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Determinants of Farm Household Fertilizer Application on Teff

***A CASE STUDY OF ANKESHA WOREDA OF AWI ZONE, AMHARA NATIONAL
REGIONAL STATE, ETHIOPIA.***

By
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***Addis Ababa, Ethiopia
July 2007***

ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES
INSTITUTE OF DEVELOPMENT RESEARCH (IDR)

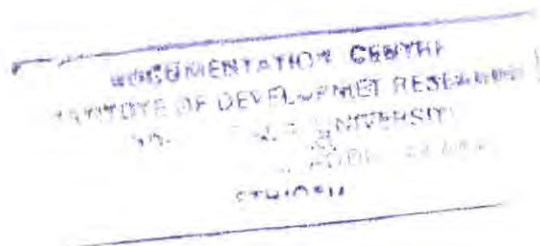
**Determinants of Farm Household Fertilizer
Application on Teff**

***A CASE STUDY OF ANKESHA WOREDA OF AWI ZONE, AMHARA
NATIONAL REGIONAL STATE, ETHIOPIA.***

**A Thesis Submitted to the School of Graduate Studies of Addis Ababa
University in Partial Fulfillment of the Requirements for the Degree of
Master of Arts in Development Studies in Environment and
Development**

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**ADDIS ABABA UNIVERSITY
SCHOOL OF GRADUATE STUDIES**

**INSTITUTE OF DEVELOPMENT
RESEARCH (IDR)**

Title

**Determinants of Farmhousehold Fertilizer Application on Teff in
Ethiopia. The case of Ankesha Woreda of Awi Zone of
Amhara National Regional State, Ethiopia.**

BY

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LIST OF ABBREVIATIONS

BoA	Bureau of Agriculture
CBE	Commercial Bank of Ethiopia
CDF	Cumulative Distribution Function
CSA	Central Statistics Authority
DA	Development Agent
DAP	Di-ammonium Phosphate
EEA	Ethiopian Economic Association
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
INM	Integrated Nutrient Management
KG	Kilo gram
K	Potassium
LPM	Linear Probability Model
MPP	Minimum Package Program
N	Nitrogen
P	Phosphorous
NFIA	National Fertilizer Industry Agency
TLU	Tropical Livestock Unit
WADO	Wereda Agriculture Development Office
WFP	World Food Program

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ABSTRACT

Low agricultural productivity and Land degradation have been important concerns in Ethiopia. Declining soils quality is the major component for declining level of agricultural productivity. Improvement of soil quality has become major policy agenda. Low fertilizer application rate coupled with inability of traditional fertility management practices have failed to maintain the soil quality at the required level. Farmers operate in different environmental context which present certain capacities, opportunities and limitations. Since fertilizer is the long researched and major productivity improving input, identification of determinants of fertilizer application contributes to improve low rate of application. Therefore, the general objective of this study is concerned with identifying demographic, socioeconomic and institutional factors that determine farmers' fertilizer application practices on Teff. Both primary and secondary data sources were used for this purpose. The data was analyzed using the probit model. It was found than farmer experience with fertilizer; Total livestock in TLU, Access to individual method of extension and number of manure application are the most important factors that positively influenced application of fertilizer on Teff. Where as Age of the households head, family size, number of compost application were found to influence the application of fertilizer on Teff negatively. Thus the implications of this study are strengthening Research and extension service, and improving farmers' access to financial capital are important areas of priority for the success of future intervention strategies aimed at improving the level of production through integrated soil fertility management practices where use of fertilizer is a major component.

1. INTRODUCTION

1.1 Background of the study

Soils are a living system of organisms reacting with organic or inorganic matter. The quality of soil comprises a range of chemical, physical and biological factors which together affect the productive potential of land. A change in any of the three factors across specific threshold results in degradation of soil quality. Soil degradation can be defined as a permanent decline in the rate at which land yields products that are useful to livelihoods. Biophysical and chemical processes of erosion, declining soil organic matter, soil nutrient depletion, and compaction, acidification, salinisation and soil pollution are often mentioned. These processes mostly occur on intensively farmed, sloping land or fragile soils. Fertile and good quality soils are essential since they compose major component for agricultural production (Scoones et.al, 1996).

Total agricultural population of Ethiopia in 2002 is close to 54 million which claims 80% of total population. This composed more than 11 million households with an average 5.15 persons per household. The national average of total land holding per household is 1.06 ha. Most of this agricultural land 74.2% was used for growing temporary crops (Girma, 2006 cited in EEA, 2006).

Ethiopian economy is highly dependent on agriculture which contributed about 48% to GDP in 2004 (NBE, 2005 cited by EEA, 2006) the contribution of agriculture to GDP growth was the highest relative to other sectors. In 2004/05, the economy grew by 8.8% of which 5.8% (or 66%) was contributed by the agricultural sector. The performance agricultural sector has been well in the last three years after a decline of 12% in the year 2002/03. The improvement in the

agricultural sector added value increase of 19% in 2003/04 (EEA, 2006).

The good performance was attributed to good weather condition, expansion the size of cultivated land (land converted from other uses like grazing, forest and fallow) and land improvement through the use of fertilizers. Again the sector contributed to 83% of total export earnings most export products (EEA, 2006).

In 2005/06 production season about 53% of cereal farmers used fertilizers. In fact, the rate of application of fertilizers still has been much lower than what the experts recommend. The CSA (2005) data reveals that on average 110kg/ha is applied with variations as high as 141kg /ha for maize, 120kg/ha for wheat and sorghum production and 90kg/ha for Teff and barely production respectively. The intensity of fertilizer application gets much worse if all cultivated land is considered. Only 43kg of both DAP and UREA was applied on a hectare of agricultural land (EEA, 2006).

Teff is an important cereal that covers considerable share cultivated land under all cereals. At national level Teff covers 27.9% of all area under cereals. Again at regional level, Teff by far exceeds in its area coverage as it covers 34.4% of the total area under cereals. The particular case of Awi Zone is no different from the above indicated national and regional statistics. Here also Teff covers 34.6% of cultivated land under cereals (CSA, 2005).

In addition to its wide area coverage the crop receives largest share of fertilizer application. At national level 31.6% of land under Teff is fertilized. Where as 48.9% of area under Teff receives fertilizers. The figures about the share of fertilizer application on Teff are much better in the case of Awi zone as 65.3% of area under Teff receives fertilizer application (CSA, 2005).

Fertilizer application relies on effective marketing and supply of the input. In the Amhara National Regional State for instance from launching of the national extension system in 1995/96 to date 2006/07 the distribution of fertilizer in the Amhara regional state has almost tripled standing at 1,223,357 quintal in this production season. The regional government plans to double the amount in the coming five years. For 2006/07 production season 39.04% of fertilizer was distributed through cooperatives down from 42.6% in preceding season but amount in the year 2006/07 has shown a 50,000qu increase. Among the major distributors *Ambassel* has considerably increased its distribution. Fertilizer distribution assumed two forms, one in credit and the other instant payment at cash. In Awi zone only 69.6% of planed fertilizer amount was supplied. A total of 84.3% was distributed to respective woredas of Fagta, Banja, Guangua and Ankesha (BoA, 2005).

In Ankesha woreda, 89.6% of 9376.5 quintal dap 97.8% of 5362.5 quintal urea supplied were distributed in the 2005/06 in the next cropping season 2006/07 , 99.7% of 11913.5 quintal of DAP and 98.5% of 7023.5 quintal of Urea supplied were distributed. As the reports of the regional bureau indicate the distribution of fertilizers has seen considerable improvement when

compared to the in the year 1997/98 (BoA, 2005).

Teff is the most important crop when application of fertilizer on cereals is considered. The relative importance in cultivation of Teff appears to merge from the wealth of genetic diversity that the country harbors in the crop species. The advantages of Teff include broad agro-ecological adaptation, suitability for various cropping systems and crop rotation schemes. In most areas the crop serves the role of catch crop and provides reliable harvest, minimal vulnerability to diseases and low post-harvest losses (Kebebew, 2003).

Teff possesses list of merits, but the crop has some implication on soil fertility decline. The crop requires intensive cultivation and provides little vegetative cover against incoming rainfall. This characteristics coupled with high crop residue removal for livestock feed contribute to increased soil erodability and high soil nutrient depletion (Hurni, 1983; Gizaw, 2003).

In spite of its immense economic importance and comparative advantages in Ethiopia, the productivity of Teff is relatively low. The national average grain yield is about 0.81 t/ha. Its low productivity has been attributed to insufficient improvement of varieties through research, low yield potentials of existing local varieties coupled with traditional cultural practice and vulnerability of the crop to lodging under high input or favorable environment (Kebebew, 2003).

1.2 Statement of the problem

The decline in productive capability soil resource has caused low and declining yields Eyasu (2002). According to Sanchez et al. (1997) crop yields are low due to poor agronomic practices, droughts, weed and pest attacks, lack of cash for investment, and soil-fertility depletion. The author emphasized several decades of continuous cultivation under low level of management have transformed originally fertile lands that yielded 2 to 4 ton per hectare of cereal grain, into infertile ones where cereal crops yields of less than 1 ton per hectare.

In the study area farmers indicate low productivity of land, decline in yield from time to time and additional requirement of inputs to sustain yields. Like other studies confirm, experts working in the area and farmers identify soil fertility decline as an important limiting factor.

In the study area farmers have long years of experience with fertilizer use, since the establishment of service cooperatives (Franzel et.al, 1989). As the figures woreda repots indicate with the launching of the national Extension program the use of fertilizer has progressed considerably. Though fertilizer response rate experiments indicated the use of fertilizer is profitable, farmers face number of problems in utilizing fertilizer.

The sufficient moisture availability coupled long years of farmers experience promises high returns to fertilizer use. But there are prevailing limitations on exclusive use of fertilizer to

improve soil fertility. Farmers in the area indicate the important role of traditional fertility improving methods of applying manure, applying compost and rotating crops. Despite the fact their role to maintain level of soil fertility is limited; farmers still practice the methods within farming system of the study area. Hence it is important to not to overlook the merits and constraints of these practices for increased use of fertilizers.

In most studies, the general context of traditional fertilization methods and determinant factors farm household fertilizer application on Teff with regards to soil fertility is not well studied. In departure, this study investigates soil fertilization methods peculiar to study area's farming system, determinant factors of institutional, socioeconomic and demographic characteristics with regards to fertilizer use on Teff. In parallel due emphasis is given on utilization of internal farm resources as inputs to improve soil fertility status mainly through compost and manure application.

1.3 Objectives of the study

The general objective of the study is concerned with identifying demographic, socioeconomic and institutional factors that determine farmers' fertilizer application practices on Teff.

Specific objectives are: To

- Explore farmers' traditional practices of soil fertilization.
- Examine demographic, socioeconomic and institutional factors that affect application of fertilizers on Teff.
- Draw implication for research, extension and policy interventions.

1.4 Significance of the study

The decline in soil fertility came about in Africa as result of population growth. Original fertility level was gradually depleted by crop-harvest removals, leaching, and soil erosion. Farmers failed to sufficiently compensate the losses by returning nutrients to soil through crop residues, manures, and use of fertilizers (Woomer et al.1994 cited by Sanchez et.al, 1997).According to Cleaver and Schreiber 1994 cited by Eyasu (2002) different traditional coping strategies were not capable of adjusting quickly enough to rapid population growth combined with decreasing farm size, soil fertility, and fuel wood availability.

Different studies indicated despite over three decades of fertilizer popularization effort in Ethiopia, the use of fertilizer by smallholder farmers is very low, for various reasons. In addition, there is evidence of large difference among farmers in use of fertilizer, even in a given

agro-climatic zone, farming system and on a given crop.

By studying the various factors affecting fertilizer use by small-holder farmers in specific areas, it is possible to formulate policies and initiate investments that most likely stimulate fertilizer use to improve soil fertility. The findings of this study benefits local government bodies in particular and development practitioners, policy makers in general, in terms of improving the knowledge in indicating contribution of determining the factors that influence fertilizer application at a unit farm household level.

1.5 Scope and limitation of the study

The study was conducted in a context of single woreda. It is specifically limited with Teff growing farmers. A sample size of 150 farm households was considered. The study dealt with a cross-sectional data of specific agricultural season. The study primarily faced constraints of time and budget. There was also lack of properly documented baseline data.

2. Literature Review

2.1 Definition and concepts

Soil quality

According to definition by Soil Science Society of America cited in Scoones et al (1999); Soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

In areas where shortage of food supply is an issue, the concern on soil quality focuses on productivity of soil, while in other areas focus goes beyond concerns of productivity to the overall sustainability of the food production systems. Sustainable agriculture involves a sustained productivity but also the protection of natural resources. The concept of soil quality is deeply rooted in considerations on sustainable production, but since the priorities change over time, soil quality cannot be aligned with the universal laws of nature. The concept of soil quality can be coined into specific consideration of soil functions to be evaluated against specific purposes (Scoones et.al, 1999).

Authors like Izac (1997) make a clear distinction between soil quality and soil fertility. Soil quality is a more basic term which includes the soil's ability to fulfill all potential uses and functions of soil. On the other hand, soil fertility primarily related to the productivity of soil. Of

course an important to note that soil productivity or soil fertility is component of soil quality.

Biophysical characteristics of soil and soil fertility

Soils differ in the availability of Nutrient stocks and depletion rates vary with soil properties. Soil property is function of soil formation and soil degradation. Soil formation rate is influenced by erosion, natural rate of build up, surface accumulation from up-slope areas. Soil formation rate is an important measure to maximum amount of loss due to soil erosion without decline of crop productivity. Soil formation rates are also important to indicate potential for regeneration when intervention measures are put in place. Major contributing parameters for soil formation include Temperature, Rainfall, length of growing period, Soil depth, slope gradient, soil unit and land cover and use. Among these the most common parameters are annual Rainfall and temperature (Hurni, 1983).

According to the computations of Hurni (1983) on the basis of results from the SCRP project, at the country level soil formation rates vary from less than 2 tons/ha to more than 22 tons/ha/year. The soil formation rates in the country show variation across different zones. The soil formation rates of Gojam region is estimated at 10-14 ton/ha/year. Primarily temperature and rainfall are the important parameters that account for the respective variations. It now requires a major investment to restore soils to a sufficient level of fertility for sustainable crop production.

2.2 Soil quality degradation

According to Scoones et.al (1999) the challenges in changes of soil quality include decline in major plant nutrients of (N, P, K), soil acidity, soil organic matter, soil biodiversity, soil compaction, erosion and use of pesticides. The changes are determined by interplay between physical, chemical, biological, and anthropogenic processes. The cumulative interactions are highly complex and that it is extremely difficult or impossible to identify simple thresholds for both soil quality indicators and management. Much effort went into identifying indicator levels or management thresholds.

Since soil fertility is the important component of soil quality its feature changes constantly (Sanchez et.al, 1997). According to Fresco & Kroonenberg (1992) cited by Eyasu (2002) soil fertility taken as an important form of renewable natural capital. In spite of this fact the important concern that hangs is the issue of nutrient capital stock especially where the essential plant nutrients in the soil show little resilience in soil.

2.2.1. Nutrient depletion as cause for soil quality decline

According to Stoorvogel and Smaling (1993) cited by Eyasu (2002), the balance between nutrient inputs and nutrient outputs carried out through different processes is negative in African soils. The study aggregated different values on variety of land-use systems, crops, and agro-

ecological zones. In the same study the loss of nutrients from cultivated lands is by far higher as compared to the consumption rate of the continent. This leaves agricultural lands with enormous level of nutrient depletion.

In the case of Ethiopia the nutrient balance study computed in the Enset-based farming system of Kindo-Koisha by Eyasu in 2002 confirmed the important role of above mentioned factors in affecting the nutrient depletion.

Nutrient depletion rates are field specific, depending on the way each particular field has been managed over decades. This results in multitude degrees of nutrient mining at the farm and field levels scale (Sanchez et.al, 1997). The results of Eyasu from Kindo-Koisha affirm the variation of nutrient balance level across type of enterprise, the socioeconomic status of households and the agro-ecology the farms/fields fall. The results, however, stressed the higher negative N balances on the farmlands compared to the results reported for other Sub-Saharan countries (Eyasu, 2002).

As the argument of Sanchez et.al (1997) the requirements for increased agricultural productivity are summed into three categories. The first one relates to the enabling policy environment for the smallholder farming through provision of improved road infrastructure, access to credit, inputs, markets and extension services. The second focuses on reversing soil-fertility depletion while the third relates to promoting intensified and diversified land use systems. Regarding improvement

of soil fertility Conway & Barbier (1990) cited by Sanchez et.al (1997) indicate the few improved soil-fertility management technologies offered to smallholder farmers combined with constraints of socioeconomic and policy distortions are important factors that deter level of soil fertility.

2.3. Debates on soil fertility management

Soil fertility management is undertaken in two important forms- application of nutrient inputs and cycling of nutrients. Nutrient inputs, at the field scale are additions from outside the system where as nutrient cycling refers to the transfer of nutrients already in the field from one component to another. Nutrient cycling is extremely important, but nutrient-depleted soils need inputs from outside the field through the process that include return of crop residues and manure from cattle that grazed harvested crop residues (Palm et.al, 1997).

