
Total	Number	60	60	120
	%	100.0	100.0	100.0

$\chi^2 = 29.1$ Asymp. Sig. (2-sided) = .000

Source: Survey data, 2008.

Being the state a major source of land ownership, 38.3% of the fertilizer adopters also owned their majority of land through crop sharing. However, all of the non-adopter owned land either from the state or inherited from family. The variation is also significant

at less than 1 percent level (Table 5.14). The possible explanation is that adopters have relative less liquidity constraint to purchase agricultural inputs and also have better oxen ownership so as to cultivate additional land of those who do not have similar endowments.

5.3 Major Production Risks and Risk Management Strategies

Rural households in drought prone areas often experience production shocks that result in low and uncertain income. The adverse impact of these on the household varies on the ability to anticipate and to cope with this uncertain income. Though the level of effectiveness varies, households have developed ex-ante risk management and ex-post risk coping strategies. Generally, the strategies include crop portfolio adjustments (e.g., growing drought resistance variety or planting multiple crops) and off-farm activity diversifications are widely practiced. This section investigates the major production risks and the types of households' risk management and risk coping strategies in the study area.

5.3.1 Major Production Risk Sources

From the total respondents 97.5% had experienced crop failure at least once in the last 3 years. Moreover, the problem was higher in non-adopters than adopters as can be observed from table 5.15. The difference is also significant at 10 percent level.

Table 5.15: Crop Failure Incidence at Least Once in the Last Three Years

Have you ever experienced crop failure		respondents category		Total
		non-adopter	adopter	
Yes	Number	60	57	117
	%	100.0	95.0	97.5
No	Number	0	3	3
	%	0.0	5.0%	2.5
Total	Number	60	60	120
	%	100.0	100.0	100.0
$\chi^2 = 9.2$		Asymp. Sig. (2-sided) = 0.079		

Source: survey data, 2008.

The major sources of crop failure identified from the survey were untimely rainfall and drought (31%), flood and drought (11.7%), and pests and crop disease (8.3%) among others. These uncontrollable factors were held responsible for crop production to be extremely risky in the area. The situation had negative influence on agricultural investments.

The low agricultural production and productivity potentially hindered consumption of modern agricultural inputs like fertilizer. The most frequent reasons cited by respondents were lack of access followed by fear of failure to repay loan if crop failure occurred.

Farmers were also asked if they are interested to use fertilizer or to increase their current use and by how much percent, provided that loan repayment is rearranged during crop failure. Conforming to our expectation, minority of the total respondents (only 25.8%) had not shown their positive interest. The most interesting result in this case was that 61.7% of the non-adopters were willing to use fertilizer and fertilize from 25 to 100% of their plots. Similarly, 83.3% of the adopters were also ready to increase the extent of use to most of their remaining plots (Table 5.16).

Table 5.16: Farmers' Willingness to Increase Use of Fertilizer If They Were Given Crop Insurance

Respondent category		if yes, % increase					Total
		.00	25.00	50.00	75.00	100.00	
Non-adopter	Number	23	16	15	1	5	60
	%	74.2	80.0%	42.9	9.1	21.7	50.0
	% of total	19.2	13.3	12.5	0.8	4.2	50.0
Adopter	Number	8	4	20	10	18	60
	%	25.8	20.0	57.1	90.9	78.3	50.0
	% of total	6.7	3.3	16.7	8.3	15.0	50.0
Total	Number	31	20	35	11	23	120
	%	100.0	100.0	100.0	100.0	100.0	100.0
	% of total	25.8	16.7	29.2	9.2	19.2	100.0

Source: survey data, 2008.

The assumption was adoption of agricultural inputs is constrained by aversion to production risk. The result supports our assumption that aversion to production risk made

farmers hesitant to apply optimal level of fertilizer. The implication is that promotion of modern agricultural input like fertilizer use should be accompanied other preconditions such as loan repayment rescheduling in time of crop failure.

5.3.2 Risk Management Strategies

Literature gives ample evidence that poor farmers, especially in drought prone areas often experience rainfall-related production shocks that result in low and uncertain income. Through time, households develop *ex-ante* risk management and *ex-post* risk coping strategies. These include crop portfolio adjustments and off-farm activity diversification.

This section of the thesis assesses the major production risks households face and the major types of risk management and risk coping strategies they practice to solve them. A wide variety of risk mitigating and risk strategies are identified and practiced in developing countries. These strategies, as discussed in literature part section 2.2, are categorized as *ex ante* and *ex post* strategies. The strategies followed by the sample households are presented, in similar fashion, as follows.

Ex ante strategies

Farmers risk mitigating strategies in the study area include crop and job desertification (or diversifying activities) or conservative mode of production, such as investing in lower risk activities; reducing consumption or precautionary saving.

Farmers were asked to rank their priority strategies among the alternative means. As Table 5.18 depicts, 52.5% of sample households practiced diversifying activities. Of the remaining households 29.3%, 10.3% and 7.5% practiced not engaging in riskier activities, reduction of consumption (e.g. reduce frequency and amount of meal per day), and other strategies respectively. Unlike the first strategy, the second strategy was more practiced by non-adopters than adopters. One implication is that non-adopters may remain persistently vulnerable to shocks by depleting their assets.

Table 5.17: Major *ex ante* Strategies by Respondents Category

Major <i>ex ante</i> strategies		respondents category		Total
		non-adopter	adopter	
Diversification (crop and job diversification)	Number	30	33	63
	%	50.0	55.0	52.5
Engaging in lower risk activities	Number	21	14	35
	%	35.0	23.3	29.2
Reducing consumption	Number	5	8	13
	%	8.3	13.3	10.8
Others(migration or combination of strategies)	Number	4	5	9
	%	6.7	8.3	7.5
Total	Frequency	60	60	120
	%	100.0	100.0	100.0
$\chi^2 = 2.346$		Asymp. Sig. (2-sided) = 0.504		

Source: survey data, 2008.

