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Determinants of Soil Fertility enhancing technology adoption and its effect on þÿ h o u s e h o l d s   f a r m   i n c o m e   i n   D Damot district

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Determinants of Soil Fertility enhancing technology adoption and its effect on households€farm income in Dega Damot district

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DECLARATION

I, the undersigned, hereby declare that this thesis is my original work and has not been presented as a thesis for a degree program in any other university, and all sources of equipment used for this thesis are properly approved.

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ABSTRACT

In Ethiopia agriculture is the backbone of national economy and source of livelihood for most of the population. Despite its importance, the agricultural sector in Ethiopia is characterized by low productivity due to soil nutrient depletion and low external agricultural inputs. The main objective of this study was identifying the key determinants farmers€ decision to adopt soil fertility management technology and its effect the adopted technologies on rural households€ farm income in case of Dega Damot district. The study was relying on cross-sectional data from 222 randomly selected households from different agroecologies and key informant interviews. The data were analyzed using Heckman two-stage models and simple descriptive statistics using STATA software.

The first stage of probit regression results of the study show that the adoption decision of soil fertility enhancing technology was driven by households€ age, farm size, size of family, number of the labor force, position of land€ education, access to credit, livestock, farm experience and awareness at a statistical significance. The study finding confirmed that both partial and complete SFM adoption lead to significant increases in farm income and net crop value. In moister kebele, complementing improved varieties with inorganic fertilizer seems most important, while in drier kebele enhancing it with organic fertilizer appears crucial. SFM is related to higher labor force, but also significantly increases farm income. These findings imply that SFM can contribute to improve farmers€ livelihoods by breaking the nexus between low productivity, environmental degradation and poverty.

The second stage result show that soil fertility enhancing technology adoption increases households farm income per timad. This implies that farmers should be encouraged to adopt soil fertility enhancing technology. Therefore, the study suggested that, the policies makers should be expanded the accessibility of credit service, dissemination of productive agricultural technology information, and creating opportunity of education for farm house hold has potential to increase soil fertility enhancing technology adoption decision and strengthen the level of adoption among smallholder farmers.

Key words: Timad, soil fertility, technology adoption, enhancement

Acronyms

ADO	Agricultural development office
DDDRDO	Dega Damot district rural development office
FAO	Food and agricultural organization
GDP	Growth domestic product
IPM	Integrated Pest Management
MoFED	Ministry of Finance and Economic Development
SFM	Soil fertility management
SFMT	Soil fertility management technology
SSA	Sub-Saharan Africa

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CHAPTER ONE

INTRODUCTION

1.1 Background of the study

In Ethiopia Agriculture contributes for about 52% of the GDP and 85% of the population is dependent directly or indirectly on it (Debebe, 2019). While agriculture is growing at 1.6% per annum, the population of the country is growing at a 3% rate and thus, is expected to double by the year 2020 (Debebe, 2019). This indicates the need to increase the productivity of agriculture to keep pace with the population to ensure an adequate supply of food in the future. Accordingly, the government has started on a massive agricultural extension program since 1994/95 to facilitate the use of improved crop production technologies, a key component of which is chemical fertilizers (Biru, 2016). However, the adoption and intensity of fertilizer application, by smallholders remained very low despite government efforts to promote its use.

Ethiopia is one of the fastest growing economies from developing countries in Africa. In the last decade, the Ethiopian Economy registered a growth of 11 percent per annum on average in Gross Domestic Product (GDP), (MoFED), 2014) compared to 3.8 % for the previous decade (World Bank, 2012), as cited in (Biru, 2016). In case, it is rated as one of the fastest growing non-oil exporting economies in the world. Accordingly this growth has been basically supported by relatively high growth in farming (MoFED, 2012). Hence, the role of agriculture in the Ethiopian economy cannot be underscore. But, it is undermined by land degradation (shibiru, 2010).

Land degradation in sub-Saharan countries is largely an outcome of the existing agricultural production system which is sources of poor agricultural practices characterized by uncertain rainfall and low inherent land productivity (Alelgn, 2011). Agriculture-based low-income countries reverse the decline of land productivity resulting from environmental degradation, and ensuring adequate food supplies to the fast-growing population is a difficult challenge. Agricultural technologies play an immense role in increasing food productivity. Therefore, agriculture is useful to examine the adoption of technologies among households. Agricultural technologies are said to include all kinds of improved techniques practices which affect the growth of agricultural output (Jain, 2009).