Fertility replenishment also enables farmers to intensify and diversify their production. They may shift from growing low-value crops to growing vegetables, livestock, or trees that produce high-value products, which may add economic sustainability through product and income diversification (Sanchez et.al, 1997). Such diversification also will contribute to environmental resilience through increased plant biodiversity. Further more some pest problems related to low soil fertility are diminished when fertility is replenished.

Nutrient balance in the soil has become an important quality indicator in the principles of international organizations like World Bank and FAO in their efforts of realizing sustainable agriculture in the tropics (Pieri et.al, 1996). As a result mainstream approaches of improving the productivity of soil focused on replenishment of most limiting nutrients for plant growth. The most important limiting nutrients for crop production are Nitrogen (N) and Phosphorus (P) (Stoorvogel, 1992 cited by Alemneh, 2003).

Restoring the most limiting nutrients to allow sustained use for production requires some form of investment there are feasible mechanisms to build up nitrogen and phosphorus levels in the soil (Smalling, 1993 cited Sanchez, 2001).

As to the proposed interventions regarding improvement soil fertility managements of agricultural productivity, there are two major debate pools (Theng, 1991 cited by Eyasu, 2002). The first pool suggests increased land productivity requires imports of fertilizer from outside the system while the second pool lays emphasis on biological process and nutrient cycling to reduce reliance on external inputs.

2.3.1. Organic Inputs Based Soil fertility management

The exclusive use of organic inputs as external nutrient sources has been advocated as a logical alternative to expensive fertilizers in Africa (Scoones et al., 1996). The main advantages of this approach are replacement of scarce or nonexistent capital for labor and the fact that cattle manures or green manures contain all essential nutrients plus C which serves as the source of energy for soil biota that regulates nutrient cycling.

Some environmental groups that advocate reliance on organic or natural farming in Africa, on the grounds that N fertilizers are harmful to the environment, costly to import and expensive for farmers to use, and in the long run not sustainable because nonrenewable resources are used to produce fertilizers (Palm et al. 1997).

The strong arguments to this pool raise issues that farmers lack of financial and basic institutional resources to sustain high external inputs and in addition risk a growing concern from harmful effects on environment from heavy N-fertilizers use (Theng, 1991 cited by Eyasu, 2002).

Constraints of on use of organic fertilizers

An important critique indicates that not all low-input systems are necessarily sustainable because degradation can occur due to soil mining unless careful management is in place (Scholes et. al, 1994 cited in Eyasu, 2002).

It takes soil fertility to grow organic inputs, be they green manures, litterfall, plant biomass for transfer, composts, or animal manures. In nutrient-depleted soils it is difficult to grow enough forage to feed cattle and produce sufficient quantities of manure (Probert et al., 1995 cited by Eyasu, 2002). Sources of organic manure are limited in most African countries. Even in Ethiopia, where livestock numbers are significant, manure is primarily used as a cooking fuel and rarely to improve the fertility of the soil (Giller et al., 1997).

The constraint to utilize biological measures to improve cycling rates of nutrients like Nitrogen through agronomic options like alley cropping and agro-forestry approaches to maintaining soil fertility are knowledge-intensive. Moreover, such nutrient management systems that have met with limited success, especially where poverty and hunger force farmers to employ desperate short-term survival strategies that take precedence over longer term sustainability practices. As authors Giller et al. (1997) emphasize efforts should be made to increase the efficient use of fertilizers through sound policies and education, to attain economic growth and food security targets while minimizing the damage to the resource base.

2.3.2. Fertilizer based soil fertility management

Fertilizer use is the obvious way to overcome soil-fertility depletion, and indeed it has been responsible for a large part of the sustained increases in per capita food production that have occurred in Asia, Latin America, and the temperate region, as well as in the commercial farm sector in Africa (Kumar, 1991).

There is nothing wrong, biophysically or environmentally, with fertilizers when properly used. Fertilizers provide the same nutrients as organic sources to plants. Plants cannot distinguish nitrate or phosphate ions they absorb from organic inputs from those they absorb from fertilizers (Borlaug et.al, 1997).

Constraints to fertilizer use

As Sanchez (2001) indicated, most smallholder farmers in Africa appreciate the value of fertilizers, but they are seldom able to apply them at the recommended rates and at the appropriate time because of high cost, lack of credit, delivery delays, and low and variable returns. Such constraints are largely due to the lack of an enabling policy environment in rural areas caused by the deficient road and market infrastructure which prevails in most African countries.

Fertilizer application by smallholder farmers to food crops is often not profitable due to the combination of high fertilizer prices, low prices for food crops, and high risk associated with lack of inputs like irrigation and reliance on rain. Thus fertilizer consumption on food crops is the lowest in the world—probably not more than 5 kg per ha of nutrients, when fertilizer use on cash crops is subtracted from aggregate statistics (Borluag et.al, 1997).

The price of fertilizers in rural areas of Africa is usually at least twice the international price. Even when fertilizer applications are profitable, many farmers cannot afford to purchase fertilizer at the beginning of the season when other, more basic needs, are pressing (Borluag et.al, 1997).

2.3.3. Integrated Nutrient Management

Conventional approaches for soil-fertility management range from recurring fertilizer applications to low external input agriculture based on organic sources of nutrients. Although both extremes work well in specific circumstances, they pose major limitations for most smallholder farmers in Africa (Eyasu, 2002).

Obviously, a combination of the two sources of nutrients of inorganic and organic, is more desirable than the use of one source to the exclusion of the other; the strategies for soil fertility should have as its central component the increased and judicious use of fertilizers, supplemented by organic fertilizer sources (Eyasu, 2002).

2.4. Major Soil fertility replenishment strategies

The maintenance of soil fertility involves the return to the soil of the nutrients removed from it by harvests, runoff, erosion, leaching, and other loss pathways (Aune, 1993 cited by Smaling et al., 1997).

The strategies for replenishment vary in order to address concerns of efficiency. Hence, in the case of P-depleted, high P-sorbing soils, the strategy opted is to rapidly replenish capital P pools, rather than less efficient, gradual build ups. In the case of N, however, the size of the capital N stocks cannot be built instantaneously like P capital stocks, so gradual build ups are needed. The critical factor is not the size of the N capital stocks, but the cycling rate. The soil-fertility replenishment approaches require a set of accompanying technologies and policies to be effective in raising and sustaining food production (Giller et al., 1997).

To serve the purpose of soil replenishment different approaches have been pursued. The yield-increasing effect of fertilizers has long been the main nutrient management technology researched, through rate-response trials of the FAO Fertilizer Programme. Presently, however, land-use planning approaches aimed at integrated nutrient management (INM), are adopted as the best combination of available nutrient management technologies, i.e., those that suit local biophysical conditions and are economically attractive and socially relevant (Smaling et al., 1997).

As each agro-ecological zone has its potentials and limitations, the number of relevant Integrated

Nutrient Management options is site specific. In the eastern African highlands, for example, with reliable rainfall and deep, relatively fertile soils, more options are available to safeguard productivity. Of late, the nutrient balance and INM have been adopted by the World Bank as key to the debate on sustainable agricultural systems in the tropics. As a consequence, work is under way to turn the nutrient balance into a land quality indicator (Pieri et al., 1996).

In order for soil-fertility investments to have national or global benefits, they must be adopted at a large scale. Soil-fertility investments in only individual scattered farms will not provide national or global benefits. The international initiative stream-lined by World Bank were adopted by the national fertilizer input unit and several fields in different parts of the country were carried out (Alemneh, 2003).

In the Ethiopian case, the strategy opted for improving soil fertility relies on the basis of these results and previous experience of FAO initiative, recommendation rates for major cereals. These outputs were later incorporated in the national extension packages which incorporated fertilizer technology as major component (Alemneh, 2003).

2.5. Fertilizer Sector in Ethiopia

Important factors underlying of fertilizer sector

Changes in Policy intervention

The Ethiopian policy blends of macroeconomic and Extension of soil improving technologies. The policy and information constraints can certainly be overcome, thereby in the longer term resulting in increased food security and reducing poverty. An excellent example of a promising approach is the Sasakawa Global 2000 projects in Ethiopia, where many policy distortions have been overcome (Borlaug et.al, 1997). The initiative mainly acted in filling the gaps that existed in previous extension system. The new Extension service had component of intensive practical trainings and it mainly operated through organs of the Ministry of Agriculture. This experience along with T&V extension system of the World Bank was later developed into participatory Demonstration and Training Extension system. It utilized demonstration plots to provide trainings to extension workers and to farmers (Tesfaye and Shiferaw, 2001).

Growing demand for fertilizer

The viability of replenishing soil in Africa has been contested by some since the level of demand for fertilizers is very low. In most African countries the demand for mineral fertilizer is low but expected to grow appreciably over the next two decades. Studies conducted indicated in some

African countries like Ethiopia, Burkina Faso and Mali indicate appreciable growth demand in fertilizers (Scoones et.al, 1996).

Recently for Ethiopian case, level of consumption has grown more pronouncedly as compared to 1996/97 amount of 147000 tons to 2005/06 consumption level of 346,000 tons. Between the years of 2003/04 and 2005/06 the consumption of fertilizer has shown a 7.9% increase in spite of significant international price increase in DAP and Urea. The demand preceded the supply in the main production areas particularly for case urea (FAO/WFP, 2006 cited in EEA, 2006).

Important measure noted for Ethiopian experience is to lower transport costs mainly achieved through the shift from low to high-analysis fertilizers. For example, in the case of Nitrogen fertilizers urea is preferred to ammonium sulfate (Borlaug et.al, 1997).

An international initiative streamlined by World Bank, aimed to restore declining soil fertility in Sub-Saharan Africa through coordinating donors, governments, NGO's, and development agencies at national and international level. In Ethiopia, with regards to management of soil fertility, the general framework for intervention arranged soil fertility management as sub component to fertilizer sector. These elements found their way into national research and extension systems. On the basis of various field trial results, the SG-2000 initiative developed a blanket recommendation for major cereal crops (Alemneh, 2003).

The general norm in Ethiopia towards maintaining or improving soil fertility, considers fertilizer use primary element. This aspect particularly lacks consideration of return of organic matter to the soil (Eyasu, 2002).

The fertilizer based extension approach in Ethiopia relies on the consideration of two major facts. First, much of the land in high potential cereal zone is already under cultivation and increased production will require increased productivity. Second, to attain required productivity level through entire package of technological inputs, improved farm and field management can't be pursued in parallel under the conditions of prevailing financial constraints. And finally the lacks of alternative and feasible technologies to fertilizer are major underlying reasons (Croppenstedt et.al, 1999).

2.5.2. Strategy in the existing fertilizer sector in Ethiopian context

2.5.2.1. Import based approach

In formulating a fertilizer sector strategy for Africa, it is important to understand the nature of industrially produced fertilizer products. Fertilizer manufacturing units are costly to construct and operate, and they must be relatively large in scale and operated near capacity to remain economic. African countries can benefit from the more favorable economies of large-scale, export-oriented production units in Europe, the USA, North Africa and the Middle East, and elsewhere by importing the required products. Considerable costs can be reduced through improved through improvements in procurement, realistic demand forecast, selection of selection

of appropriate fertilizer types and consolidation of annual fertilizer requirements (Borlaug et.al, 1997).

Fertilizer import and marketing with regard to fertilizer import, the foreign exchange needed was financed through loans, donor assistance, and government treasury. The fertilizer sector in 1990s has been deregulated and opened for private competition. As fertilizer plays a very crucial role in achieving food security, the government is highly involved in the sector by making credit available to farmers and encouraging more fertilizer use. The level of fertilizer use exceeded that of 2004/05 production by 7%. In 2004/05 a budget of 122 million USD was allotted (EEA, 2006).

2.5.2.2. Increased Credit for input use

Capital investments are different from subsidies in that they have a profit expectation in the long-term while subsidies are short-term removals of constraints. Therefore, it may be advisable for society to assume some of the costs involved in moving farmers from unsustainable to sustainable production systems, in recognition of the socially and environmentally desirable externalities involved (Cleaver & Schreiber, 1994 cited by Sanchez et.al, 1997).

Local access to credit at reasonable interest rates is important to finance initial costs of purchasing inputs. Micro-credit facilities, following the Grameen Bank model have been replicated in Ethiopia. In local credit schemes loans provisions reach up to 50% for the cost of

inputs with encouraging recovery rates of 90% or higher (Quinones & Takele Gebre, 1996 cited by Beyene, 1998).

Shortage of capital to finance agricultural production and marketing activities is one of the major problems the Ethiopian smallholder farmers face. Smallholder farmers need agricultural credit to meet short term requirement of working capital and long-term investment in agricultural and other income bearing activities credit for short term requirement usually is used to buy fertilizers and to a lesser extent to buy improved seeds that can increase yield and production (EEA, 2006).

The commercial bank of Ethiopia (CBE) is the largest source of agricultural credit in the country according to (FAO/WFP, 2006 cited in EEA, 2006). More than 2.5 million which accounts for less than 25% of total smallholders, obtained credit for purchase of inputs, mainly for the purpose of fertilizer purchase in 2005/06. The bulk of this credit was provided by the intervention of the regional state governments to under write the loan. In last five years credit disbursed showed an upward trend in last five years.

2.5.2.4. Improved Research and Extension system

There is also a room for considerable gains from improving the effectiveness of research and extension programs in soil fertility management. National extension services also need to mount mass-education campaigns to teach farmers to use fertilizers in the most efficient manner possible, such as appropriate formulas and combinations of nutrient sources, timely application,

optimum planting densities, and timely weed control (Borlaug et.al, 1997).

There are several positive feedbacks to soil-fertility replenishment. It is more likely that sound agronomic practices will be profitable in replenished areas than in depleted ones. In recognition of the fact that resource poor farmers don't adopt recommended packages at once, alternative way to improve benefits of these package elements in prevailing context revealed contributions of improved agronomic practices. As a result yield improvements have been secured in resource poor areas (Alemneh, 2003).

2.6 Empirical Literature

From range of different elements, certain characteristics of farm households and components of the external environment affect the Adoption decision made by farmhouse hold towards using the specific technology like fertilizers. Additionally, adoption studies on area of improved maize of fertilizers; consider certain demographic and socioeconomic variables as proxy to measure variation in wealth or resource endowment. Economic manual CIMMYT (1993) establishes the importance of considering these elements as proxy measure. In parallel to farm household characteristics, t^he external environment under which farmer operates affects farmer adoption decision. Here important institutional factors of access to extension and credit are usually examined.

Different empirical literatures in Ethiopia have used number of variables that serve as proxy

measures for internal and external factors that individual households encounter. In table1, some of the studies in Ethiopia are summarized and presented.

Table 1 Summary of Empirical Literatures Reviewed

Name of author	Year	Dependent Variables	Explanatory Variables	Model used
Itana Ayana	1985	Use of Fertilizer or improved seeds	Literacy level, age, labor supply, farmland fragmentation, value of livestock owned, number of oxen used, farm size, unavailability of cash or down payment, adequacy of rainfall, fertility of land, prices of farm outputs, non-farm income, extension contact	Probit model
Mulat Demeke and Andre Croppenstedt	1996	Fertilizer adoption	Age, Sex, Educational level, total value from sale of crops, number of adults, number of dependents, number of oxen, size of cultivated land, access to extension services, access to all weather road, access to bank services, ratio of price of output to cost of fertilizer	Tobit model
Lelissa Chalchissa	1998	fertilizer use for specific season Fertilizer applied per hectare Amount of fertilizer purchased Urea applied per hectare	Age, Sex, Education level, household size, draught power per farmer, livestock owned, cultivated land, cropping pattern, land quality, land tenure, price-cost ratio, access to credit, service to extension, radio, distance to the fertilizer centre, manure application, crop damage, improved seed availability, off-farm income, land tax per farmer	Probit and Tobit models
Tesfaye Zegeye, Bedassa Tadesse and Shiferaw Tesfaye	2001	Adoption of improved maize technologies	Age, Educational level, farm experience, family size number of dependents, Religion, farm size, cultivated land, area under maize, labor, livestock ownership, extension services, credit availability	Logit model

Table 1 continued

Mulat Demeke and Lelissa Chalchissa	2002	Fertilizer adoption (use of fertilizer and intensity of fertilizer use)	Age, Sex, Education level, household size, draught power per farmer, livestock owned, cultivated land, cropping pattern, land quality, land tenure, price-cost ratio, access to credit, service to extension, radio, distance to the fertilizer centre, manure application, crop damage, improved seed availability, off-farm income, land tax per farmer	Probit and Tobit model
Assefa Admassie and Gezahegn Ayele	2002	Adoption of fertilizer, improved seeds or chemicals over the last three years	Age, Education level, gender, ethnicity, religion, wealth position, Labour, availability of credit facility, number of oxen, distance from the main road, access to information	Logit and Probit model
Techane Adugna	2002	Fertilizer applied per hectare (fertilizer area considered)	Age, Sex, Education level, off-farm income, family labor, hired labor, health status, service to extension, manure application, proportion of steep slope lands, access to input credit	Tobit model
Endrias Geta	2003	Proportion of area under improved sweet potato	Age, Education level, gender, off-farm activity, farming experience, labor available, farm size, livestock owned, farmers' perception of variety characteristics, extension contact, distance to market	Tobit model
Yisehak Gecho	2005	Adoption of improved maize	Age, farm size, labor, education, farm experience, Ownership of house, farm size, Oxen, Total livestock, availability of fertilizer on time, cash shortage, credit, access to extension, off-farm, Input price, distance to output market	Tobit model

3. METHODOLOGY

3.1 Description of the Study Area

Ankesha woreda is found in the Amhara Regional State, in Awi administrative Zone, 425km north of Addis Ababa and 140km south of Bahirdar. Awi is an administrative zone representing the Agaw ethnic group. The woreda extends over a total area of 95,503 ha (WADO, 2006). Out of this total area 37025 ha is under cultivation by smallholder farms. The altitude ranges from 1500m to 2800m in High Relief Mountain called Fuddi. The geographical location of the area lies between $36^{\circ}47'6''$ and $36^{\circ}56'34''$ longitude East and $10^{\circ}45'4''$ and $10^{\circ}59'52''$ latitude North (Alehegn, 2001). According reports of the wereda a minimum temperature of 9.7°C and 27.3°C at Dangla. Asmare et al, 1998 reported a population density of 161 persons per km^2 .