In both groups the diversification strategy has got important emphasis. The main component of diversification was engaging in off-farm activity in both groups (Table 4.6). The result also shows that diversification was more practiced in adopters. Moreover, engaging in lower risk activities (including use of fertilizer) and reducing consumption was more practiced by non-adopters than adopters. But, the variation was not significantly different at 10% level of confidence. This means any measure practiced to as *ex ante* risk management was not important factor for inhibiting or enhancing fertilizer adoption in the area.

However, care must be taken in interpreting this result. Because the second strategy (i.e., not engaging in riskier activities), could hinder application of modern agricultural input such as fertilizer and improved seed variety. This may have a negative consequence on increasing production and productivity of agriculture. The implication is that the *ex ante* risk management strategies may have negative consequence on the poor farmers to remain on poverty. The findings are consistent with Dercon and Christensen(2007).

Ex Post Risk Management Strategies

As far as risk coping strategies of the study sample households is concerned, like *ex ante* strategies, engaging in off-farm income activities was practiced by majority (46.7%) of the total respondents. Of which, 51.7% were non-adopters, while only 41.7% were non-adopters.

Table 5.18: Major Risk Copping Strategies by Respondents' Category

Ex post strategies		Respondents category		Total
		non-adopter	adopter	
Off- farm Activities (including cash or food for work)	Number	25	31	56
	%	41.7	51.7	46.7
Depletion of fixed asset	Number	18	12	30
	%	30.0	20.0	25.0
Reduce consumption	Number	8	4	12
	%	13.3	6.7	10.0
Risk sharing(including remittance)	Number	9	13	22
	%	15.0	21.7	18.3
Total	Number	60	60	120
	%	100.0	100.0	100.0
$\chi^2 = 3.903$		Asymp. Sig. (2-sided) = 0.272		

Source: Survey data, 2008.

The second most important strategy was fixed asset depletion (such as selling livestock, trees, and other fixed assets), practiced by 25% of respondents as prior strategy. Literature gives evidence using this strategy as risk coping may lead to persistent poverty. Because it may influence the next production negatively thus, lead to auto correlated income risk. Income smoothing by consumption adjustment can be an option to reduce income risk. But in the study area this strategy is little practiced. The low income of households in the area could not allow them to practice this strategy.

CHAPTER SIX

ECONOMETRIC RESULTS AND DISCUSSIONS

6.1 Analysis of Farmers Risk Attitudes

Adoption studies give evidence that farming is a risky activity especially under rain fed agriculture, in which return on investment varies from year to year, because of exogenous variables such as weather, pests, and crop diseases. It was hypothesized that risk aversion is one of the major constraints in the rain fed agriculture that can delay or avoid fertilizer adoption.

To empirically examine the link between risk attitude and fertilizer adoption of sample farmers, the coefficients of Arrow-Pratt and Downside risk aversion parameters were estimated using equations (9) and (10). The marginal contribution of fertilizer input (estimated at market price) to farm income (at current market price) of each sample household was considered so as to analyze the risk behavior of farmers' to variance and skewness (i.e. also known as second and third moments of profit respectively) of their profit. The coefficients of the two parameters were estimated using OLS method, i.e., each farmers AP and DS coefficients on fertilizer input were fitted to OLS.

Table 6.1 shows that risk attitude statistics towards the use of fertilizer, which is considered as important input in the production process. Let us briefly explain the coefficients one by one. "A negative and significant constant implies that farmers are underutilizing the input under consideration, while a positive coefficient signifies overuse of the input" (Simtowe, 2006:9). In this case the constant is significant implies that farmers do not exhibit a profit maximizing behavior. This also implies the expected marginal return is not equal to the factor price. As stated by Groom *at al.* (2006), by definition we should not observe a significant constant term in the model linking the derivatives of moments with respect to the input under consideration.

Table 6.1: Risk Aversion Indicators Coefficients*

Parameter	Coefficients		t	Sig.
	Coeff.	Std. Error		
Constant	.506	.056	9.076	.000
Q2(associated with Arrow-Pratt risk coefficient)	2.651	1.611	1.645	.103
Q3(associated with downside risk)	1.195	1.773	.674	.502

* Dependent Variable: Decision to adopt

Source: Survey data, 2008.

The parameter (Q2) associated with Arrow-Pratt (AP) measure of risk aversion is positive, as expected, though not significant. The sign indicates that farmers exhibit AP risk aversion, i.e., they are willing to sacrifice a proportion of their expected income to avoid the risk associated with fertilizer input in their production process. It implies farmers are concerned to maintain their average income (they obtain from experience in previous cropping seasons) than take risk of adoption that makes them to jump to higher income to the opposite level of income shock.

The parameter associated Downside risk (DS).i.e., with the third moment of profit (skewness) is positive but not significant, conforming to the expectation. The positive coefficient indicates that farmers do exhibit DS risk aversion. i.e., they are risk averse to a profit distribution that is skewed towards negative values. The interpretation is that farmers prefer to avoid the disaster level of income as a cost of higher profit.

The possible explanation may be, in the absence of livelihood security, the poor may follow conservative mode of production to maintain the minimum level of income that sustains life rather than taking risk of adopting fertilizer than can generate higher profit (income). Because, if production risks (crop failure) has occurred, risk taking may lead to complete loss (higher negative profit) so that it will be difficult for vulnerable households to recover from these shocks. This result consistent with that of Kounouri *et al.*,(2006).

6.2 Risk Aversion among Wealth Groups

The relationship between the choice of inputs and wealth will depend on how risk aversion changes with wealth. It was hypothesized the households with relatively better wealth status are less sensitive to risk. Because they have better security to safeguard against shocks such crop failure. To this end the following steps were followed:

First, the sample households were categorized in to five equal wealth groups using their total income. For simplicity of measurement household annual income (sum of both farm and non-farm income) was used as proxy variable as wealth measurement of households in 2006/2007.

Second, the households were also categorized into three risk attitude groups' bases on sign individual risk premium coefficient. As indicated in section 6.1, farmers were categorized in to three risk groups. Third, to see the association between wealth status and risk attitude of farmers a cross-tabulation was done between the two variables. And the result is presented in Table 6.2.

Table 6.2, shows an interesting association between risk and wealth groups. Of the total respondents 17.5%, 45.8% and 36.7% were categorized as risk neutral, risk averter, and risk taker respectively based on the sign of risk premium of each farmer. Not surprisingly, a significant factor for differential risk taking behavior seems to be associated with their wealth status. With regard to the risk neutral households, the assumption was risk attitude of these farmers' remains constant (show equal number distribution among all wealth levels) irrespective to change in the wealth level.

Table 6.2: Risk Aversion among Different Wealth Groups

Risk category		wealth quintile					Total
		Lowest Q	Second Q	Medium Q	Fourth Q	Highest Q	
Risk neutral	Number	7	3	5	3	3	21
	%	29.2	12.5	20.8	12.5	12.5	17.5
Risk taker (negative RP coef.)	Number	8	5	6	17	19	55
	%	33.3	20.8	25.0	70.8	79.2	45.8
Risk adverse (positive RP coef.)	Number	9	16	13	4	2	44
	%	37.5	66.7	54.2	16.7	8.3	36.7
Total	Number	24	24	24	24	24	120
	%	100.0	100.0	100.0	100.0	100.0	100.0

$\chi^2= 34.275$; Asymp. Sig. (2-sided)= .00

Source: own calculations from survey data 2008.

Unlike our expectation, the first row (Table 6.2) shows the number of risk neutral farmers decreases as wealth decreases, though not consistent, from 33.3% to 14.3% as we move from the first quintile (the poorest group) to the fifth quintile (the relatively richest group), i.e., an inverse relationship between the two variables. The possible explanation of this result can be farmers will be more likely to take risk as their wealth level increases, other factors held constant.

One major objective of this analysis was to examine risk attitudes of farm households in different wealth categories. As expected, the number of risk averter farmers decreases from 66.7 % to 8.3% as wealth status increases from the second quintile to the fifth quintile, indicating inverse relationship between risk aversion and wealth. The interpretation is that the poor are risk averse. One of the serious implications of this result is that risk avoidance by poor farmers may inhibit investment in modern agricultural inputs like fertilizer which have significant contribution to agricultural productivity and food security. This in turn may lead to poor farmers to remain in vicious circle of poverty. The explanation is consistent with Dercon and Christensen (2007) findings. To substantiate this explanation from different angles, further analyses were done by

associating fertilizer adoption wealth status of farmers at the end of this section and econometric analysis in section 6.3.

Similarly, of the total sample farmers 45.8% were risk takers. As our expectation, risk taker farmers decreases as the wealth status with in the group falls and vice versa, indicating positive association between risk taking and wealth status. The explanation is poorer farmers are less likely to involve in riskier investments. But, as wealth level of these households raises their capacity to resist income shocks also rises. As a result the richer households are more likely to involve in riskier but with higher return activities such as adoption of modern agricultural inputs. To empirically test this implication further analysis was done in the econometric analysis section 6.3.

To compare risk aversion behavior between adopters and non-adopters of fertilizer a cross tabulation was done between the variables. And the result is presented in table 6.3.

Table 6.3: Risk Aversion by Household Category

Adoption category	Risk category			
	Risk neutral	Risk takers	Risk averse	Total
Non adopter	15(71.43)	19 (34.55)	16 (47.05)	60(50)
Adopter	6(28.57)	36(65.45)	18(52.94)	60(50)
Total	21(100)	55(100)	34(100)	120(100)

*Numbers in braces indicate column percentages

Source: own calculation from survey data, 2008.

As can be observed from the Table 6.3, of the total risk neutral respondents 71.43% were non-adopters. Similarly about 47% percent of risk adverse respondents were from non-adopters. However, about 65.5% of the risk takers were adopters. It implies either risk neutrality or risk aversion behavior, which was higher in non-adopters, has constrained adoption of fertilizer.

6.3 Econometric Estimation of Factors that Affect Fertilizer Adoption

As highlighted in the literature review, adoption of agricultural inputs is constrained by a number of interwoven factors such as credit constraint, limited access to information, aversion to risk, inadequate farm size, insufficient human capital, absence or untimely supply of complementary inputs and lack of transportation.

However, not all factors are equally important in different areas and for farmers with different socio-economic situations. This means the decision to adopt or not for a particular input varies depending the farmers age, education, household size, landholding size, livestock ownership and other factors that indicate the wealth status of farmers. This section of the study is devoted to test the relative effect of the variables under consideration toward fertilizer adoption in the study area. the problem of multicollinearity was checked using correlation matrix as presented in annexes 2,3,and 4.

Table 6.4 presents the logit estimates of the determinants of likelihood of fertilizer adoption. A chi-square test which measures the goodness of fit of the model is significant at 1 percent level, signifying a good fit .i.e., the model is adequate.

With regard to age variable, other things remained constant; it was assumed that older farmers tend to be less risk takers than younger ones to adopt fertilizer. As Table 5.1 shows, the average age of household heads was high, which about 51 years. There was also no significant age variation between adopters and non-adopters. In this study area age variable had positive but insignificant coefficient, indicating that age has no importance with adoption of fertilizer. The sign contrasts with Getahun *et al.*,(2006). In Simtowe(2006), age coefficient was reported as negative and significant at 1 percent level, signifying the older the households the less likely to adopt hybrid maize in Zambia.

Higher education has been mostly associated with higher probability of risk taking (e.g., Croppenstedt et al., 1999). To test this hypothesis in the study area an education dummy was included in the logit model. The variables education of household head and

membership in association were positively related to fertilizer adoption, but not significant at 10 percent, indicating both variables had not influenced fertilizer adoption. In this analysis, the low importance of education may be due to two possible reasons. In the study area, the average year of schooling is very low to bring significant effect on agricultural innovations. The reason is consistent with that of Moscardi and de Janvry(1977), Lelissa and Mulat(2002) found in their respective study areas. Another possible reason is that assuming the young generation is expected to have better education; most young farmers are landless or own small land which discourages engaging and investment on agricultural activities. But, care must be taken in considering education effect. The literate adopters are higher than illiterate adopters as shown in the descriptive analyses.