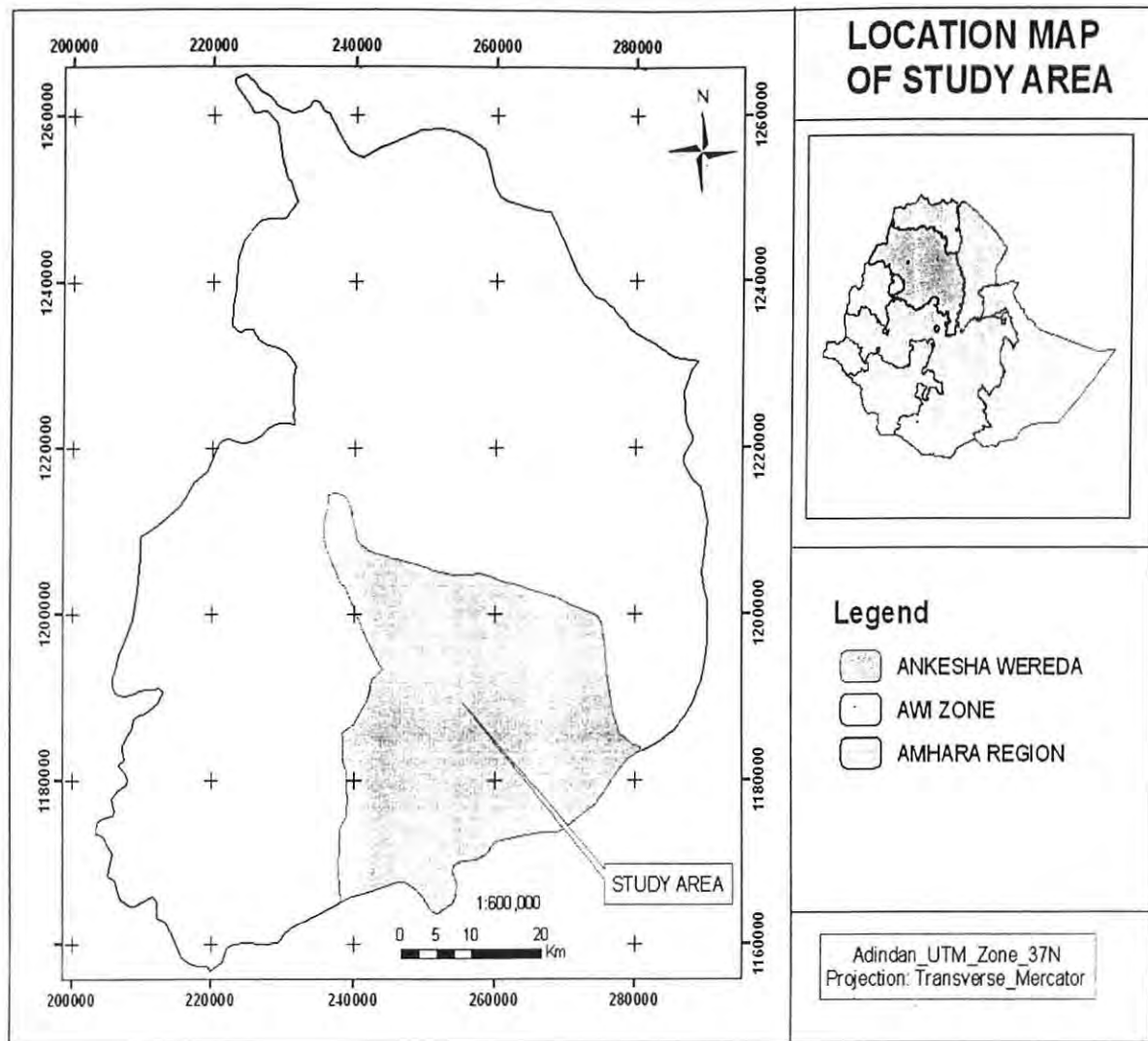


Figure 1: location map of the study area

3.2 Sampling Procedure

The study area, Ankeshaworeda was selected based on its:- long experience of Teff production, Teff covers the largest area of land cultivated, potential for fertilizer use, accessibility and representation of cereal-livestock farming system characteristics. The study employed a two-stage sampling technique. Five Kebeles were selected from 31 Kebeles across the Woreda with

consideration of accessibility and importance of the crop. Here, relevant extension experts at the woreda level were involved in every stage.

The selection of 150 sample farm households were carried out through random sampling with precaution not to include non-Teff growing farmers in the year 2006/07. The sampling frame was secured from pre-harvest assessment of crop by ministry of agriculture desks at kebele. The final sample composed only 139 household heads with criteria of identified farmers who managed Teff farms either on their own land, shared in or rented in lands. Thus farmers who were registered to grow Teff in pre-season assessment but for various reasons did not grow Teff were excluded.

3.3 Methods of data Collection

Source of Data

The study used both primary and secondary data sources. The secondary source of information was gathered from woreda, regional office of agriculture, *Adet* research centre and the regional bureau of land use and administration. Where as Primary data source were farm household head and key informants.

Data collected

Both qualitative and quantitative type of data was collected for the study. Qualitative data on soil types and soil fertility management practices with respect to farming system characteristics of the study area. Quantitative data on total livestock holding size, farm land size allocated to Teff cultivation, family size, amount and type of fertilizer application, Teff yield, farm household income, etc.

Tools of Data Collection

The study utilized both formal and informal methods of data collection. In the informal survey procedure, semi structured interview schedules were used to guide the focus group discussion and key informant interviews. In the formal survey procedure, structured questionnaire was used. Where pre-testing was carried out to test relevance and clarity of questions included. Enumerators who administered the questionnaire work as development agents in the study area.

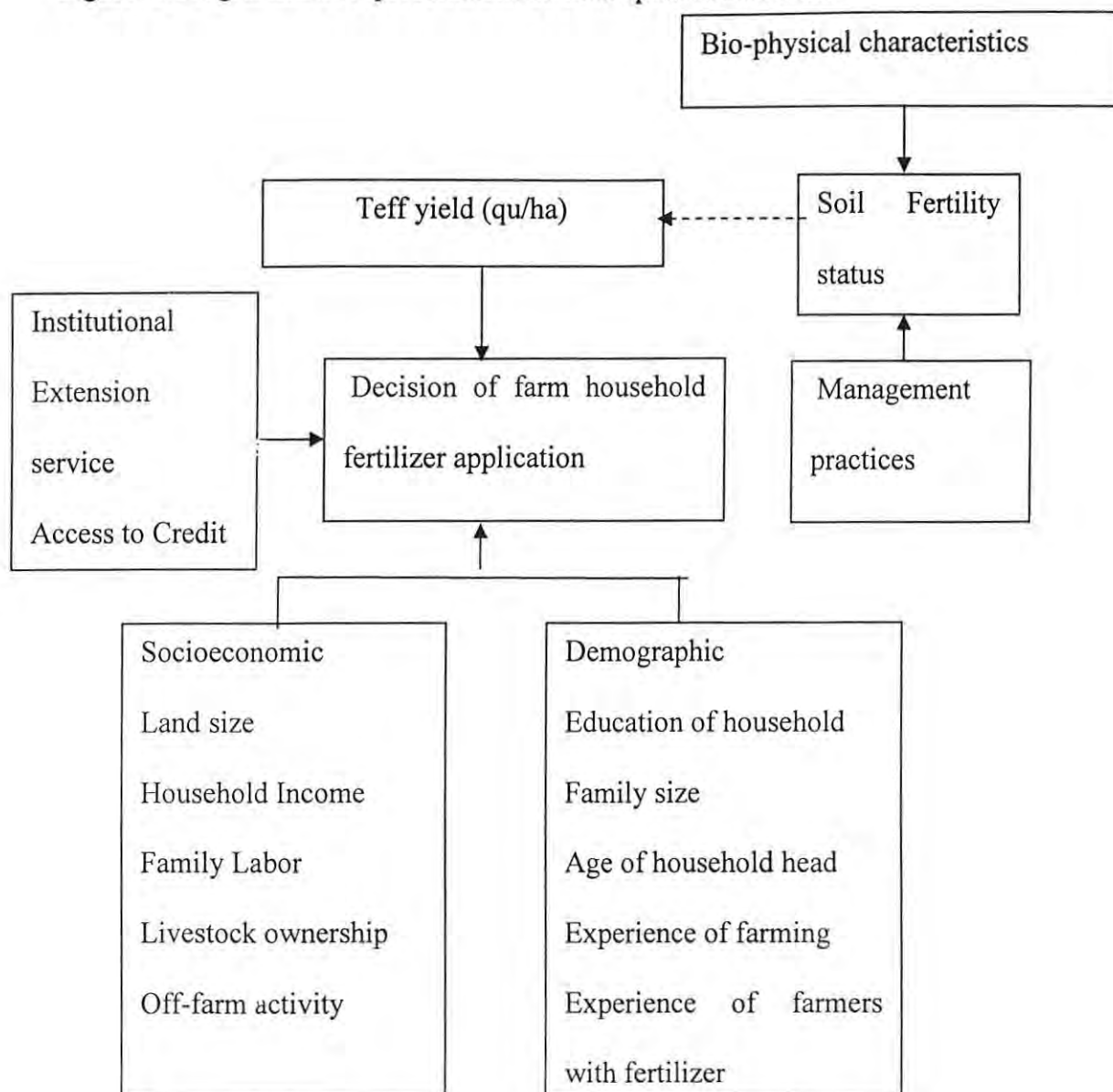
3.4 Method of Data Analysis and Analytical frame work

Adoption studies concerned with factors that influence farmers' decisions require careful examination of interaction between the characteristics of the technology and the characteristics of the farmers and farming systems that might accommodate the technology (Tripp and Woolley, 1989 cited in CIMMYT, 1993).

The designs of adoption studies focus on knowledge of specific issues of farmers potentially affected, comparison of the characteristics of the technology with farmer's traditional practices, and understanding the technology diffusion process to decide which factors deserve attention (CIMMYT, 1993).

Adoption is a function of physical, social, institutional, economic merits associated with the new technology, the amount of initial financial requirement to adopt, and accessibility to information (Feder et al.1985 cited in Techane, 2002). Large body of literature adoption of high- yielding varieties and improved crop management practices points towards a number of factors operating in a quite complex and interactive ways that condition the adoption decision of farmers (Lapar and Pandey, 1999 cited in Techane, 2002) Adoption decisions are reference point for much of empirical work that generally employs limited dependent variable methods to test the relevance of specific factors for a particular site, region or country (Feder et. al, 1985 cited in Yisehak, 2005).

Figure: 2 Diagrammatic representation of Conceptual framework



Source: Own formulation

3.4.1 Discrete Regression Models

Discrete regression models are models in which the dependent variable assumes discrete values. The simplest of these models is that in which the dependent variable Y is binary (it can assume only two values denoted by 0 and 1) (Gujarat, 1995 and Madalla, 1997). According to Gujarat (1995) and Madalla (1997), the three most commonly used approaches to estimating such models are the Linear Probability Model (LPM), the Logit model and the Probit model. The Linear Probability Model is the model, which expresses the dichotomous dependent variable (Y) as a linear function of the explanatory variable (X).

Different authors suggest the use of Cumulative Distribution Function (CDF) of random variable is used to model regressions where the response variable is dichotomous, taking 0-1 values. The Cumulative Distributions Functions (CDFs) which are commonly chosen to represent the 0-1 response models are the Logit (logistic CDF) model and the Probit (normal CDF) Model.

Logit and Probit models are the convenient functional forms for models with binary endogenous variables Johnston and Dinardo (1997). These two models are commonly used in studies involving qualitative choices. To explain the behavior of dichotomous dependent variable we will have to use a suitably chosen Cumulative Distribution Function (CDF). In some applications the normal CDF has been found useful. The estimating model that emerges from normal CDF is popularly known as the Probit model Gujarat (1995). The logistic and Probit

formulations are quite comparable, the chief difference being that the logistic has slightly flatter tails than the normal curve approaches the axes more quickly than the logistic curve. Therefore, the choice between the two is one of mathematical convenience and ready availability of computer programs (Gujarat, 1995).

3.4.2 Model Specification

The issue of whether or not a farm household apply fertilizer on Teff field assumes yes or no answers. The dependent variable is a binary variable, for use (=1) or not use (=0). Among several discrete models, probit model is chosen for this particular study. The probit model guarantees that the estimated probabilities lie in the (i.e. the normal distribution function with the range [0, 1]). The probit model helps in assessing various determinants and provides predicted probabilities adoption (Madalla, 1992)

Following Madalla (1992) the Probit model is specified as follows

$$\begin{aligned}
 Y_i^* &= \beta X_i + u_i & i &= 1, 2, \dots, n \\
 Y_i &= Y_i^* \text{ if } Y_i^* > 0 \\
 &= 0 \text{ if } Y_i^* \leq 0
 \end{aligned}
 \tag{1}$$

Where,

Y_i = the observed dependent variable, in this case application of fertilizer on Teff.

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

X_i = vector of factors affecting adoption of fertilizer use

β_i = vector of unknown parameters

u_i = residuals independently and normally distributed with mean zero and a common variance

□

Econometric software “STATA 9” was employed to run the Probit model. Probability of adoption can be expressed as

$$P_i = \text{prob}(y=1) = F(\beta'x)$$

In case of adoption of fertilizer use, the same approach can be adapted.

$$\text{Prob}(Y=i) = F(\beta'x)$$

Where $\beta'x$ is set of parameters that explain the influence of change in the explanatory variables x , of the farm household decision on the adoption of fertilizer use and i takes the value of 1 and 0. $Y=1$ if a farmer adopts fertilizer and $Y=0$ if he/she does not. With the assumption that there is a critical or threshold level (Gujarat, 1988 cited Mulat and Lelissa, 1999; Mc Fadden, 1974 cited in Desta, 1990) given the index I_j^* , then the farmer will adopt fertilizer if $I_j = I_j^*$ ($y=1$), other wise he/she will not. The unobservable utility, I_j , is related to actual decision to adopt fertilizer. The larger the value of I_j , the greater utility individual I receives from choosing the option $Y_i=1$ (Griffith et al, 1993 cited in Mulat and Lelissa, 1999).

Hypothesis and Definition of Variables

Dependent Variable of the study

Fertilizer use on Teff (FERTUSTFF)

The dependent variable of the Probit model has binary variable. In this study the dependent variable takes the value of (0) and (1). (1) if the respondent used fertilizer on Teff and (0) if the respondent did not use fertilizer on Teff.

Independent Variables of the study

Age of the household head (AGEHHH)

The age of a farmer can generate or erode confidence towards improved technology. In other words, with increased age a farmer can become more or less risk averse to new technologies (Techane, 2002). It's possible that as the age of farmers gets older their agility to cope with labor demanding fertilizer use is weakened. Another reason indicated by Lelissa, 1998 relates it decline of farmers income level and low input/fertilizer purchasing ability that comes along. Itana, 1985; Gezahegn and Assefa, 2002 relate age with older farmers inflexibility to using technology. It is hypothesized that a farmers with young age have more probability of using fertilizer. Agility of individual farmers to cover financial costs, relates to experience of farming, reflects the effects of age structure of the household (Yishak, 2005; Mulat and Croppendesat, 1996).

Experience with fertilizer use (FEXPFER)

Experience of farmers with fertilizer has positive and significant relationship with fertilizer use on Teff. Farmers observation of the technology characteristics. Better experience contributes positively to better observation of technology characteristics, improvements of the related agronomic practices and realization of the benefits associated with the technology use (Techane, 2002; Mulat and Cropp, 1996; Gezahegn and Assefa, 2002). Farmers with more experience appear to have often full information and better knowledge and are able to evaluate the advantage of the technology. Experience will improve the farmer's skill at production (Yishak, 2005). Hence, it is expected that farmers with longer years of fertilizer use are more likely to use fertilizer on Teff.