Formal training on modern inputs dummy variable (1= if yes) was also included in the model. As anticipated, the result shows training had positive association with fertilizer adoption significant at less than 5% level. The marginal analysis also shows that other factors held constant at their mean level, formal training affected farmer's probability to adopt fertilizer input by 61.3%, significant at 1 percent level. The implication is that farmers who acquired better knowledge (e.g., via training) are more likely to adopt or at least try the input than those with out training.

Agro-ecological factors, such as location of the village, variation in rainfall, soil quality, and production potential often influence agricultural technology adoption. In addition to agricultural potential, other factors such as infrastructure and availability of markets for inputs and outputs also vary by agro-ecology. And variation of these variables is visible at the local level, even at the farm level. Variables which were identified to influence at plot level were included in the analysis but rain fall was used to control for agro-ecological factors.

Wealth indicators are often assumed to influence adoption decisions. In this study, it was hypothesized that wealth is expected to affect adoption decisions for a number of reasons, including that wealthier farmers who have greater access to resources may be more able to assume risk. For example, size of landholdings is often used to measure farmers'

wealth. Landholdings may also reflect the social status and prestige associated with owning land, and possibly the ability of a farmer to obtain credit (Doss, 2003).

The average land holding of farmers in the Woreda is 0.68 hectare and the sampled households own an average 0.63 hectare (Table 4.5), which is very small. Thus, the numbers of oxen needed are also small. This may be the reason that the insignificant relationship between number of oxen and the probability of adoption.

Access to credit and adoption of modern inputs is given much emphasis in many empirical studies. To test the variable's (credit) effect in the study area, it was included in the adoption model. The result shows, as expected, a positive and significant at 1 percent level, signifying a strong impact on decision to adopt. The odds in favor of adopting fertilizer increased by a factor of 29.6 for adopters probably because they had better credit access. The marginal effect analysis also shows credit access affected a farmer's probability to adopt fertilizer by 67.5%, other variables remained at their mean level, significant at 1% level of confidence. This implies that households with better access to credit are more likely to have higher probability of adopting fertilizer than those with out access.

The variable family size was included as an explanatory variable. Two opposite relationships were expected with regard to risk taking and family size. On the one hand, the higher the family size implies the higher is the subsistence consumption needs. Thus, the household is less likely to take risk of adopting fertilizer, given the small land ownership and erratic nature of rainfall. On the other hand, family labour is important input to adopt fertilizer. Moreover, a larger family size means greater availability of off-farm income, which is a major source of livelihood in the area. . This in turn has important role to reduce liquidity constraint of households. Thus, in both the latter cases large family size will have positive association with adoption of fertilizer.

Table 6.4: Factors That Affect Adoption of Fertilizer (logit model)

Explanatory Vars.	Coef.	Odds Ratio	Z-value	P-value
age	0.013	1.013	0.440	0.662
sexdy	0.865	2.375	0.760	0.448
hhsz	-0.198	0.820	-1.060	0.290
training_cat	1.845**	6.326	2.340	0.019
credit	3.388*	29.621	4.070	0.000
no_oxen	0.436	1.546	0.740	0.457
education	0.309	1.362	0.400	0.691
manu_use	0.000	1.000	-0.090	0.929
sour_land	4.784*	119.585	3.310	0.001
membership	1.435	4.200	0.930	0.352
_Irisk_gro~1	-0.568	0.566	-0.490	0.625
_Irisk_gro~2	-1.88**	0.152	-2.430	0.015
slop_cat	1.846**	6.332	2.460	0.014
soil_ferti~y	1.169	3.220	0.970	0.332
off_farm	0.001***	1.001	1.800	0.072
lsize_timad	-0.042	0.959	-0.140	0.890
Constant	-7.434**		-2.650	0.008

Number of valid obs = 119

LR chi2(16) = 97.73

Prob > chi2 = 0.0000

Log likelihood = -33.617733

Pseudo R2 = 0.5924

*, **, *** represent significant at 1%, 5%, and 10% respectively.

Source: Model Output, 2008.

The results of the binary logit model supports support the first assumption. Result from the logistic regression shows that family size and fertilizer adoption has negative association, but not significant at 10 percent level. It signifies that household size was not important factor to influence fertilizer adoption in the area. The finding contrasts to that of Croppenstedt *et al.* (1999). As per the same authors, the conclusion was that subsistence pressure increases the likelihood that farmers' fertilizer use and extent of use of fertilizer input.

Table 6.5: Marginal Effects of Adoption Variables

Explanatory variables	Partial derivates(dy/dx)	Z	P-value	Mean value of variables
age	0.003	0.440	0.662	50.908
sexdy*	0.212	0.800	0.426	0.824
hhsiz	-0.049	-1.060	0.290	6.017
traini~t*	0.431	2.710	0.007	0.613
n_credit*	0.675	6.130	0.000	0.429
no_oxen	0.108	0.740	0.458	0.882
n_educ~n*	0.077	0.400	0.690	0.538
manu_use	0.000	-0.090	0.929	553.109
sour_l~d*	0.640	7.130	0.000	0.168
n_memb~p*	0.326	1.170	0.242	0.958
Irisk~1*	-0.141	-0.500	0.618	0.118
Irisk~2*	-0.439	-2.810	0.005	0.412
slop_cat*	0.429	2.820	0.005	0.504
soil_f~y*	0.278	1.090	0.274	0.908
an_off~m	0.000	1.820	0.068	1532.870
lsize_~d	-0.010	-0.140	0.890	2.534

Source: Based on Model Output, 2008.

Another important factor analyzed in the adoption model is the level of off-farm income. It was hypothesized that the more the farmer earns off-farm income the less liquidity problem he/she faces so that he/she is more likely to adopt fertilizer even in the absence of credit access. As expected it has positive sign and significant at 10 percent level of confidence level. For a unit increase in off-farm income, the probability of a farmer to adopt fertilizer increases by a factor of 1.01. Though it is not strong, the association is consistent with recent findings by Getahun *et al.*(2006). They reported that total income of a household had strong and positively association with intensity of adoption of improved wheat varieties, significant at 5 percent level (ibid).

Variables number of oxen owned, manure or compost used, and soil fertility a have no significant impact on decision to adopt fertilizer.

Analysis of Risk Aversion and Fertilizer Adoption

The variable of particular interests in this study is the effect of risk-premium, which proxies the risk attitude of each farmer in the sample. As assumed in the model specification section 3.3, risk premium, $RP >$, implies the farmer prefers risk less world i.e, the farmers are ready to sacrifice certain amount of income in order to avoid the risk associated with adoption of the input under consideration (Groom et al. , 2006). To examine its relative effect on adoption of fertilizer, it was included as one of explanatory variable in the adoption model.

The steps followed to incorporate risk premium are the following. First, risk premium for each farmer is estimated using equation (11). The computed risk premium shows three groups of farmers who have positive, zero, and negative values. Second, farmers were categorized in to three: risk adverse (if $RP > 0$), risk neutral (if $RP=0$), and risk takers (if $RP < 0$). Third, two risk group dummies (using risk neutral as reference group) were created. As indicated before $RP > 0$ implies the farmer is characterized by a positive willingness to pay certain profit (income) to avoid a risk event. Then the risk groups were included in the logistic regression as explanatory variables.

Both risk variables showed negative sign, signifying risk attitude is inversely related to fertilizer adoption. As expected the risk adverse group ($Irisk_gro=2$) is negative and significant at 5 percent level of confidence. The interpretation of the result is that being a farmer is risk averter the odds in favor of adopting fertilizer decreases by a factor of 0.152. The marginal effect analysis also shows more meaningful results. As shown in Table 6.9, the risk aversion behavior decreased the probability farmer's decision to adopt fertilizer by 43.9%, significant at 5% level of confidence. The explanation is clear. Farmers' decision to adopt fertilizer is influenced by their risk preferences. This implies that risk aversion has a series implication in fertilizer adoption.

CHAPTER SEVEN

CONCLUSIONS AND POLICY IMPLICATIONS

7.1 Conclusions

As highlighted in the literature review, adoption of agricultural inputs are constrained by a number of interwoven factors such as credit constraint, limited access to information, aversion to risk, inadequate farm size, insufficient human capital, absence or untimely supply of complementary inputs and lack of transportation. However, all factors are not equally important in different areas and for farmers with different socio-economic situations. This means the decision to adopt or not for a particular input varies depending on the farmers age, education, household size, landholding size, livestock ownership and other factors that indicate the wealth status of farmers.

Empirical studies give evidences that farming is a risky activity, especially under rain fed agriculture. Production risk arises mainly from the natural environment factors, and is associated with uncertainties in climate. Further more, return on fertilizer varies from year to year, because of exogenous variables such as weather, pests, and crop diseases. Thus, production risk is one of the major constraints that can delay or avoid technology adoption in the rain fed agriculture.

It is frequently argued that aversion to risk and production risk make farmers to avoid or hesitate to apply the optimal level of fertilizer. However, in Ethiopia empirical evidence on farmers risk aversion and fertilizer use is limited. Most of the studies conducted in this country did not explicitly address this issue. Thus, this study was conducted to examine how risk aversion lead to a reduced use of fertilizer, and to examine if risk aversion is associated with household's wealth status. Then the findings obtained in this study may contribute in informing policy makers to incorporate the issue at macro level, and planners and experts at micro level. To this end an empirical analysis was done using descriptive and econometric analysis in comparative fashion between adopters and non-adopters of fertilizer.

The descriptive analysis of most of the household and agro-ecological characteristics assumed to influence fertilizer adoption were found to have significant variation between the adopters and non-adopters. From this analysis the variables age, sex, education of head, and marital status variations between the two groups were significantly different. Thus, it can be concluded that these variables could be important factors in adoption decision.

With regard to access of households to institutions, training, extension service, and access to credit were analyzed. Considering the selected three variables of particular interest, adopters had greater access to formal training on modern input utilization. The number of extension visits, fertilizer credit access and oxen ownership were also higher in adopters than non-adopters. The two important reasons given by the non-adopter farmers for not using the available credit were lack of access followed by fear of crop failure. As expected, lack of access and risk aversion problems were higher in non-adopters than adopters

Household economic indicators were also analyzed using land holding, oxen ownership, and farm and off-farm income as proxy variables. And all variables showed significant difference at the traditional confidence intervals. The average farm income of sample households was low. Engaging in off-farm income activities has got a lion's share in generating household annual income. The off-farm income of non-adopters and adopters was larger than their respective farm income. The implication is food security is difficult to achieve with the existing mode of agricultural production.

The average land holding size was 0.64 hectare, which is lower than the region's average 1.09 ha, and adopters have relatively larger land holding than non-adopters. Being the state a major source of land ownership, substantial number of the fertilizer adopters also owned their majority of land through crop sharing. The difference was also significant at less than 1 percent level, indicating adoption of fertilizer was influenced with relative resource endowment of sample households.

In the area the major sources of crop failure identified were untimely rainfall and drought, flood (excessive rain in good seasons), pests and crop disease. These uncontrollable factors were held to be responsible for crop production to be extremely risky in the area. With regard to risk management strategies households practice diversifying activities, not engages in riskier activities, reduction of consumption (e.g. reduce frequency and amount of meal per day), and other strategies respectively. In both groups diversification of activities has got important emphasis. The main component of diversification is engaging in off-farm activity. It implies the low potential and high risk in agriculture has probably forced all households not to rely on it. This in turn may discourage investment in the sector.

As far as risk coping strategies in the study area was concerned, engaging in off-farm income activities is practiced by majority of respondents. The second most important strategy was fixed asset depletion practiced respondents as priority of strategy. In general, households' off-farm labor supply can be seen as an ex-ante and ex-post income smoothing strategy, mainly due to lower income from agriculture.