Family size (FMSZ)

Family size is taken as a proxy measure for the number of potentially active family members. Increased production or increased input use affects the demand for labor (Feder et.al., 1985 cited by Techane, 2002). Higher size provides more access to family labor which serves vital role in the absence of well developed labor market (Mulat and Croppendesat, 1996). According to Tesfaye et.al, 2001, technologies that require seasonal labor are less attractive to families with limited family labor. The number of family in the survey considered were only individuals that permanently live in the household. Hence, it was hypothesized that availability of labor is positively influence the adoption of improved maize technology.

Total Land size (ha) (TLDSZ)

This variable is expected to positively influence the decision of fertilizer use. Hence, farmers who have relatively large farm size will be more initiated to use fertilizer on Teff. In this particular study size of total land size considers land under all uses and different tenure arrangement. It is measured in hectares. According to Mulat and Croppendesat, 1996 size of land owned by a certain household relates with family size and quality of land. Yishak, 2005 also indicates that land size captures wealth and capacity to bear risks associated with the use of technology. Other authors like Assefa and Gezahegn, 2002 indicate that land size is important when the technology requires involvement of an extra cash investment. It is expected to be positively associated with the decision to adopt improved maize technologies. This means that farmers who have relatively large farm size will be more initiated to use fertilizer on Teff. And the reverse is true for small size farmers.

Total Family Labor (ME) to land (ha) ratio (TLLBRRT0)

Smallholders cultivate their land with greater intensity and since fertilizer use is land saving, it was expected that farmers intensively use the input. In areas where labor market is less developed, family labor is vital in undertaking farming activities. Hence, larger family size relates positively to fertilizer use. Other studies also indicate increased fertilizer use with larger size of land a household commands. Higher ratio of total family labor in man equivalent to size

of land under all uses, is expected to indicate of nature intensive cultivation in the area (Mulat and Croppendesat, 1996). Thus, the ratio of total labor in man equivalent to size of land in hectare was expected to influence the decision of farmers to use fertilizers on Teff positively. The ratio depends on measures of total family size and size of land the household owns.

Livestock ownership in TLU (LVTLU)

This variable defined in terms of Tropical Livestock Unit (TLU), serves as a proxy for the capacity to bear risks of using new technology such as fertilizer and capture. Livestock may also serve as a proxy for oxen ownership, which is important for farm operations. The livestock units owned by a farm household represent source of ready cash for purchase of inputs plus it secures sources of draft power, manure, and food. Access or direct ownership is important for soil fertility management. It was expected that this variable would have positive influence on use of fertilizers.

Proportion of land allotted to Teff out of Total Land in ha (PRLTFF)

Teff is labor and input intensive enterprise. Therefore, as the share of land committed to Teff increases the tendency to apply fertilizer is expected to increase. Hence, share of total land cultivated and land allotted to Teff is considered as one variable. It was expected that larger area allotted to Teff enterprises leads to high probability of fertilizer use.

Teff yield in quintal/hectare (PRDTFF)

Increased Teff yield per hectare is expected to result from the use of fertilizer on Teff. In addition better yield ensures higher financial return needed for purchase of inputs. Hence, it was expected better Teff yield positively influences the use of fertilizers on Teff.

Access to extension (WEMLA)

The study considered method of extension in the local area as a variable. Value of 1 is given if a farmer has access to individual method of extension and 0 if otherwise. Information access through individual method allows first- hand information on improved technological inputs. According to Yisehak, 2005; Tesfaye et.al., 2001 access to extension information plays important role in influencing the probability of adopting improved maize varieties. In other studies, information from extension service has an influence on farm households' fertilizer adoption decision (Bezabih, 2000 cited by Techane, 2002; Nkonya et al., 1997). Thus individual farmers that have access to individual method of Extension were expected to fertilizer on Teff.

Financial constraint to use fertilizer on Teff (DFCNUFR)

Financial resources are important for purchase of farm inputs like fertilizers. In the case of fertilizer use, the high price constrains farmers use on their crops. In this study farmers were

asked if they faced financial constraint to use fertilizers on Teff. If the farmer faced financial constrained it takes value of (1) and (0) if the farmer did not face financial constraint.

Access to credit (DUCRTY)

Several studies have shown that access to credit plays a significant role in enhancing the use of fertilizer. Credit relieves financial constraints to use fertilizers either bought from market or on the basis of credit (Bezabih, 2000 and Ngongola et al. 1993 cited by Techane, 2002; Lelissa, 1998; Croppenstedt et al., 1999; Tesfaye et.al., 2001). In the present study, access to credit in the last three years was considered. (1) If the farmer had used credit in one of the last three years and (0) if otherwise. Thus it was hypothesized that access to input credit would have positive influence use of fertilizer.

Number of Manure application on Teff (NMATFF)

Manure refers to animal dung which households apply on their field to improve soil fertility. In this study number of manure application is considered when the land is left fallow, right before the land is ploughed or after sowing. It was expected that more number of manure application influences fertilizer use on Teff negatively.

Compost application (NCATFF)

Compost application is another common land quality improving input. Compost includes household refuse, litter-fall, wasted feed, wastes of small ruminants kept in a pit for some time. It was expected that more frequent application of compost discourages the use of fertilizers on Teff.

Practice of crop rotation (CRPROT)

Crop rotation is a common practice in the study area. The study considered the change of crop enterprises over the plot of land in different crop growing seasons. Farmers undertake this activity to improve quality of land. The variable was taken as (1) if the farmer practiced crop rotation on his/her Teff and (0) if the farmer did not practice crop rotation. The practice of crop rotation was expected to influence the decision of farmers to use fertilizers on Teff positively.

Table 2: Summary of explanatory variables

Variables	Description and measurement
AGEHH	Age of household head (year).
FMSZ	Family size of household (number).
TLLBRRTO	Ratio of total family labor in man equivalent (ME) to size of land (hectare) under all uses given in ME/ha
FEXPFER	Farm experience of household heads with fertilizer (years).
FRMSZ	Farm size of household (hectare).
LVTLU	Total livestock owned by the farm household (TLU).
FCNFR	Face financial constraint (=1, if yes; =0, if no)
DUCRTY	Access of farmer to fertilizer and seed on credit (=1, if yes; =0, otherwise)
WEMLA	Access to individual extension method (=1, if yes; =0, otherwise)
PRPTFF	land allotted to Teff out of the Total cultivated land
PRDTFF	amount of Teff produced per hectare (quintal/hectare)
NMATFF	Number of manure application on Teff (number)
NCATFF	Number of manure application on Teff (number)
CRPROT	Change of crop enterprise over a given plot of land in different growing seasons (=1, if yes; =0, if no)

4. FARMING SYSTEM OF THE WOREDA

4.1 Agricultural Development Activities and Institutions

Agricultural inputs

According to latest reports of woreda more 95% of the farm households have access to extension coverage, since its introduction in the year 1995/96. Most of coverage is through minimum package programs and the rest through preparation of field days and farmer days on regular intervals. Family package program is at early stage. Recently farmers' training centers are built across the woreda and there are three Farming Training Centers (FTCs) which already have started giving trainings (WADO, 2005).

In addition, there are two major cooperatives in the area: Hulegeb cooperative and the irrigation scheme cooperative. The first is engaged in provision of inputs, purchasing farm outputs and supplying essential items like fertilizers and improved seeds while the irrigation scheme cooperative is limited to arranging turns in use of water. But latter is limited only to farmers who utilize irrigation schemes (WADO, 2005).

Improved technologies such as fertilizers were introduced in the early 1970s in parts of the woreda following the establishment of service cooperatives. For last production of 2005/06 year about 11879.5 quintals of DAP and 6920 quintals of urea were used in the woreda (WADO, 2006). There is also a considerable use of improved seeds in the area. The highest share goes to Maize at 1144.5 quintals followed by wheat which is 250 quintals (WADO, 2006).

Agricultural inputs for animal production are mostly confined to veterinary services. In this regard there are three veterinary clinics. Veterinary medicines are sold in the clinics and local drug vendors.

4.2. Crop and Livestock Marketing

Current Marketing Practices: Markets serve as places for transaction and are medium for communication to farmers. In the study area, towns of Gimjabet and Azena are wholesale markets for crops and livestock. The market days are scheduled in weekdays (Tuesday, Thursday and Saturday) for both towns.

Marketing of crops: The farmers of the study area are engaged in the production of food crops and cash crops. Crops outputs sold to fulfill their cash needs for different household demands and social obligations. The most marketed outputs are Teff, Noug, Maize and Wheat in their order of importance. The major problem with crop marketing in the area is low bargaining power of farmers against the middle men in local market.

Marketing of livestock and livestock products: farmers commonly sale livestock at Gimjabet and Azena markets. Under normal conditions, farmers sell small ruminants (sheep and goats) followed by heifers and bulls for immediate needs of cash. Under emergency conditions, farmers sell mules, horses, cows and oxen to meet acute cash shortages such as seed and food shortages in the later season.

4.3. Farm household socio- economic circumstances

4.3.1 Labor

Farmers in the focus group discussion indicated that they face labor shortages for some critical farm activities. Most critical activities include weeding and harvesting for the major crops like Teff and Maize.

In Kebeles like Hateta and Sosestu Gimjabet where food crops are dominantly cultivated family labor is the most important. Unfortunately family labor scarcity is growing as more families are sending their children to school while some get seasonally employed in nearby and other commercial farms. As a result herding of livestock has become difficult. In the other parts of the woreda where cash crops like Maize, Red pepper are dominant the use of hired labor is highly practiced. Payments for services rendered can be in cash or in kind. The price paid shows high variation. At peak seasons it reaches up to 15 Birr/day. Also use of communal labor has an important role. Usually families that have lineage and households living close by exchange family labor especially at high times of land preparation, harvesting and processing of outputs.

4.3.2 Land Tenure arrangement

Farmers indicated that first land allocation ensured large size farm lands for individuals. The size allotted ranged from 2.5-10 ha. The then political serving individuals had been, granted a land size of 7.5 ha. In the first distribution, all that counted was the ability of the individual to clear

the forest and bring as much land as possible under cultivation. The present day intensively cultivated farm lands down from *Azena* town to lowlands of the Woreda are results of the distribution. The distribution was based on estimates and no measurements were used. By then the population size was small, and relatively there was enough land.

After the establishment of service cooperatives redistribution was undertaken on the basis of family size with considerations of equity issues. Redistribution was limited to distribution on land which had already been cultivated before. This ensured that the land under forests stayed intact. Grazing lands were planned for respective village and restrictions were laid. Enforcement of restrictions was difficult that resulted in recurrent conflicts among members of different villages.

The latest redistribution took place in the year 1997 which stripped of considerable some of land from politically involved individuals in prior regime and redistributed to landless. So the farmers started to manage their pieces of land to the best of their knowledge and resources. This led to increased use of inputs like fertilizers.

Farmers agree that productivity of their farmland has decreased in recent times. Farmers relate change in productivity with serious decline in soil fertility. The traditional soil fertility management practices like rotating crops and fallowing are constrained small land holdings. In addition the low availability of manure following the decline in productivity of animals coupled

with high demand for household energy aggravates the problem. All these in effect add up to pose limitation on farmers' traditional soil fertility improvement practices.

4.3.3 Crop production

Adequate and reliable rainfall in this zone dominantly enhanced rain fed agriculture through out the area and has supported a wide range of crops. Rain fed crops mainly produced under –low input level remain to have stagnated production with further decreasing trend.

Teff, Maize, Barely, Finger millet, Noug and wheat are major cereals. Other important crops like Potato, Red pepper, Gibto are components in the farming system of the study area. Except in the case of Maize and wheat, other crops grown are local varieties.

The Woreda has about 1200 ha of irrigated land but farmers are restricted to grow mainly crops like barley, potato and hardly any perennial crops despite of environmental suitability for number of annual and perennial crop varieties.

Farmers have some justifications as to why they grow different crops. For example: The most important cereal- Teff fetches high market value, its suitable for injera making and produces high quality straw for livestock feed. Although Teff has so many advantages, it requires high labor input and traction power. The farmers ranking criteria show that some give greater weight for the diversity of home use of the crop than its market value. Others emphasize its role in generating

cash either to purchase larger quantity of lower priced crops or use the cash to pay for inputs and services. Improved seeds were introduced more ten years ago. Farmers use selected local seeds from own cultivation, through exchange and purchase from the market.

Maize has high productivity level compared to all other crops grown in the study area. Recently the price has improved. In maize-based farming system the maize stalks serve important role of livestock feed and fuel-wood. The enterprise commands high labor and input use. Weeding is the most labor demanding agronomic practice of all. There is high demand for improved seeds but there is serious supply constraint.

Barley is preferred as it is used for many food and local beverages like injera, kita, tabita, kolo and Tela. It is less demanding in respect to management as compared to Teff. The straw can be used for animal feed. In some parts of the woreda Barely is cultivated under irrigation and hence it plays important role of supplementing food availability through allowing early harvest.

4.3.4 Livestock Production

Livestock species that are generally kept to make-up the livestock resources of Ankesha woreda include cattle, horses, sheep, donkey, mules and goats. Bees and poultry are also the enterprises practiced very widely by the farmers to support the livelihood of the farming community. The proportional holding of the mixed livestock species varies across the woreda depending on the vegetation type and farming system. Small ruminants make the highest proportion of the

livestock holding. While the woreda supports large number of large ruminants. The importance of small ruminants has been observed to be consistent across the woreda. The number of sheep exceeds that of goats (WADO, 2005).

4.3.4.1 Livestock productivity

Generally speaking, the cumulative changes that have occurred to the farming system gradually brought a negative impact on livestock productivity. Because of serious feed shortage problem, farmers indicated that milk production has declined to the level of 1.5 liter a day. The decline of livestock productivity seems to be in line with the depletion of the feed resources, which necessitated diversified herd structure that favors small ruminants.

4.3.4.2 Feed sources and management

Feed is the primary problem that livestock raising faces in the zone. The scarcity of livestock feed is primarily due to expansion cultivation on to grazing lands which are also practically suited for cultivation and secondly communally used grazing lands are with no rules regulating the number of livestock and rather subject to kind of utilization pattern which has led to decreased grass production (Alehegn,2001) .

The principal feed sources of livestock in the woreda are mainly natural pastures and crop residues .Grazing is practiced communally at any season of the year. Farmers strategies to combat the overwhelming feed shortage during the critical period of April and May include,

conserving of crop residues for late dry season use, reducing the livestock number through selling the less desirable ones and buying additional crop residues. Maize Stover is collected and preserved as a feed and fuel source, farmers also had a tradition of leaving out the maize Stover on farm fields where in situ grazing takes place to some extent.

The natural grass pasture can support the animals from late July until February without supplementary requirement. Supplementation of crop residues begins with barley, Noug and straws from February on wards. Feeding of maize stover as supplement starts in February and stretches to June. Although Teff straw feeding begins at the same time with maize Stover, farmers tend to economize it in anticipation of its late dry season use when feed shortage is more pronounced. In contrary, Teff straw feeding delays until mid of June when plowing activity reaches at peak and other dependable feed resources are depleted. Finger millet straw is offered to animals at last when all other crop residues are depleted towards the transition time to green feeds because of the palatability problem. Hay making is also a common practice in the study area.

Oxen get the first priority in receiving supplementary feeds and others follow in preference. Young and lactating stocks are given equal priority to supplementation because of their increased energy requirement for growth which otherwise questions their survival. Sheep and goats have the least priority in receiving supplementary feeds.

4.4 Soil and Water management

4.4.1 Topography of Ankesha Woreda and Soils Characteristics

Plain terrain marks the physiography of the woreda. The topography of the area mostly consists of plains, hills, valleys and cliffs, most of the landscapes are suited to agriculture. Generally, flat land and land with gentle slope is abundant and comprises about 70% of the woreda. Hilly topography covers about 27% of the area while valley, ups and downs and marshy area make up the rest 3% of the woreda. According to the WADO (Unpublished), brown soil is the predominant soil type in the woreda constituting 75%. The second most abundantly found soil type is red soil (15%) followed by black soil (10%) (WADO, 2005).

Table 3 Land physiographic and soils of Ankesha Woreda

Topography	%	Soil type	%
Flat land	70	Red soil	15
Mountainous	27	Brown soil	75
Valley	2	Black soil	10

Source: WADO (2005)

4.4.1.1 Soils

According to the Amhara Water Bureau socioeconomic survey report (2003), the soils types such as Alisols, Acrisols and Nitosols dominate high rainfall areas of western part of the Amhara region that includes Awi Zone.

According to farmers' perception, in the woreda the dominant types of soils are Red Brown, Black and Red. Although farmers and WADO described the soils by their color, there exist some discrepancies between them. The difference in landscape and physiography contributes to the different area coverage of the soils. The dominant soil type is Red Brown soil and is mainly found on flat to gently sloppy area. While Red soil has limited area coverage as compared to other soil types and it is normally found in sloppy areas.

Farmers' perception and description of soil types in the area

The knowledge of soils color is important in that it dose not only help in understanding the formation of soils but also enables one to comprehend the soil composition including the biological and chemical changes responsible for such composition. The available organic matter is responsible for the dark coloring of the soils. However, it should be pointed out that it is not only the amount of organic matter that contributes to the colors of the soils but presence of iron, manganese and the physical characteristics also play vital roles in giving soils their due colors. Generally the color of the oxidized iron is red, but could vary from red, yellow or dark gray depending upon the water molecule and the quantity of oxidized iron (ANRWBS, 2003).

Red Brown soil

Red soil is characterized by easy workability, susceptible to be washed out and relatively better drained. This soil type is most suited to crops like maize, coffee, finger millet, wheat and red pepper. Depending on crop type it requires an average ploughing of 6 times which at times can extend to 12 times. It has higher weed infestation and shows relatively better response to fertilizer application.

Black soil

This soil type demands heavy working but has low drainage and most found on gentle sloping areas and foot hills. It has low weed infestation but it is highly susceptible to water logging. Lands with this soil type are mainly used for grazing lands. Black soil shows little response to fertilizer application. Teff is most suited crop for black soil. Noug and Finger millet also give better productivity. But usually Maize fails in the black soil.

The status of soil erosion

In the study area, Farmers indicate the increased rate of soil erosion in terms of increased run-off even under normal rainfall amount. Old structures at the bounds of farm lands required frequent maintenance. In addition increased silt is observed in water ways and traditional irrigation

channels. Farmers explained that at times of heavy rainfall water ways are breached and farm lands are flooded. Moreover, Water ways are becoming deeper while increased number of rills are appearing on farm and grazing lands. Experts also agree with increased rate of soil erosion in some kebele like Hateta and Sosetu-Gimja-bet. In these areas an average soil depth of 0.5-1 meter is common. But experts agree that in most parts of the woreda the extent of soil erosion is minimal.

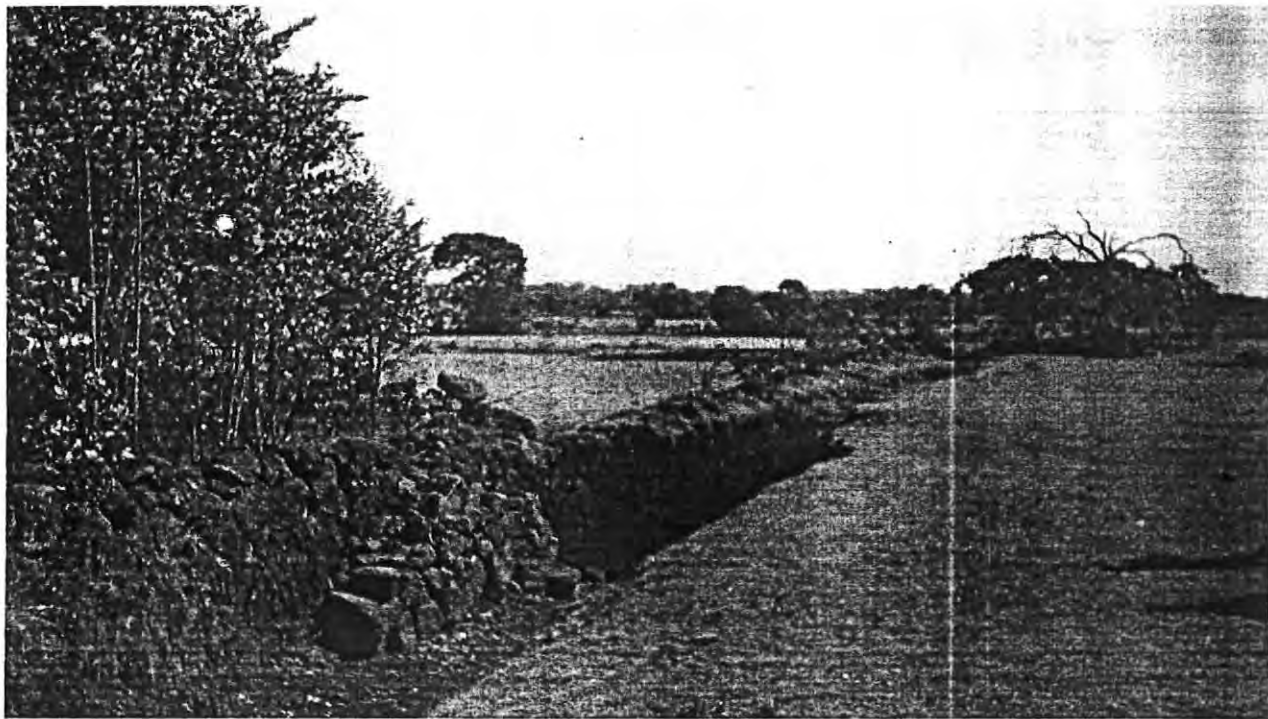


Figure 2 .Water-ways between adjacent Farmlands

4.4.1.2 Soil fertility management

The most important problem in cereals- dominated farming system of this zone is rapid decline in soil fertility as a result of continuous cultivation and nutrient mining. This necessitates the use

of external inputs like fertilizers. Among the different soil fertility improvement inputs, Fertilizer has important role as the area enjoys adequate moisture during growing season (Alehegne, 2001).

The important Phosphorus inputs to farmer fields consist primarily of fertilizers and organic sources such as biomass, manures, and composts gathered from outside the field. The P content of plant residues and manures is normally insufficient to meet crop requirements. As a result, P fertilizers are almost always necessary to overcome P depletion (Sanchez, 1976 cited by Palm et.al, 1997).

In the case of Nitrogen inputs to a field consist mainly of fertilizers, biomass transfers, Biological Nitrogen Fixation, animal manures or composts produced outside the field, and nitrate capture from subsoil depths beyond the reach of crop roots. Biological Nitrogen Fixation becomes an input upon the conversion of atmospheric N₂ gas into plant N by symbiotic plants followed by the addition of plant Nitrogen to the soil (Eyasu, 2002).

4.4.1.3 Soil fertility Improvement Techniques

Fertilizer Application

Farmers in the Woreda have long years of experience in using fertilizer since the establishment of service cooperatives. After the launching of the national extension package, the level of

fertilizer use has considerably improved. The progressive use of improved seed especially for maize and wheat enabled increased rates of fertilizer use from year to year. However, the important limitation that farmers face is high price of fertilizer.

In the last three years, there is considerable change in price of outputs. As an example the Price of Teff was 147 birr/qu three years back but at the time of the survey it stood at 350 birr/qu and the same goes for price of Maize which was 75 birr/qu three years back to 125 birr/qu at the time the survey was taken. Despite the fact that the higher price for outputs contributes to the profitability of fertilizer use, its susceptibility remains to be under question. As Tesfaye (2003) indicated the high prices of outputs can be result of the inefficient, low yielding technologies that are being employed, which neither provides farmers with adequate incomes nor consumers with food at accessible prices. Farmers can increase their incomes through improvements in productivity and expanded production. In our case much rests on improvement of farm productivity.

Priority in fertilizer application was given to maize followed by Teff and Red pepper. Maize received priority among cereals since its yields were severely depressed without application of fertilizers. Crops like Finger millet, Barely, Noug, Potato rarely receive fertilizer.

Manure Application

One of the best known fertility resorting practice in this zone is application of manure. Manure is usually applied at homesteads in the dry season and on fallowed farm lands out of homesteads in the rainy season. As there are no markets for manure in the area only livestock holding was the

primary source of manure acquisition. This creates a special demand for holding animals with in the farm through ownership or share in livestock.

According to Murwira et.al (1993) cited by Eyasu (2002) most smallholder farmers apply cattle manure which is usually collected from enclosures where cattle spend the night. But the manure provides nutrients at rates that are too low to meet crop requirements and prevent decreases in soil organic content.

In other study, the quality of manure is often compromised from poor management and the quality and nutrient composition also is affected by the quality and quantity of feed. As a result the value of manure as a source of N ranges from high-quality manure that increases crop yields to low-quality manure that depresses crop yields (Palm et al. 1996).

In most parts of the central and northern highlands Ethiopia, manure is normally dried and used as important fuel and only rarely it is spared for use as fertilizer (Gryseels and Anderson (1983) cited by Tesfaye (2003)). In an agreement to the above results, in the study area, manure is largely consumed as an important fuel source. Though farmers realize the benefit of using manure to improve soil fertility, they face number of constraints on its wider scope of application. The major constraints include lo availability of manure and problem of transporting the manure to distant farm lands. Normally the task of transporting is the responsibility of women and children.

The practice of direct manure application by keeping cattle in fields has been abandoned in the area. Reasons farmers give include problem of livestock theft and compaction of the soil surface from the trampling of livestock. Although manure is the major soil fertility input available throughout the study area, majority of farmers are forced to practice spot application before planting. The manure is then spread out and incorporated at ploughing. So far, no recommendations had been issued with regards to the method, time, and rate of application.

According to survey results, the number of manure application is more or less uniform across all respondents. For example, on Teff manure is applied at most twice before sowing. While crops like Maize and Red pepper receives manure application of 2-4 times.

Compost Application

According to Giller et.al (1997) The gathering of green plant material from boundaries or adjacent fields and their addition to another field is known as biomass transfer. Most of the biomass transfers practiced by farmers consist of leguminous plants and grasses. In the study area sweepings of organic matter from the floor and compound, droppings of small ruminants, ash from the fireplace and feed leftovers composes composts. Farmers noted that household refuse increased the thickness water holding capacity and structure of the soil, and served as mulch during the bare fallow period to keep the surface moist. For households with a compost pit, household refuse was one of the major ingredients of composite it was continuously put into

the pit. Recent extension approach has incorporated specific recommendations on the rates of compost application and its preparation procedures.

According to survey results, the number of compost application is more or less uniform across all respondents. For example, on Teff compost is applied on average 0.3 times before sowing. While Maize on average receives 0.7 times of compost application.

Use of Crop residues

Crop residues include the above ground plant tissue remaining in the field after grains, tubers and other economic products have been harvested. Residue management may include complete removal by burning or grazing. Crop residue return refers to the use of crop residues for soil protection or improvement (Smith and Elliott, 1990 cited by Eyasu, 2002). As indicated earlier N and P are the most limiting nutrients of crop production. Most of the P in cereal crops and grain legumes is accumulated in the grain and removed from the field at harvest.

Appropriate crop residue management captures loss of these important nutrients. In smallholder farms most crop residues are not returned to the field where they were produced because they are used for cattle fodder, fencing, or cooking fuel. This results in 100% removal of the P accumulated by crops for human nutrition (Brouwer & Powell, 1993 cited by Eyasu, 2002). In the same token, in the study area, crop residues from Teff are almost completely removed. The

highly valued straw is either harvested for own livestock feed or else is sold at the market because it fetches good price. As different studies indicate Teff fields suffer from little or no return of crop residues. The other most important crop residues of Maize, Noug, Finger millet are either collected for fuel or left livestock grazing. The recent promotion of making crop residues and other biomass into compost is believed to enhance the role of crop residues as major inputs to improve soil fertility.

4.4.1.4 Traditional Soil fertility Management Practices

Fallowing

Farmers are very much aware about the purpose of fallowing practice. Fallowing had widely been practiced in the past. The problem of serious land shortage nowadays has made practice of fallowing impossible. As an option farmers change their farmlands into grazing lands when the land usually fails to support crop production.

Crop rotations

Major crop rotation followed by most farmers under rainfed conditions is cereal-cereal rotation system; specifically (a) Teff-Noug–barley-Finger millet rotation, (b) Teff-red pepper-Maize-Finger millet rotation, and (c) Teff–red pepper-Maize rotation. Presently the important legume *Gibto* in rotation of crops has been abandoned or limited only to marginal lands that do not support cereal crop. On the other hand Noug has become important replacement in crop rotation

scheme of farmers because it has higher market value as compared to that of Gibto.

4.4.1.5 Supplementary Soil Fertility enhancing interventions

The productivity of soil relies on both physical and chemical characteristics. Apart from improving problems of nutrient depletion, appropriate physical measures contribute towards better realizing the benefits of improving inputs. In this regard soil and water conservation measures play an important role. The soil and water conservation measures include physical and biological measures. The physical measures include traditional and introduced ones promoted by experts and government bodies.

Physical and Biological conservation measures

According to soil and water conservation and agro forestry experts a combination of agronomic, biological and physical measures are carried out to tackle the problem of soil erosion on both individuals and communal lands.

Physical conservation measures constitute two types traditional and Introduced measures. Traditional measure includes diversion channels, and drainage ditches while Introduced measures include check dams, soil bunds, stone bunds and cut-off drains.

Traditional drainage ditches are peculiar feature of the farming system which normally are

constructed using the plough. The main objective is drain excess rainfall by collecting and channeling excess run-off to water ways at the margin of farm lands. The water ways are planned collectively to curb possible damage of collected run-off on farm lands. The ditches constructed through repetitive ploughing. Every year ditches are reoriented in consideration gradient difference amount of run-off. Normally they are spaced with interval of 2-7 meters. These important traditional physical measures are rarely applied on non-farm lands.



Figure 3. Traditional Drainage Ditches



Figure 4 Traditional Stone Bunds

Among the introduced measures stone bunds is most preferred as it retains large amount of productive silt and attains stability in short period of time. According to woreda experts the application of stone bunds is limited to high slope (>20 degrees). Kebeles like *Aysa*, *Messela* and *Tulta* widely practice stone terracing. Soil bund is promoted in areas dominated with plain topography. Here the availability deep soil profiles allow construction of soil bunds. Much success hasn't been scored in this line as construction demands a lot of labor and additional tools. To relieve the problem of lack of tools, the woreda soil and water conservation desk provides spades on loan.

In addition the woreda assists in technical areas for physical measures construction. So far, most works were undertaken by mass mobilization. But in last two years there is greater emphasis towards relying on individual efforts.

Although limited in scale some agronomic measures like planting of Nitrogen fixing trees such as *Sesbania* are practiced to stabilize farm boundaries and serve the purpose supplementing livestock feed. While *vetvier* grass is used for treatment of gully in combination with check dams.

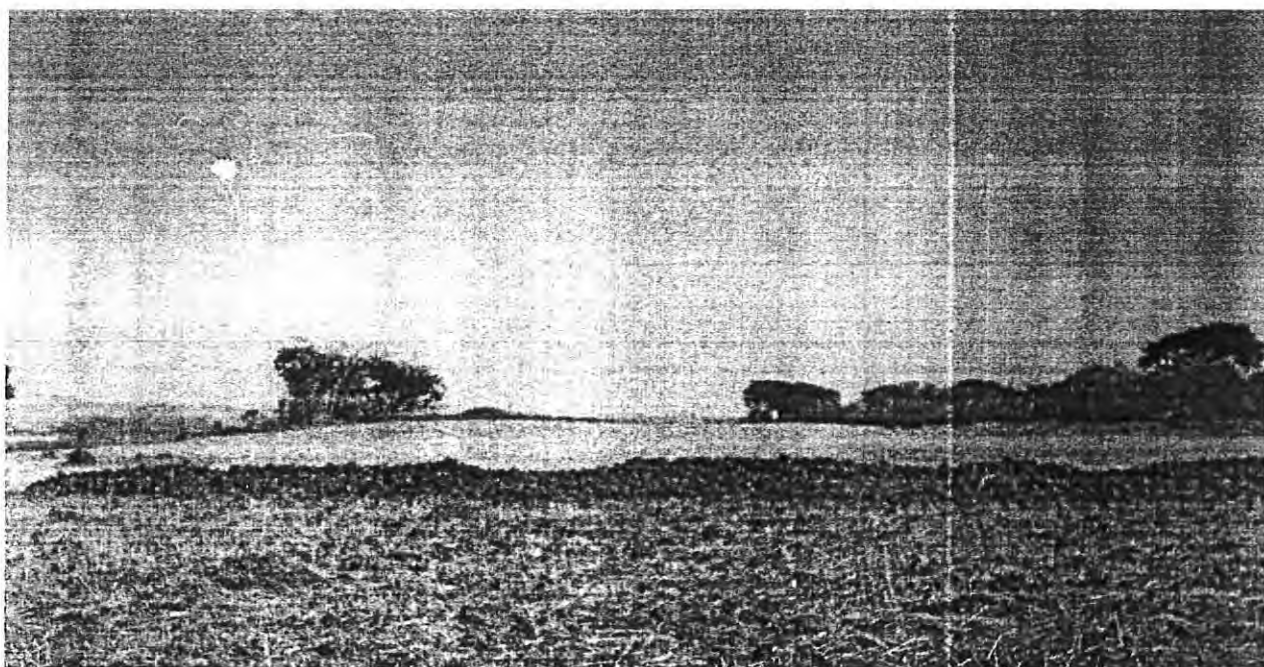


Figure 5 Stone Bund on the edge of Farmlands

5. RESULT AND DISCUSSION

5.1 Descriptive Analysis

In order to understand the socio-economic and institutional characteristics of the Users and non Users, the descriptive analysis is summarized and discussed under household characteristics, institutional characteristics and input use.