In addition to the descriptive analysis made, further analysis was also done using OLS method to estimate the risk attitude parameters and logistic regression analyses to estimate other factors including risk that affect adoption of fertilizer. And from the findings of the significant variables the following conclusions were drawn out.

The analysis of risk attitudes of farm households in relation to their wealth status has showed interesting results. As expected, the number of risk averter farmers decreases as wealth status increases, indicating inverse relationship between risk aversion and wealth. The interpretation is that the poor are risk averse. One of the serious implications of this result is that risk avoidance by poor farmers may inhibit investment in modern agricultural inputs like fertilizer which have significant contribution to agricultural productivity and food security. This in turn may lead to poor farmers to remain in vicious circle.

Using the moments based approach it was tried empirically examine the relative risk premium related to fertilizer use among farmers of different wealth groups. The finding showed that the farmers exhibited absolute Arrow-Pratt risk aversion towards the use of fertilizer. As expected, risk aversion and fertilizer use was negatively related. The implication is that farmers are willing to sacrifice a proportion of their expected income (profit) to avoid the risk associated with fertilizer input in their production process.

An econometric estimation of selected variables that were hypothesized to affect fertilizer adoption was done using logistic model. Formal training on modern inputs had positive association with fertilizer adoption significant at less than 5% level. Access to credit and adoption, as expected, had positive associations significant at 1 percent level, signifying a strong impact on decision to adopt. This implies that households with better access to credit were more likely to have higher probability of adopting fertilizer than those with out access.

Another important factor analyzed in the adoption model was the level of off-farm income. As expected off-farm income had positive sign and significant at 10 percent level of confidence level, indicating farmers liquidity constraint to purchase modern inputs like fertilizer can be, at least partially, reduced by the amount of off-farm income earned.

Both risk aversion and risk taking variables showed negative sign, signifying risk attitude was inversely related to fertilizer adoption. As expected the coefficient risk adverse group is negative and significant at 5 percent level of confidence. Farmers' decision to adopt fertilizer was significantly influenced by their risk preferences. This implies that risk aversion has a series implication on fertilizer adoption.

7.2 Policy Implications

- In the area due to small farm size and harsh weather conditions almost all households are characterized by chronic food insecurity. Any effort to achieve food security should enhance both farm and off-farm income in a way that reinforce each other.
- The availability of fertilizer credit is not a solution by itself unless it is accompanied by better rearrangement on repayments. Farmers should be given repayment grace period in times of complete crop failure. Credit access should not also associate with the wealth status of farmers such as oxen and landholdings so as to address the poor to participate in the application of modern inputs.
- The study reveals that when considering promoting modern inputs, it is important to assess the wealth distribution of households and its implications for risk preferences towards the use modern inputs such as fertilizer.
- When considering promoting modern inputs, it is important to assess the higher moments of income (the higher expected income or loss due to use of modern input) and its implications for risk preferences towards the use modern inputs such as fertilizer.
- A notable finding is that credit access and extension service had increased the likelihood of fertilizer adoption. However, the problem is not a mere availability, but lack of financial capacity to purchase inputs, especially to non-adopters, as a key constraint to adoption and fear of repayment of credit if crop damage occurs, which is common feature in the study area. Thus, the input supply policy should be revised in the context of farmers' constraints.
- Promoting specific training on application of modern inputs is vital to enhance the fertilizer use and intensity of use by farmer.

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QUESTIONNAIRE

Dear Respondent,

As you are well aware, use of modern inputs such as fertilizer and improved seed varieties have significant contribution to increase production and productivity of agriculture thereby enhance food security. Any effort to design strategies aimed at technology adoption must start with identifying the determinants of it. This questionnaire is, therefore, designed for a study whose overall objective is to identify and analyze the potential determinants technology adoption in *Saesi Tsaeda-Emba woreda*. Therefore, you are kindly requested to give genuine responses. I would like to assure you that the information you are going to provide will be exclusively used for academic purpose and will remain confidential.

Thank you

A. Questionnaire number _____.

Interviewed by _____.

Date of interview: Date _____

Month _____ Year _____.

B. Geographical Situation of the household

Tabia (kebele) _____.

Kushet(village) _____.

C. Household category

1= adopter

2= Non adopter

I. Household Characteristics: composition by sex, age, education, occupation

1. Socio- demographic characteristics

1.1 Name of HH¹¹ head _____

Age of HH head _____

Sex of HH head: 0= male 1=female

HH size _____ Adult male _____ Adult female _____

¹¹ HH= Household

Children less than 15 years old _____

1.2 Marital status 1= married 2= unmarried 3= widowed
 4= divorced 5= separated

1.3 Education of head

 1= no education 2= literacy (*meserete timhert*)
 3= 1- 4 grade 4= above 4 grade
 5= extension education 6= other, specify _____

1.4 Training of head

 1= SWC¹² 2= animal health and breeding
 3= marketing 4=how to apply modern input
 5=other, specify _____

1.5 Religion

 1= Orthodox 2= Catholic 3= Islam 4= Protestant

1.6 Are you member in any association\ organization?

 1= no 1= Edir 2 = farmers association
 3= Equb 4= women's assoc. 5= Youth assoc.
 6= Cooperatives 7= other, _____

2. Occupation status of HH members

2.1 Have you engaged in agricultural activities (farming) during the fiscal year 1999/2000 cropping season?

 1= yes 2= No

2.2 If "No", reason.

 1= health problem 4= student 7= lack of farm land
 2= lack of Oxen 5= disabled 8= lack of finance
 3=unable due to age 6= not interested 9= other; specify _____

2.3 are your family members of the household are engaged in agricultural activities?

 1= yes 2= No

2.4 If yes, how many members

 Adult male _____ Adult female _____

 Children up to age of 15 _____

¹² SWC= Soil and water conservation

II. Access to Institutions and Infrastructure

3. Household's access to infrastructures: market, transportation service, and roads.

Se. No.	Type of service and type of road	Are services available in your PA 1= yes 2= no	How much time does it take to reach these services(single trip) (Use code)	The type of transportation that you use to reach these service providers (Use code)
	A1	A2	A3	A4
	Town market			
	Cooperatives shop			
	Bus station			
	All weather road			
	Seasonal road			
	Demonstration center			
	Farmers training center			
	Vet clinic			

Code for A3- Time to access

1= less than 30 minutes

3= 1-2 hours

2= less than one hour

4= 2-3 hours

5= more than three hours

Code for A4 – Type of transportation

1= on foot

2= Animal transport (horse, mule, etc).