5.1.1 Household Characteristics

Out of the total respondents, 81(58.3%) households that grow Teff were Users of (DAP or Urea) fertilizers while 58(41.7%) households were non-Users.

5.1.1.1. Demographic characteristics

Education level of household heads

About 37% of the total respondents were literate (can read and write). Among the Users 46.9% were literate while only 33.4% of non Users were literate, bearing percentage non-significant difference. Primary education level attainment is important in the case of formal education. As can be seen in table 4, about 21% of Users and 15.9% of non-Users attained primary level education of grades (1-6). This generally indicates that users have better educational background

than non-users. Other studies showed that better education level of farmers improved access to relevant information regarding the use of improved technologies like fertilizers. However, the study results show that there was no significant systematic association between use of fertilizers and attainment of certain educational level.

Table 4 Distribution of the Sample Households by Education Status

Characteristics		User		Non-user		X2-Statistics
		N	%	N	%	
Education status of the HH head	Illiterate	26	32.1	31	49.2	8.112NS
	read and write	21	25.9	11	17.5	
	Primary	17	21	10	15.9	

NS = not significant N = Number of respondents

Source: Computed from the field survey data, 2007

Social status of the household head

The important social status categories considered in this study are community members and political membership. By political member it is meant that the respondent is member in any of lower administrative units of the government. As shown in table 6, among the respondents 20.8 % are political members while 67.8 % are community members. The rest composes of local militia members and spiritual leaders each taking 5.4%. As shown in Table 5, about 28.4% of users and 12.7% of non-users belong to social status category of political membership. In fact, this can relate to better opportunities that political members enjoy as compared to non-members with regards to access to crucial elements like access to trainings and credit.

The other category is community member which refers to individuals that are not involved in any membership of political activity. From this category 56.8% are users while the majority or 79.4% are non-users. The survey result indicates a significant and systematic association at 5% between use of fertilizers and belonging to social status category of political leadership.

Table 5 Social status of household heads

Characteristics		User		Non-user		X ² -Statistics
		N	%	N	%	
Social Status of household head	Political member	23	28.4	8	12.7	10.844**
	Community member	46	56.8	50	79.4	

** Represents level of significance at 5% N = Number of respondents

Source: Computed from the field survey data, 2007

Farm experience of respondent farmers

The age of the sampled households ranges from 19 to 72 years. The average age of Users was about 40.91 years, while that of non-Users was 46.89 years. The average family size of the sample for users was 5.93 while that of non-users was 6.14. The other demographic variable Farm experience is one of the household characteristics. This relates to experience that a farmer acquired in years by undertaking farming activities. As farming age increases farmers can gain more information about different aspects of a given technology in use. On average, the sample respondents had about 22.66 years of farming experience. As shown in table 6 average farm experience of users was about 20.56 years. While on the other hand, mean farming experience

of non-users was 25.73 years. The results of the study indicate that about 21.5% of the respondents have less than 10 years of farming experience while 28.2% of them had more than 15 years of experience. Most respondents (67.8 %) have a farming experience ranging between 5 -14 years while (38.6%) years farming experience. The survey result reveals that non-users had more years of farm experience than Users. Farming experience and family size are proxy measures to age of the household head. As the results in Table 7 indicate that there is significant mean difference between Users and non-users at 1% with regards to variables age of the household head and farming experience.

The study results showed that average fertilizer use experience of respondents is 9.77 years. Unlike the case of farming experience, Users have 10.98 years of fertilizer use experience while non-users have 8.29 years of fertilizer use experience. Fertilizer use experience showed a significant mean difference at 1%. This can be explained as farmers with more experience to fertilizer use can easily understand the benefit of fertilizer use and also benefit from detail information associated with important agronomic practices.

Table 6 Age and experience of farming of household heads

Characteristics	Users		Non -users		t-statistics
	Mean	SD	Mean	SD	
Age of household head	40.91	10.48	46.89	12.2	-3.159***
Total family size	5.93	1.95	6.14	1.88	-.675NS
Farming experience of the household head	20.56	10.61	25.73	12.13	-2.726***
Farming experience of the household head with fertilizer	10.98	5.846	8.29	5.176	2.878***

*** Represents level of significance at 1% N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

5.5.1.2 Socioeconomic characteristics

Labor

Family labor is the important source of labor in undertaking different farm activities. In the absence of well developed labor market in most rural areas of Ethiopia, Family labor plays an important role for undertaking farm operations. As other adoption studies indicate availability of labor does affect fertilizer application and farm operations such as weeding and land preparation, etc associated with its use. This study based its analysis by taking economically active family labor force based on the assumptions used by CSA (1996 cited by Techane, 2002). Accordingly, economically active age group lies between 15 to 64 years. The average number of active labor of sampled households translated to man equivalent for the whole sample was 3.35. If this result is compared with the average family size of 6.01, on the average only 55.7% of the family

member provides active labor force and which can actively be engaged in an economic activity. On the average, Users slightly have more number of economically active labor (3.384) than non-Users (3.357), though bearing mean difference not statistically significant (Table 7).

Table 7 Age, family size and labor of the Sample Households

Characteristics	Users		Non Users		t- value
	Mean	SD	Mean	SD	
Age of household head(year)	40.91	10.48	46.89	12.2	-3.159***
Active labor (number)	3.384	1.338	3.357	1.138	0.127NS
Family Size (number)	5.93	1.954	6.14	1.875	-0.875NS

NS = not significant

**Represents level of significance at 1%

Source: Computed from the field survey data, 2007

As it is indicated in table 8, Out of the total respondents 24% reported that at least one person from their family was involved in off-farm work. Relatively larger proportion of User households (44.4%) engaged their family members in off-farm activities than non-users (30.2%), indicating a significant systematic association between off-farm activities and fertilizer use at 10%. The most important off-farm job is petty trade in which 52.8% of users and 57.9% of non-users engage in. The income earned from off-farm job serves as a readily cash source for purchase of inputs.

Out of the total sampled households 29% reported that they used hired labor during the production year for which the survey was conducted. Table 9 shows that 77.8% of users and 63.5% of non-users hired labor to undertake different farm operations showing a significant systematic association at 10%. Regarding labor arrangement use of communal labor is an important option as 70.4% of users and 68.3% of non-users responded to have relied on its use. This implies that fertilizer use requires more labor especially during its application and for weeding (Table 8).

Table 8 Distribution of the Sample Households by labor use

Characteristics	Response	User		Non-user		X2-Statistics
		N	%	N	%	
Shortage of labor		N	%	N	%	0.120NS
	Yes	61	75.3	49	77.8	
	No	20	24.7	14	22.2	
Use hired labor	Yes	63	77.8	40	63.5	3.551*
	No	18	22.2	23	28.5	
Use communal labor	Yes	57	70.4	43	68.3	0.075NS
	No	24	29.6	20	31.7	
Off farm job	Yes	36	44.4	19	30.2	3.064*
	No	45	55.6	2	10.5	
Type of off farm	Daily labor	7	19.4	11	57.9	12.151NS
	Petty trade	19.7	52.8	11	19.7	
	Wood work	4	11.1	2	4	

* Represents level of significance at 10% N = Number of respondents NS=non-significant

Source: Computed from the field survey data, 2007

Land

Productive land is the basic asset of farmers. In the study area on the average 1.32 hectares of land was available per household. Farmers were asked regarding size of land they manage under different tenure arrangement, almost all (98.7%) of respondents owned land. In addition 49% of respondents had rented in land while 32.9% of respondents had shared in land. Most Teff growers (87.3%) of respondents don't share/rent out their land.

Table 9 Type of Landholding of households

Landholding of households	N	%
own land	147	98.7
shared in	49	32.9
shared out	4	6
rented in	73	49
rented out	10	6.7

Users have a mean of 0.891ha of own land where non-users have 1.114 ha of land with significant mean difference of at 5%. Size of own land on average is larger in Kebeles like *Shumata*, *Chebachebasa* and *Sosestu-Segno*. In these areas as farmers indicated application of fertilizers on Teff causes lodging effect. In the case of rented in land users have 0.626 ha of land while non-users rent in 0.355 ha of land. Renting in land is an important option where shortage of land is highly pronounced. Most lands are rented in for their qualities of better productivity, access to irrigation or owners incapacity to operate for a given season. With the prevailing problem of land shortage, farmers rent in lands that lie far out. This in effect makes use of fertilizers an important alternative. Farmers indicated that to ensure a good return for the higher costs involved fertilizers are used more. The mean in size of shared in land, users with 0.373 ha

and non-users with 0.731 ha showed insignificant mean difference. Larger size of shared in land brings in greater output amount even after paying land and labor dues in kind. Hence smaller amount of fertilizer is applied. The size of shared out land indicated significant mean difference at 5%. Users have 0.008 ha of their land shared out but non-users shared out land size of 0.257 ha.(Table 10).

Table 10 Size of household land holding

Characteristics (size in ha)	User		Non-user		t-statistics
	mean	SD	mean	SD	
own land	0.89	0.51	1.11	0.56	-2.49**
rented in land	0.63	0.94	0.36	0.54	2.041**
shared in land	0.37	0.28	0.73	0.47	0.86NS
shared out land	0.008	0.07	0.06	0.26	-2.19**
rented out land	0.06	0.07	0.27	0.27	-0.35NS
homestead land	0.25	0.23	0.23	0.20	0.454NS

** Represents level of significance at 5% N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

As shown in table 11 Users allotted a land size of 0.846ha but non-users allotted 0.684 ha. Size of land allotted to Teff has significant mean difference at 5%. Since Teff enterprise involves high labor in starting from preparation of land to threshing; the production costs involved are high. The concern for profitability emerges when use of inputs is considered. Among some important enterprises in the farming system, the size of land allotted to Barely with a mean 0.102 ha for users and 0.117 ha for non-users at 10% significance level.

In the study area Barely is mainly grown on homestead lands and mostly under irrigation. These lands are fertilized with applications of manure, compost and house refuses. Barely is cultivated more than once on relatively small but irrigated lands to serve objective supplementing short fall in food and source of cash. Almost all farmers indicated to use no fertilizer on irrigated lands. Another important feature for the crop is that relative to other crops like potato, Barely on average requires 4-6 times of land preparation. This directly relates to the availability of traction power which non-users lack. The combination of readily cash availability to the less competitive nature of enterprise for fertilizers allows farmers to use more on Teff. Also the size of land allotted to potato showed a significant mean difference between users with a mean of 0.0752 ha and non-users with a mean of 0.046 ha. Even though potato is grown for similar objectives like Barely, it requires relatively more frequent, on average 10-12 times, preparation of land. This requires more traction power especially when other equally demanding enterprises like Teff are grown in parallel. As can be seen from table 12, users allotted more land to grow potato. This can possibly be the effect of better resource that users command.

Table 11 Size of land allotted to major crops

Characteristics (size of land in ha)	User		Non-user		t-statistics
	mean	SD	mean	SD	
Teff	0.85	0.55	0.68	0.38	2.0**
Maize	0.53	0.99	0.53	0.44	0.03NS
Finger millet	0.16	0.22	0.18	0.23	-5.24NS
Noug	0.31	0.29	0.27	0.28	0.97NS
Barely	0.10	0.23	0.05	0.12	1.64*
Potato	0.075	0.11	0.05	0.08	1.83*

* and ** Represents level of significance at 5% and 10% NS= not significant

Source: Computed from the field survey data, 2007

Livestock Ownership

Farm animals serve several purposes in the study area. They are sources of cash income, draught power, household consumption, transportation and source of manure (as an organic fertilizer and fuel). Based on Storck et al. (1991), the livestock population number was converted into livestock unit (TLU), so as to facilitate comparison among the farm groups.

On the average a household had 8.05 TLU with standard deviation of 6.17 TLU. Users owned a larger number of livestock compared to the non-users of 5.83 TLU. The mean difference with regards to total livestock ownership is significant at 5%. The implication is that Users have more access to financial resource by selling their livestock to purchase fertilizers and any other complementary inputs and they are able to repay debts. In addition, Users use farm animals to transport their produce to the local markets and inputs from suppliers. The results have in table 12 show that, Users own more horse 0.72 TLU, mule 0.059 TLU and sheep 2.03 TLU compared to non-users 0.47 TLU, 0.25 TLU and 1.16 TLU respectively with mean difference significant at 1% level for ownership of sheep and horse. At 5% significance level users own cows 1.34 TLU while non-users 0.95 TLU. As other studies indicate, the important aspect in ownership of cows in the farming system allows additional source of income from sale of calves, bulls and dairy products like butter.

Table 12 Livestock Ownership of the Sample Households

Livestock Types(TLU)	User		Non user		t-statistic
	Mean	SD	Mean	SD	
Ox	1.61	1.95	1.41	1.56	0.69NS
Cow	1.34	1.57	0.95	0.84	1.79*
Heifers	0.70	1.19	0.62	0.63	0.51NS
Bull	0.66	1.01	0.50	0.63	1.08NS
Donkey	0.15	0.39	0.12	0.36	0.46NS
Mule	0.06	0.25	0.03	0.20	0.89NS
Horse	0.72	0.71	0.47	0.57	2.86***
Sheep	2.03	2.02	1.16	1.17	3.01***
Poultry	0.02	0.49	0.03	0.07	-0.94NS
Total TLU	8.05	6.17	5.83	3.43	2.56**

***, ** and * Represents level of significance at 1%, 5% and 10%. NS= not significant

Source: Computed from the field survey data, 2007

Livestock production, purpose and feed source

Out of the total respondents, 70% users and 50.8% of non-users feed their livestock from own grazing plots. While 42.5% of users and 23% of non-users, buy feed from market. Also 95% of users and 80.3 % non-users indicated use communal lands for livestock grazing as another option. As shown in table 13 there is systematic association significant at 1% and 5% respectively. This is indicative of a diversified livestock feed management of users as compared to non-users. But still 55% of Users faced shortage of livestock feed while 26.2% of non-users faced the same problem. There is systematic association between fertilizer use and type of feed sources significant at 5%. Consideration of survey results with regards to total livestock ownership indicated Users had 8.05 TLU while non-users had 5.83 TLU as a result shortage of feed is more pronounced in the case of users. As it is indicated in Table 13 regarding the issue of

as to how respondents utilize the livestock resource, 80% Users and 67.2% non-users utilize the resource for household consumption. There is significant systematic association between use of livestock resource for generating cash and fertilizer use at 10% level. At the same significance level of 10%, (85%) of users and 72.1% of non-users utilized livestock resource for cash. This is an important piece of information that indicates farmers who have access to readily cash income source are able to important external inputs like fertilizers.

Table 13 Livestock production, purpose and feed source

Characteristics (Use of livestock resource)		Users		Non-users		X2-Statistics
		N	%	N	%	
household consumption	Yes	64	80	41	67.2	2.98*
	No	16	20	20	32.8	
Cash	Yes	68	85	44	72.1	3.51*
	No	12	15	17	27.9	
Feed source and availability						
Own grazing land	yes	56	70	31	50.8	5.39**
	No	24	30	30	49.2	
Market	yes	34	42.5	14	23	5.89**
	No	46	57.5	47	77	
communal land	yes	76	95	49	80.3	7.41***
	No	4	5	12	19.7	
Have enough feed	yes	44	55	16	26.2	5.89**
	No	36	45	45	73.8	

*** and ** Represent level of significance at 1% and 5% N = Number of respondents

Source: Computed from the field survey data, 2007

Total annual income

Crops, livestock and off farm activities are the sources of income in the study area. The annual average total income earned by sampled farm households was 4211 Birr. The survey results show that minority of the sampled farmers (8.1%) earned a total income of less than 1000 Birr during 2006/07-production year. While about 38.9% of the total respondents earned annual income within the range of 1000-3000 Birr. The rest 52.1% of the total respondents earned income amount of at least 3000 Birr. On average users, earned about 4050.4 Birr while non-users earned 4491.7 Birr. One important note is that a large amount of crop produced has been lost from heavy rainfall in specific cropping season. As table 14 shows though mean difference in income is not significant, non-users on average earned more income. The reason behind is that out of the total sampled respondents 40.3% of them are from maize and red pepper growing Kebeles of *shumata* and *chebachabasa*. The farmers in the two kebeles mainly specialize in these crops do not usually apply fertilizer to Teff. Lesser application of fertilizers on Teff is caused by competitive requirements of dominant crops of Maize and Red pepper coupled with the high lodging problem of Teff in these areas.

Table 14 income of sample households

Characteristics	Users		Non-users		t-statistic
	mean	SD	Mean	SD	
Total annual income	4050.4	4864.5	4491.7	6235.5	-0.477NS

N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

5.1.2 Institutional Characteristics

Extension service

The major institutional services discussed under this section are extension service and credit provision. With regards to provision of extension service, the major extension methods carried out in the study area include individual and group methods. More than 92% of total respondents consulted Development Agents in their locality. The number of respondents who have access to individual extension contact for users was 18.5% while non-users 4.8%. In addition respondents who had only access to group extension composed for 9.9% users and 27% non-users. The respondents didn't usually rely on single method of Extension. Thus 67.9% of Users and 60.3% had access to both individual and group extension methods. There is a significant systematic association between fertilizer use and method of extension at 1%.

In terms of extension service coverage no important difference is observed. With regards to fertilizer use the most effective method of extension is individual contact. This method of extension involves self initiated and it can serve as a good measure to explain the role of extension service in use of external inputs like fertilizers. In the case of fertilizers, it directly relates to access to detailed information on fertilizer use as well as other agronomic practices that enhance the benefit of fertilizer use. It is also important to note that most extension agents frequently visit farmers who actively participate in extension packages. In the wereda, limitation

to the extensive use individual extension contact is physical as most of farm households are distant from extension agents' offices. On average Extension Agents are expected to cover distances of more than 3 hours within the specific Kebele.

The results reported in table 15 indicate 81.5% of Users and 70.4% of non-users consulted DA atleast twice in a month. Contact with extension agents does not show significant difference corresponding to increased number of extension agents. The woreda agriculture bureau claims more than 95% coverage through the combination of all extension methods. Both 70.4% of users and 74.6% of non-users didn't serve as model farmer in last three years. This is explained shift away from demonstration based extension approach.

Table 15 Access to Extension Service

Characteristics		User		Non-user		X2-Statistics
		N	%	N	%	
Consult DA	Yes	76	93.8	58	92.1	0.17NS
	No	5	6.2	5	7.9	
Type of extension method	individual	15	18.5	3	4.8	12.8***
	Group	8	9.9	17	27	
	both individual and group	55	67.9	38	60.3	
	don't know	3	3.7	5	7.9	
Frequency of consulting DA (month)	Once	10	12.3	14	22.2	7.13NS
	Twice	17	21	13	20.8	
	at least twice	49	60.5	30	54.9	
	don't participate	5	6.2	6	7.9	
Model farmer (last three years)	Yes	24	29.6	16	25.4	0.32NS
	No	57	70.4	47	74.6	
Crop type	Maize	12	53.3	9	64.3	17.3NS
	Teff	2	9.1	0	0	
	Wheat	2	9.1	0	0	
Hosted demonstration fields	Yes	22	27.2	21	33.3	0.65NS
	No	59	72.8	42	66.7	
Visit demonstration fields or field days	Yes	34	42	19	30.2	2.13NS
	No	47	58	44	69.8	

*** Represents level of significance at 1% N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

Credit

Sustaining farmer's adoption of intensive practices require not only developing more input-responsive technologies and high quality extension service but also well-functioning input market through which inputs such as fertilizer are made available in the desired quantity, type and at reasonable prices (Beyene, 1998).

Some studies indicate that about 80% of fertilizer sales in the country are on credit basis. Larger quantity of fertilizer is channeled on credit basis through the procurement process arranged by the local government offices (such as agriculture and cooperative offices). In addition to higher percentage in fertilizer and improved seed credit schemes for petty trade and small-scale business are included. Credit allocation is major problem as most of the amount is biased towards Kebele officials. Also service provision schemes are limited to Kebeles of surrounding towns.

According to the survey result shown in table 16, about 78% of users and 85.7% of non-users took credit for different purposes. Most credit amount was used for fertilizers in the case of users 34% in 2006/07 and for non-users used 30% of the credit amount in the same production season. There is no important difference as to what purpose of credit was used. Non-users took fertilizer on credit. The fact that these considerable numbers of farmers do not use fertilizer on Teff relates to presence of other competing enterprises. From this result it can be observed that other

competing crop enterprises leave little for fertilizer use on Teff.

Table 16 Distribution of the Sampled Household by Access to Credit

Characteristics (in the last three years)	Response	User		Non-user	
		N	%	N	%
used credit	yes	63	77.8	54	85.7
	no	18	22.2	9	14.3
purpose of credit 2005/06	fertilizer	18	37.5	15	37.5
	fertilizer and seed	12	25	8	20
	fattening	9	18.8	4	10
purpose of credit 2006/07	fertilizer	19	38	19	41.3
	fertilizer and seed	13	26	9	19.6
	fattening	10	20	7	15.2
purpose of credit 2007/08	fertilizer	18	34	15	30
	fertilizer and seed	14	26.4	11	22
	fattening	12	22.7	10	20

N = Number of respondents

Source: Computed from the field survey data, 2007

5.1.3 Input Use of sample households

Fertilizer is the major modern technology used by farmers. Since cereals like Teff are mainly grown to meet the food requirement of the farm households, they receive high priority next to cash crops.

The survey results have shown that the sample households use less than the recommended rate of 150 kg /ha (100kg/ha DAP and 50kg/ha UREA). The average combined fertilizer (DAP and Urea) application rate on Teff by the sample households was 38.87 kg/ha with standard deviation 57.19 kg/ha (Total area under Teff considered). This implies that on the average sample households applied only about 25.9% of the recommended rate. In addition, there is a wide gap between DAP and UREA application rates compared to the 2:1 ratio which is recommended by extension service. The results have shown that sample farmers on the average applied 31.05 kg of DAP and 7.82 kg of UREA per hectare (3.9:1 ratio) implying nutrient imbalance in favor of DAP fertilizer.

5.1.3.1 Fertilizer use and soil productivity

Users had a mean 0.85 ha covered under Teff while non-users had 0.765 ha of land under Teff. Fertilizer use across amount of Teff produced for users with mean 6.51 quintals and non-users 5.05 quintals showed significant mean difference at 10%. According to WADO,2005 average Teff yield per hectare is 8.86 qu/ha. This amount is slightly above the national average of 8.01

qu/ha. The results of the survey indicate that productivity of Teff showed 2.04 qu/ha for users and 1.69qu/ha for non-users significant mean difference at 10%. It is important to note that productivity of Teff relies on number of factors that range from timely requirement of land preparation, better selected seed, application of inputs (mainly fertilizers) and timely agronomic practices like weeding. To undertake these crucial farm operations ownership, availability of both family and hired labor and readily access to cash resources.

Table 17 Fertilizer use and land productivity

Characteristics	user		non-user		t-statistics
	mean	SD	mean	SD	
Land covered by Teff (ha)	0.85	0.13	0.77	0.09	1.06NS
Amount of yield (qu)	6.51	6.38	5.05	3.17	1.59*
Teff Yield (qu/ha)	2.04	1.34	1.69	0.79	1.75*

* Represents level of significance at 10% N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

5.1.3.2 Type of Teff variety

The major local selected seeds include Tezez, Davo and Goheno. Tezez variety is relatively new to the study area. As Tezez gives higher yield it is mainly grown for market. The other two varieties of Davo and Goheno have been in use or long period of time. Their productivity and market demand has shown a decline. Out of the total sample households all respondents used selected local seed. As shown in table 18 among users 34.6% used Tezez, 24.7% grew Davo, and again 24.7% grew the variety Goheno. Tezez mainly is grown for market. While the varieties of

Davo and Goheno are grown to pursue the objective of household consumption. In the case of Non-users about 46.6% grow Tezez, 8.6% Davo and 24.1% Goheno. Non-users grow more of Tezez as farmers claim this variety gives better yield. But since Tezez is relatively new farmers in the area have limited experience. In contrast, Goheno and Davo, have been in use for long period. From long years of use, the two varieties give lower productivity without the use of fertilizers. Consequently lower productivity induces higher fertilizer use.

Table 18 Type of Teff variety

Characteristics		User		Non-user		X2-Statistics
		N	%	N	%	
Name of Teff variety	Goheno	28	34.6	27	46.6	8.68 NS
	Davo	20	24.7	5	8.6	
	Tezeze	20	24.7	14	24.1	
	All varieties combined	4	4.9	2	3.4	

N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

5.1.2.3. Objectives of Teff production

In the area, improved Teff seeds are unavailable. It has been more than 12 years since improved seeds were distributed to the farmers in the area. Therefore, farmers grow locally selected seed to pursue varied objectives ranging from producing for market to resistance to hardships and requirement of low input.

As shown in table 19 higher percentage of non-users 23.5% pursue the objective of producing for

market where 20.2% users agree to the same objective. Farmers who actually can not produce enough sell their Teff outputs and in exchange purchase low priced food items like barely and finger millet. On the other hand farmers who produce enough mainly sell certain amount but keep larger amount for their own consumption. The cash earned is mainly to cover for production costs like labor, purchase of inputs and sharing or renting land.

Table 19 Objectives of Teff production

Characteristics	Users		Non-users	
	N	%	N	%
Main objective for market	43	20.2	38	23.5
Main objective for market and consumption	76	35.7	52	32.1
Main objective for resistance to hardship	45	21.1	42	25.9
Main objective for seed	22	10.3	18	11.1

N = Number of respondents

Source: Computed from the field survey data, 2007

5.1.3.4. Use of Manure and compost by Households

The survey result has shown that farmers are using manure and compost as a complement with fertilizers. In this study application of Manure and Compost use was considered on number of application on Teff farms. As the results reported in table 20 indicate non-users on average have

used manure 0.644 times while Users on average have applied manure 1.23 times on their fields with mean difference significant at 5% level. The same holds true for number of compost application. Non-users on average used 0.49 times while users used 0.90 times. Better livestock ownership mainly ensures availability manure in large amount.

Table 20 Use of Manure and compost by Households

Characteristics (frequency in number)	User		Non-user		t- statistics
	Mean	SD	mean	SD	
Manure application	1.23	1.01	0.57	0.64	2.25**
compost application	0.90	0.70	0.49	0.54	1.98**
weedicide application	0.10	0.44	0.02	0.13	1.29NS
weeding on Teff	2.79	1.21	2.84	1.14	-0.86NS

** Represents level of significance at 5% N = Number of respondents NS= not significant

Source: Computed from the field survey data, 2007

5.1.4 Analytical Result of Probit model estimation

Before the estimation of the model parameters, it is important to look into the problem of multicollinearity or association among different selected explanatory variables. For this case, the VIF was used to test the association between continuous explanatory variables.

To avoid serious problem of multicollinearity, it is quite essential to omit the variable with the VIF value exceeds 10 (this will happen if R^2 exceeds 0.90 i.e. highly correlated) from the Probit analysis. Based on the VIF result, all variables used in the model estimation have no serious problem of multicollinearity (appendix 3).

A set of 14 explanatory variables (11 continuous and 3 discrete) were included in the Probit analysis. These variables were selected on the basis of theoretical explanations, personal observations and the results of the survey studies. To determine the best subset of explanatory variables that are good predictors of the dependent variable, the Probit regression was estimated using statistical software program (STATA 9). All the above-mentioned variables were entered in a single step. The model estimation results of the variables used in the model are presented in table 21.

As the results of Probit estimation reported in table 22 indicate, out of the total 14 explanatory variables of demographic like age of the household head, Family size of the household and

Farmers experience on use of fertilizers; socioeconomic characteristics of Total labor to land ratio, Total livestock owned in TLU and institutional characteristics of access to individual extension method affect the use of fertilizers on Teff. In parallel land quality improving inputs like number of manure and compost application showed significant influence fertilizer on Teff. The results of the model indicated that other variables like Total land size in hectare, Proportion of land under Teff to total land size and practice of crop rotation showed insignificant influence on use of fertilizers on Teff.

Table 21 Probit estimation of variables that affect fertilizer use on Teff

Variables	Marginal effect	Coefficient	z-value
CONSTANT		0.4027	0.22
PRTFF	0.0832	0.2187	0.16
TLDSMD	-0.3718	-0.9775	-0.67
TLLBRRTO	0.1343	0.3531	2.06**
PRDTFF	-0.0174	-0.0456	-0.38
WEMLA	0.2784	0.8666	1.93*
DUCRTY	0.1187	0.3122	0.83
DFCNFRUS	-0.1481	-0.3992	-1.41
CRPROT	0.2191	0.5589	1.39
NCATFF	-0.1767	-0.4645	-1.71*
NMATFF	0.1704	0.4479	1.74*
FMSZ	-0.0549	-0.1445	-1.88*
FEXPFER	0.0357	0.0938	3.93***
AGEHHH	-0.0153	-0.0402	-3.51***
LVTLU	0.0297	0.0779	2.59***
Number of observation = 138			
Log pseudo likelihood = -68.67			
Wald χ^2 (14) = 43.11***			
Pseudo R^2 = 0.2686			

*, ** and *** show significance levels of 1%, 5% and 10% respectively.

Age of the household head (AGEHHH)

In confirmation with hypothesis, farmers with young age have more probability of using fertilizer. The marginal effect of 0.0153 showed significant and negative relationship with fertilizer use on Teff at level of 1%. Other things held constant, an increase of in the age of the household head causes less likelihood of fertilizer use. The result agrees with studies of Yishak, 2005; Mulat and Croppenstedt, 1996.

Experience with fertilizer use (FEXPFER)

As it was expected, farmers with longer years of experience of fertilizer use are more likely to use fertilizer on Teff. The analytic result of the Probit model indicated a positive and significant marginal effect of 0.0357 at 1% level of significance. Other things held constant, as the number of years the farmer has experience with fertilizer increase, the likelihood of fertilizer use on Teff increases. This finding agrees with the study undertaken else where in Ethiopia by Mulat and Croppenstedt, 1996 and Yishak, 2005.

Family size (FMSZ)

Contrary to the hypothesis Family, the results of the probit estimation for household size produced a negative and significant marginal effect of 0.0549 at significance level of 10%. Given

that other things held constant, households with large family size are less likely to use fertilizers on Teff. This result differs from results other studies that indicate positive effect of family size in adoption of labor demanding technologies.

Livestock ownership in TLU

The probit model result indicated that number of tropical livestock unit (TLU) affected positively and significantly the probability of fertilizer use on Teff at 1% significance level. This result shows that those farmers with large number of tropical livestock units are more likely to use fertilizer on Teff than those who own small number of TLU. The positive association between fertilizer use on Teff and number of TLU indicates that herd size creates better opportunity to earn more income from livestock production. The income generated from livestock helps farmers to buy or use fertilizer on credit. This finding agrees with the study undertaken else where in Ethiopia Getahun et al. (2000) cited by Yishak (2005); Itana (1985); Assefa and Gezahegn (2004).

Access to extension (WEMLA)

Access to extension service through individual method of extension has positive effect on use of fertilizer at significance level of 10%. The Probit estimation reported marginal effect of 0.278. As it was initially expected extension service through individual method has an influence on the

farmer's decision to use fertilizers on Teff. Similar results were reported by Bezabih (2000) cited by Techane (2002); Nkonya et al. (1997) and Lelissa (1998).

Number of Manure application on Teff

As to the number of manure application on Teff, result of probit estimation model has positive and significant marginal effect of 0.170 for the number of manure application on Teff. It has significance of 10% level. This implies that as the number of manure application increases, the probability of increasing fertilizer use is more likely. This result is in contrary to the finding of Lelissa (1998).

Compost application

Contrary to prior expectation the probit model estimation on the number of compost application has marginal effect of 0.177. The coefficient has negative sign and is significant at 10%. This implies that as the number of compost application on Teff increases the use of fertilizers on Teff is less likely. Given the high interrelationship of crop and livestock enterprises, more number of livestock ownership imposes competitive demand of using crop residues for feed. In addition, livestock ownership relates to better financial resource. But on the contrary household with limited livestock resource can spare crop residues for making compost and command less financial resources to purchase fertilizer.

6. SUMMARY AND CONCLUSION

6.1 Summary

Soil fertility is function of biophysical characteristics and the management practices undertaken. The level of soil fertility has declined in the study area. This decline is mainly manifested through low level of crop output. The study area has largest cultivated land under Teff. Teff is an important crop as it fetches higher market value and grows over a wide range of agro-ecological and land quality levels. Despite of multitude choices available for improving soil fertility on Teff, use of fertilizer assumes primary role in the study area.

The farming system of the study area supports the rain fed crop production system with limited irrigation practice. In study area, food crops like Teff, maize, Finger millet, Barely and Potato assume prominence over legumes. In the crop production system the important scheme of crop rotation is in place. Recently, more land is being devoted to Noug at expense of other legumes . As a result the practice of crop rotation has left out an important legume *Gibto* and replaced it with Noug.

Suitable environment; progressive trend of fertilizer use coupled with long years of farmers experience made fertilizer use viable. Farmers decision of fertilizer use has priority that varies depending the important factors like market value, soil quality and performance of the crops either with or with out fertilizer application. The most preferred fertilizer type on Teff is DAP. In accordance to consideration of soil quality use of Fertilizer on soils with black-black and black-

red colors is minimal. Farmers associate problem of high lodging effect on these soils when fertilizer is applied. In the same line food crops in the study area receive low priority to fertilizer application.

Data was collected through structured questionnaire, focus group discussion and review of secondary documents. A two-stage sampling procedure was applied to select sample farmers. This study has examined important aspects of traditional fertilization methods in the farming system. Emphasis was given to consideration crop livestock interaction on improvement of soil fertility on Teff. Further more detail analysis of fertilizer use was carried with the help Probit model estimation. The results of the study demonstrated that farm variables of demographic, socioeconomic as well as institutional factors significantly influence farmers decision of fertilizers use on Teff.