3= animal cart

4= Automobiles

5= others, specify _____

4. Have you ever been visited by extension agents in the last three years?

1= Yes

2=no

5. If your answer is yes, what inputs/ information do you get from the extension agents?

Type of assistance	How relevant is the information?			
	Tick	Very relevant	Quite relevant	Not relevant
SWC technical support/advice				
Land management information				
Home economics information				
Modern input application				
Credit management				
Other:				

Ser .no	source of income (use code)	Amount of income earned annually (in birr)	Did the HH has any type of saving? 1= yes 2= no
	B1	B2	B3

Code: For question B1

1= Salary obtained from employment in activities in others agriculture yield by any member of the household

2= from the sale of fuel wood fruits

3= from trade

4= from the sale of timber

5= from the sale of handicraft products

6= from free food aid

7= from cash for work and food for work

9= from remittance

10= If other specify _____.

6.3 HH agricultural production in 2000

Type of crop	Level of yield harvested		
	In local units	In Kg	Value of yield (in birr)
Teff			
Wheat			
Sorghum			
Barley			
Pea and bean			
Maize			
lentil			
vegetables			
Fruits			
Honey			
Others (list)			

6.4 HH saving characteristics

Do you have any saving habit?

1= Yes

2= No

If the HH has any saving, then	
Type of saving (use code)	Amount (value) of saving in cash (in Birr) per year
B4	B5

B4- Type of saving

1= in cash

2= in crop

3= in fixed assets

4= in livestock

5=other, specify _____

IV. Household resource endowment

7.1 Household resource endowment; livestock and land ownership in 1998 and 1999 E.C.

Se. No.	Type of livestock	Number of the livestock 0= if the HH has no livestock; actual number= otherwise		
		1998	1999	remark
1	Cattle- Oxen for ploughing			
2	Cattle- Cows			
3	Cattle- Calves			
4	Goat			
5	Sheep			
6	Donkey			
7	Horse			
8	Mule			
9	Camel			
10	Poultry			
11	Modern beehives			
12	Traditional beehives			
13				
14				
15				

8. How do you characterize the soil fertility of the majority of land holdings?

1=High fertility

2=Moderate fertility

3=Infertile

9. Soil type your holdings on average

1= sandy(hutsa)

2= *Baekel*

3= *walka*

4= *mekih*

10. Source (means) of majority land ownership?

1= the state

4= Crop sharing

2= Inherited

5= Common land

3= Rent

6= If other, specify _____

11. Slope category of each plot
 1= Flat
 2= moderately steep
 3= Very steep

V. Agricultural Production Characteristics

12. Agricultural production characteristics of the HH

1. Have you harvested any agricultural output during the year 2007?

- 1= Yes 2= No

If your answer in Q8.1 is yes, then

2. Season of harvest

- 1= summer 2= summer & winter

3. Type of labor used in the farming:

- 1=Family labor
 2=on crop sharing basis
 3=Exchange of labor with relatives or neighbors
 4= hired labour
 5= if other, specify _____

If you used hired labour, its cost in Birr _____

13. Modern input utilization patterns in 1999/2000 cropping season.

Se. no.	Have you used fertilizers in 1999/2000? 1= yes 2= no	If your answer in D1 is yes, then		Have you used compost + manure 1= yes 2= no	If your answer in D2 is yes, then		Total Seed used		Local variety		Improved variety	
		Amount in (Kg)	Its value (in birr)		Amount in (Kg)	Its value (in birr)	Amount in (Kg)	Its value (in birr)	Amount in (Kg)	Its value (in birr)	Amount in (Kg)	Its value (in birr)
	D1	D2		D3	D4		D5		D6		D7	

If your answer is yes in D1, skip to questions 8.8 – 8.12

13.1. When did the HH start to use fertilizer? _____

13.2. What part of your land is fertilized last year?

1. Total 2. 1/4th 3. 1/2 4. other, specify.....

13.3. Did you have any knowledge about fertilizer before you start to use it?

- 1= Yes 2= No

13.4. If your answer is yes, since when? _____

13.5. From whom did you learn about fertilizer for the first time? _____

- 1= Agriculture and Rural Dev't Office (extension service)
 2= District (Woreda) administration
 3= Neighbors or friends

- 2. Death of head, spouse or other person
- 3. Illness of head, spouse or other person
- 4. Inability to sell outputs or decrease in output price
- 5. Pests or diseases that affect crops
- 6. Others, specify.....

23.3. Have ever experienced crop failure in the last five years?

- 1= Yes
- 2= No

23.4 If yes how often in the last five years?

- 1=Once in five years
- 2=twice in five years
- 3= three in five years
- 4= four to five years
- 5= always

23.5. If yes, reason.

- 1= flooding
- 2= weed damage
- 3= animals damaging crops
- 4= untimely rain fall
- 5= drought
- 6= others, specify.....

23.6. What are/is your strategies to prevent risk or to mitigate the impact of risk?

- 1= Diversifying activity
- 2= Engaging in low risk activity
- 3= Migration
- 4=saving or storage
- 5= others, specify.....

Rank the strategies in order of their importance to you. .

23.7. What are/is your strategies to manage risk (i.e. after the risky event occurs in reducing its impact)?

- 1=Savings as precaution (grain storage) or reduce consumption (e.g. meal per day)
- 2=Sell of live stock and other assets (depletion of assets)
- 3= Informal; arrangements to share risks such as mutual support, credit arrangements, etc.
- 4= Family labour adjustments including children
- 5=Remittance
- 6= Food aid
- 7=others, specify.....

Rank the strategies in order of their importance to you. .