The important demographic factors include age of the household head, total family size and farmer experience with fertilizer. Only experience of farmers with fertilizer has positive and significant effect on use of fertilizers on Teff. The socioeconomic variables include total livestock in TLU and total land ratio to labor. Both variables affect the use of fertilizers on Teff positively and significantly. The remaining important institutional factors are method of extension in the local area and use of credit. Access to individual method of extension positively and significantly affected the use of fertilizers.

Apart from consideration of the above important management elements that improve quality of land were included. Thus variables that represent number of compost application and number of manure application and practice of crop rotation were considered in relation fertilizer use on Teff. Hence, the results indicate that more number of manure applications has positive and significant influence on application of Teff. Farmers perceive its role in improving soil fertility. Application of manure is selective and seasonal depending on crop type and land use type. Manure on Teff is carried out in the rainy season. Due to very limited availability of manure and transportation forced farmers to resort towards spot application.

Major gap is on utilization of manure is specification on “how to” determine the right proportion and efficient application of this scarce resource. In the case of compost, more number of compost application influences application of fertilizer on Teff negatively. Farmers claim availability of various inputs for compost making in abundance. The important constraints for large scale preparation relates to competitive requirement for resources like labor and land. Unlike the case of manure farmers get technical advice from extension agents.

6.2 Conclusion

Farmers devise different coping mechanism to check the declining productivity level of their fields by utilizing different options. However, the existing practices of soil fertility management practices are inadequate to relieve the problem of declining crop productivity. Consideration of farming system reveals that there is a room for integrative use of soil fertility technologies. In the

environmental setting like Ankesha, farmers utilize multitude of technologies to improve soil fertility. The practices range from fertilizer, manure, and compost application to practices of crop rotation and fallowing.

Decision on input use relies on range of household characteristics and institutional factors. In the study area, soil quality improving technologies like fertilizer application relate to intensive farming practices. Households with smaller total land size, higher labor to land ratio, higher proportion of land committed to Teff use more fertilizer on Teff. The factor of readily availability of cash to farm households for purchasing inputs has an important role. Since fertilizer is the only input purchased in the study area, availability of financial resource either in cash or credit is vital. Larger size of livestock holding in TLU allows better financial resource and use of credit contribute increased use of fertilizers. The constraints of improved livestock productivity can be relieved through better crop residue management and promotion of forage cultivation to supplement communal grazing.

Farmers with detailed information and experience with technologies use more fertilizers. Farmers with longer experience to fertilizer use and who have access to individual method of extension enjoy detailed technical aspect of fertilizer use and additional information on better agronomic practices. Extension efforts directed towards improving the skills of farmers on detail aspects of fertilizer use.

However, the use of fertilizer in the study area is highly constrained by increased age of the household head. With increased age of household heads, the ability of utilizing resources like labor and land declines. Their ability to generate better financial resource declines as a result farmers cut back use of purchased inputs. Extension and credit institution may find the result useful in targeting specific packages. Also larger family size of farm household constrains the use of fertilizers. Important to note larger family size increases the demand for food. To sustain increased demand for food farm households grow more food crops and relatively have limited cash resources. Hence families with large family size tend to use less fertilizer on their Teff fields. Introduction of improved crop varieties, disease control and strengthening of credit schemes are possible areas that can improve the financial resources.

The important inputs that serve to improve soil quality are fertilizers, manure application, and compost application in their respective order of importance. Fertilizer use confirms with more application of manure. In contrast more application of compost relates with less use of fertilizers. Next to fertilizers, manure is an important input to improve soil fertility. As to how effectively manure contributes to improvement of soil fertility is possible area of research. Focus area for research and extension can be in the aspects of improved management of manure, determination of right amount and application rate. The commendable approach of technical assistance on compost preparation and application should be strengthened. Another focus area for Extension is on promotion of woodlots. In parallel, supplementary technologies of soil and water conservation need to be promoted on individual farm lands.

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ANNEXES

Annex 1: Conversion factors used to compute tropical livestock units.

Types of animal	TLU
Cow	1
Oxen	1
Bull	1
Calf	0.75
Sheep and goat	0.40
Donkey	0.50
Horse/mule	0.80
Chicken	0.013

Source: Storck et al. (1991).

Annex 2: Conversion factors used to Estimated Man-equivalent (ME).

Age group	Male	Female
<10	0.00	0.00
10-14	0.35	0.35
15-50	1	0.80
>50	0.55	0.50

Source: Storck et al., (1991)

Annex 3: Cropping calendar for other major crops

<i>Farm operation</i>	<i>Teff</i>	<i>Maize</i>	<i>Finger millet</i>	<i>Barely</i>	<i>Noug</i>	<i>Potato*</i>
<i>Land preparation</i>	<i>mid-April to mid-August</i>	<i>mid-April to end of May</i>	<i>mid-March to late June</i>	<i>mid-March to mid-June</i>	<i>mid-July to mid-September</i>	<i>mid-July to mid-September</i>
<i>Planting/Sowing</i>	<i>mid-July to late August</i>	<i>mid-May to mid-June</i>	<i>late June to mid-July</i>	<i>mid-June to mid-July</i>	<i>mid-August to late August</i>	<i>mid-September</i>
<i>Fertilizer application DAP</i>	<i>mid-July to late August</i>	<i>mid-May</i>	----	----	----	----
<i>Fertilizer application UREA</i>	----	<i>late July</i>	<i>late June</i>	----	----	----
<i>Weeding (1st and 2nd)</i>	<i>mid-September to mid-December</i>	<i>mid-June to late July</i>	<i>mid-August to mid-September</i>	<i>mid-July to mid-August</i>	<i>mid-September to mid-October</i>	<i>late September to mid-October</i>
<i>3 rd and 4 th</i>	---	<i>mid-August to early September to late September</i>	---	---	---	----
<i>Harvesting</i>	<i>mid-January to mid-February</i>	<i>Late November to mid-December</i>	<i>Mid-December to mid-January</i>	<i>late September</i>	<i>mid-December to January</i>	<i>mid-January</i>
<i>Threshing</i>		<i>mid-February to mid-April</i>	<i>mid-January to mid-April</i>	<i>mid-November</i>	<i>mid-January to late February</i>	---

* Potato grown in the rainy season Source: Computed from the field survey data, 2007

Annex: 3 Test for multicollinearity of explanatory variables used in the estimation of the Probit model

Variables	R2	VIF
AGEHHH	0.0767	1.376
FEXPFER	0.0652	1.552
FMSZ	0.0045	1.195
TLDSMD	0.0303	1.034
TLLBRRTO	0.0073	1.007
LVTLU	0.0399	1.042
PRPTFF	0.0083	2.189
PRTYTFF	0.0226	1.023
DUCRTY	0.0051	1.005
NMATFF	0.0337	1.257
NCATFF	0.0255	1.461

Annex: 4: Determinants of Farm household fertilizer application on Teff: Ankesha Woreda of Awji Zone

1. Farm Household Characteristics

1.1 Name of house hold _____

1.2 Number of years lived in this area _____ (years)

1.3 Religion of household head

1- Orthodox 2- Protestant 3- Muslim

1.4 Sex of household head

1- Male 2- Female

1.5 Age of the household head _____ (yrs)

1.6 Level of education of the household head

1- Illiterate 2- Read and writes 3- Primary school (1-6)

4- Junior school (7-8) 5- Secondary school (9-12) 6- Religious education

1.7 Years of farming experience to date _____ (yrs)

1.8 Years of farming experience with fertilizer to date _____ (yrs)

1.9 Family size and educational level of family members number of permanent members in the household by age and sex

S.N	Name	Age			Sex		Educational status
		below 14	14-60	above 60	M	F	
1							
1							
3							
4							
5							
6							
7							
8							
9							

1- Illiterate 2- Read and writes 3- Primary school (1-6)

4- Junior school (7-8) 5- Secondary school (9-12) 6- other specify

1.10 Age category and family members undertaking farming activities

Age category (years)	sex		Total	How many full time work in the farm	How many part time work in the farm	How many have full time off-farm activities
	M	F				
Children 11-14 years of age						
Adults 15-64 years of age						
Elders over 64 years of age						

1.11 What is household head position in the community?

1- Political Leader 2- Spiritual leader 3- elder

4- Member 5- other specify

2. Land

2.1 Total farm size _____ (ha)

2.2 How far is the furthest parcel away ? _____ in minutes

2.3 Land tenure and land use

Type of Land type	Size in ha
-------------------	------------

Farm land	
Own land	
Rent in	
Rent out	
Sharecropped in land	
Sharecropped out land	
Grazing land	
Homestead land	

3. Labor Resource for Teff Production

3.1 Do you use hired labour for the following Teff production activities

production activity	Yes	no	number labour hired
plowing			
planting			
weeding			
harvesting			
threshing			

3.2 What are your reasons for not hiring labor?

- 1- Have enough labor 4- Too expensive
2- No labor for hiring 5- Used communal labor
3- Other specify
4. Livestock Ownership

4.1 Do you keep livestock?

- 1- Yes 2- No

4.2 If yes, state the types and number of livestock employed in 2006.

No	Types of livestock	Number of livestock			
		Total	Owen	Rented	Shared
1	Ox				
2	Cow				
3	Heifer				
4	Sheep				
5	Goat				
6	Donkey				
7	Horse				
8	Mule				
9	Poultry				

4.3 To what Purpose do you use your livestock resource?

1- household consumption 2- Cash income 3- Drought power

4- Transportation and 5- Other specify

4.4 What is the source of animal feed ?

1. Own farm 2. Market 3. Communal grazing area 4. Own grazing

4.5 Do you think your animals have adequate feed in different seasons?

1. Yes 2. No

4.6 If not, what are the most difficult months of feeding the animals?

1. wet season 2.dry season 3.all season

5. Crop production

Consumption/Distribution of Teff Varieties

5.1 Rank the use Teff produced by objectives

Objective	Yes	No
1. Market/cash		
2.Household consumption		
3. Market and consumption		
4.Resistance Hardship		

5.2. Major Problems

5.2.1 What are the major constraints you faced in producing Teff?

Category	Rank	List a maximum of 2(two) important constraints	List of constraints to select
Production		1st 2nd	1-Farm tools 2- Weed problem 3-Land shortage 4-Suitable variety 5- Unreliable rain fall 6-other specify
Marketing		1st 2nd	1-Low output price 2-High input cost 3- Other specify
Management		1st 2nd	1-Labour management 2-Land management 3- Financial management 4- Soil fertility 5-Other specify
Information		1st 2nd	1-On improved techniques 2-On improved varieties 3-Other specify
Financial		1st 2nd	1-Access to Credit 2-High interest 3-Unfavorable repayment schedule 4-Other specify

6. Soil and water conservation methods

6.1 Is soil erosion a problem on your farm?

1. Yes 2. No

6.2 If yes, what measures do you apply on your land?

1. Soil bund 2. cut-off drain 3. stone bund/terrace 4. drainage ditches 5. live fencing 6. other specify

6.3 Is soil fertility an important problem for Teff production?

- 1-Yes 2-No

6.4 If yes, how do you curb the problem?

1. applying more input 2. selective use varieties
3. leaving the fallow 4. practising crop rotation
5. other(specify)

7. Access to Credit and Extension

7.1. Credit

7.1.1 Have you receive credit during the last three years?

- 1-Yes 2-No

7.1.2 If yes, indicate source of credit, amount and purpose

Year	Source****	Amount	Purpose*	Type of credit**
2004/05				
2005/06				
2006/07				

Purpose* 1-Fertilizer 2-Seed 3-Herbicide 4-Other specify

Type of credit ** In terms of cash-1 Ox-2 Fertilizer-3 Other specify-4

Source of credit**** formal-1 informal-2

7.1.3 Do capital/cash or credit is limiting in your adopting of fertilizer?

- 1-Yes 2-No

7.2 Extension

7.2.1 What is the method of extension contact?

- 1-Individual contact 2-Group contact 3-both methods

7.2.2 Have you participated in field day or demonstration?

- 1-Yes 2-No

7.2.3 Do you Owen radio?

- 1-Yes 2-No

7.2.4 If yes, have you listened to agricultural program on radio?

- 1-Yes 2-No

7.2.5 Name the local Teff varieties grown last crop year (2006/07) _____

8. Fertilizer use

8.1 When did you first become aware of fertilizer use? _____

8.2 When did you start using fertilizer? _____ year in E.C

8.3 Have you ever used fertilizer?

1. Yes 2. No

8.4 Did you use fertilizer on Teff during the last crop season?

1. Yes 2. No

8.5 If yes, indicate area covered and amount used

Type of fertilizer	Area coverage (in ha)	Amount used (kg)
DAP		
UREA		

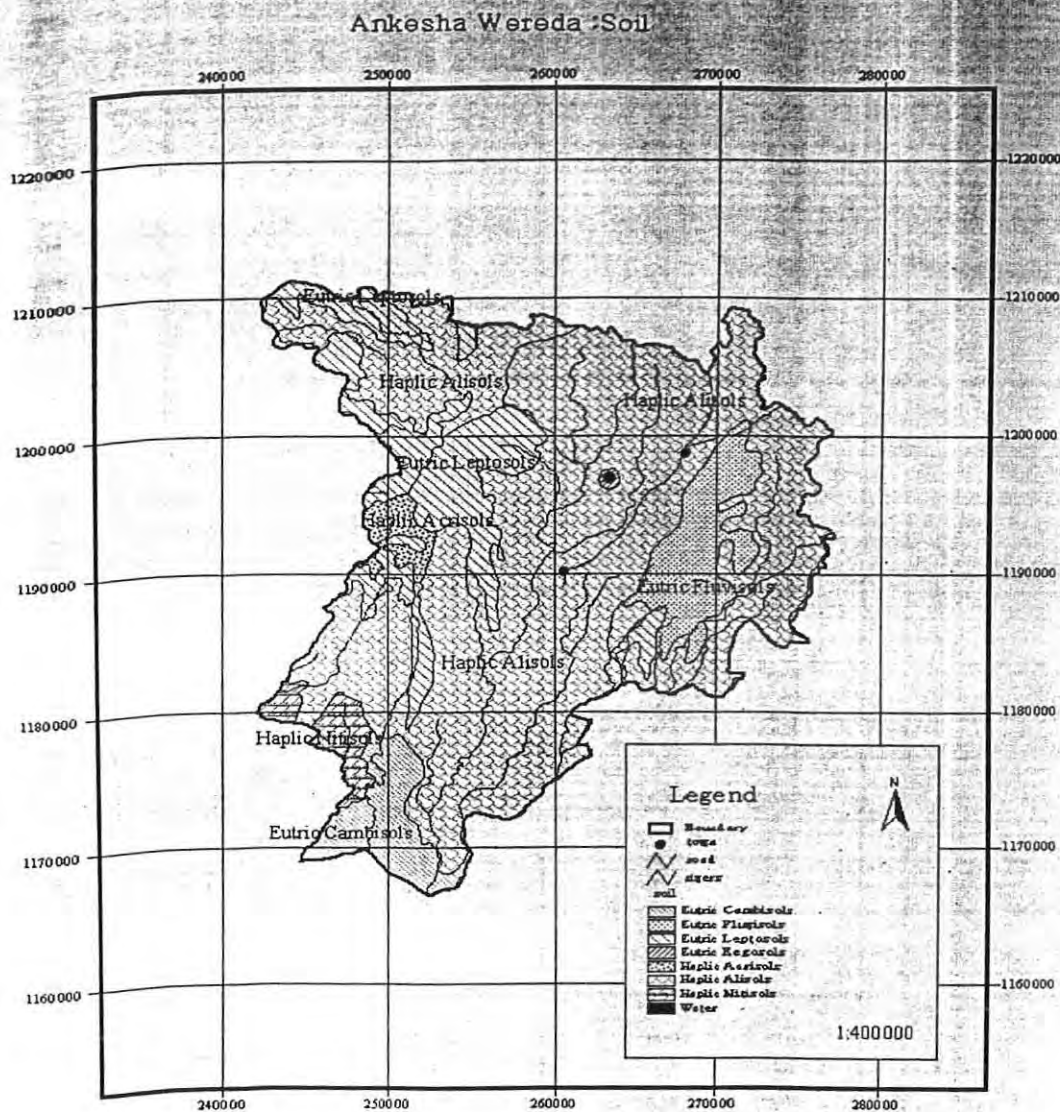
8.8 Do you apply fertilizer on crops other than Teff?

1-yes 2-No

9. Income of sampled household in the year 2006/07

Income	Amount birr (use per year)
Crop production for sale	
Livestock raising including poultry for sale	
Sales of trees and wood products	
Off farm /non farm activity	
Remittances	
Others specify	

Annex 5: Soil Map of Ankesha Wereda



Declaration

I declared that this thesis is my original work and has not been presented for a degree in any University. All the sources of material used for the thesis are duly acknowledged.

Name: MIKIAS AMARE

Signature: 

Date: August, 2007

Place: Addis Ababa

This thesis has been submitted for examination with my approval as a University advisor

Name: Workneh Negatu

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