V. Assessment of Risk and Risk Preferences

24.1. What yields (or production on your farm) do you expect in a good, medium and bad year for your main crops with and with out fertilizer?

Crop	Yield. Quintal per tsimdi with out fertilizer			Yield. In Quintal per tsimdi with fertilizer			Causes of poor year, rank for each crop(use code)
	Good year	Medium year	Bad year	Good year	Medium year	Bad year	
Teff							
Wheat							
Sorghum							
Barley							
Millet							
Pea and bean							
Maize							
Others(list)							

Code for causes of bad year

1= Drought

2= Hailstorm

3= Pest

4= Disease

5= Excess rain

6= untimely rain fall

7=other, specify_____

24.2. If you had the choice between a crop which gives X quintal in a good year but no yield in a bad year which crop would you prefer to plant?

Choice 1

	Good year	Bad year	Choice
Crop 1	20	0	
Crop 2	19.5	2	

24.3. If you had the choice between a crop which gives X quintal in a good year and Y quintal in a bad year, which crop would you prefer to plant?

Choice 2

	Good year	Bad year	Choice
Crop 1	19.5	2	
Crop 2	18	4	

Choice 3

	Good year	Bad year	Choice
Crop 1	18	4	
Crop 2	16	6	

Choice 4

	Good year	Bad year	Choice
Crop 1	16	6	
Crop 2	13	8	

Choice 5

	Good year	Bad year	Choice
Crop 1	13	8	
Crop 2	11	8.5	

Choice 6

	Good year	Bad year	Choice
Crop 1	11	8.5	
Crop 2	10	9	

24.4. Given insurance, are you willing to use or would you increase your use of fertilizer/tsimdi?

1=Yes

2= no

If yes, by how much

Rate(in %)	25	50	75	100
Tick				

Annex 2: Correlation Matrix of variables employed in the adoption model

	res_cat	age	hhsiz	traini-t	n_credit	no_oxen	n_educ-n	m	anu_use	n_fert-k
res_cat	1.0000									
age	0.0058	1.0000								
hhsiz	0.1129	-0.1703	1.0000							
training_cat	0.4420	0.0344	0.0780	1.0000						
n_credit	0.4658	-0.0096	0.0865	0.2341	1.0000					
no_oxen	0.4038	0.0268	0.2703	0.2447	0.2956	1.0000				
n_education	0.2788	-0.3721	0.2541	0.1987	0.0876	0.1474	1.0000			
manu_use	0.2778	0.0232	0.1581	0.2877	0.2260	0.4750	0.0052	1.0000		
n_fert_risk	0.3568	-0.0420	0.0633	0.3170	0.2080	0.1930	0.1514	0.0783	1.0000	
n_marital	0.2638	0.0858	0.5922	0.0990	0.0298	0.3608	0.3081	0.1590	0.0842	
sour_land	0.4083	-0.1569	0.1194	0.1722	-0.0714	0.2514	0.2364	-0.0118	0.1193	
n_membership	0.1239	-0.0631	0.1596	0.1778	0.0121	0.1353	0.1419	0.1306	-0.0855	
risk_group	-0.2426	-0.1518	-0.1801	-0.0314	-0.0543	-0.1059	-0.1840	-0.1290	-0.0256	
slop_cat	0.2438	0.0424	-0.1482	0.1102	0.0097	0.0238	0.0246	0.1017	0.1235	
soil_ferti-y	0.0844	0.1190	-0.0221	0.2233	0.0419	-0.1280	-0.0631	0.0532	0.1184	
an_off_farm	0.2998	-0.0645	0.2987	0.2126	0.1284	0.2583	0.1006	0.1179	0.0990	
lsize_timad	0.2922	0.0512	0.2896	0.2606	0.2456	0.4806	0.0137	0.7527	0.1481	
		n_mari-l	sour_l-d	n_memb-p	risk_g-p	slop_cat	soil_f-y	an_off-m	lsize_-d	
n_marital		1.0000								
sour_land		0.1215	1.0000							
n_membership		0.0976	0.0941	1.0000						
risk_group		-0.2304	-0.0677	0.0315	1.0000					
slop_cat		-0.0576	0.2210	-0.1239	0.0453	1.0000				
soil_ferti-y		-0.0221	-0.0117	-0.0668	0.0109	0.1478	1.0000			
an_off_farm		0.2751	0.1556	0.1049	-0.1901	-0.0265	-0.0382	1.0000		
lsize_timad		0.2038	0.1641	0.1426	-0.1631	0.1761	0.0574	0.1542	1.0000	

Annex 3: Correlation Matrix of variables employed in the extension model

	extvdmy	n_credit	res_cat	no_oxen	hhsize	n_memb-p	sex	lsize_-d
extvdmy	1.0000							
n_credit	0.2561	1.0000						
res_cat	0.1624	0.4709	1.0000					
no_oxen	0.2107	0.2955	0.4034	1.0000				
hhsize	0.0047	0.0860	0.1124	0.2702	1.0000			
membership	0.1317	0.0140	0.1251	0.1355	0.1596	1.0000		
sex	-0.0249	-0.0044	-0.1974	-0.3701	-0.5299	-0.1235	1.0000	
lsize_timad	0.0825	0.2465	0.2929	0.4808	0.2895	0.1430	-0.1945	1.0000

Annex 4: Correlation Matrix of variables employed in the credit model

	n_credit	landdmy	sexdy	no_oxen	n_memb-p
n_credit	1.0000				
landdmy	0.1856	1.0000			
sexdy	0.0044	0.1931	1.0000		
no_oxen	0.2955	0.4910	0.3701	1.0000	
n_membership	0.0140	0.1502	0.1235	0.1355	1.0000

DECLARATION

I, the undersigned, declare that this thesis is my original work and has not been submitted for a degree in any other university. All the sources of materials used for this thesis have been duly acknowledged.

Name: Bahre Haileselassie

Signature: BPP

Place: Addis Ababa University

Date of Submission: 28/11/08

Advisor's Name: Dr. Workneh Negatu

Signature: _____

Date: _____