Agriculture is the dominant economic activity and is characterized by low input, low output farming. The farming system incorporates crops and livestock. Thus, the adoption of soil fertility management technology is the best solution to increasing households€ income by improving soil fertility and to reducing the use of organic fertilizer (Jain, 2009). The adoption of compost, chemical fertilizer, manure technologies and sustainable agricultural practices that enhance agricultural productivity and improve environmental outcomes remains the most practical option to increase households€ income, food security and poverty alleviation. The adoption of compost and manure technology is very important for small-holder farmers by reducing the cost of fertilizers (Biru, 2016) The objective of this study will to assess the determinants of soil fertility management technology adoption behavior of smallholder subsistence farmers and its impact on households€ income

Dega Damot woreda is a comfortable place and the main source of households€ income is an agricultural product. But agricultural productivity is reduced gradually due to the shortage of adoption of new technology by cause of poor soil fertility. Other factors identified included lack of awareness; labor force effect education, age, land quality, socio-economic factor and the like affects agricultural productivity. Despite the achievements in addressing these constraints, fertilizer use among smallholder farmers remained below expectations, thus necessitating further investigation into the emerging determinants of fertilizer use among smallholder farmers in the highlands of Ethiopia.

1.2 Statement of the problem

In Sub-Saharan Africa (SSA) countries, low and declining of soil fertility due to net nutrient extraction by crops and soil erosion are responsible for low agricultural productivity and food insecurity (Hassan, 2010; Nakhumwa and Hassan, 2012). According to Sanchez et al. (1997) indicated that among others, the breakdown of traditional soil nutrient management practices because of population pressure is responsible for nutrient depletion in SSA. But, different researchers argue that population pressure induce households to strengthen agricultural production, invest in land improvements and develop land saving innovations eventually resulting in enhanced resource conditions and possibly improved wellbeing (melese, 2018)

Farmers in rural areas of Ethiopia have been facing the challenges of declining agricultural productivity. One of the key reasons for this is decreasing soil nutrient degradation due to poor soil fertility management. Since the 1970s; the Ethiopian government has intervened the agricultural sector to overcome this problem through the promotion of various land and soil management technologies such as compost and manure. However, soil degradation has continued leading to decline in agricultural productivity (Alelgn, 2011). Low agricultural productivity, poverty and soil erosion are closely related problems in Ethiopia. Farm productivity in Ethiopia is very low as a result of lack of agricultural inputs, due to outdated farming, deforestation, overgrazing, declining soil fertility, and continuous soil erosion, depletion of organic matter, uncertain land tenure and recurrent droughts, all in combination with high population pressure (Alelgn 2011).

West Gojjam is naturally endowed with ample natural resources and good potential to produce ecosystem services. The basin is suitable for the growth of a wide range of tropical, subtropical and temperate crops. However, the area has been continuously exploited for the historical development of agriculture and human settlement and the present condition is very acute (Simane et al 2016). Soil resource under intense pressure from population growth and poor management, and soil erosion are very serious and its adverse effect on agricultural production has been continuous. As a result, the livelihood of the farming community faces sever constraints related soil erosion, soil acidity, the decline of soil fertility, water scarcity, and shortage of livestock fodder.

Dega Damot woreda is one of the marginalized woredas found in west Gojjam. The woreda is characterized by high soil erosion due to poor soil management coupield with rugged topography. The farmers in this woreda have been used the land for different purposes without considering sustainability of the topsoil resources. As a result, the productivity of the soil has been abjectly declining in the last few decades and without fertilizer most land does not produce good agricultural products. Moreover, some land gives off their service to the community. The report of the district agricultural development office showed that fertilizer to the land ratio in the district was 8-10 kuntal organic fertilizer per timad whereas the recommended level was 15-20 kuntal organic fertilizer and above 100 kg inorganic fertilizer per timad. This is another reason which has made this area be chosen for the study to identify constraints of soil fertility enhancing technology adoption. However, there is a dearth of information on the determinants of low adoption of this specific technology, involved as well as the effect on household incomes and the usage and adoption of those technologies are below the recommendation. To fill this gap, this paper was intendng to evaluate which factors affect the adoption of soil fertility management technology and the impact of soil fertility enhancing management technologies on households€ agricultural income in Dega Damot district.

1.3 Objective of the study

The objective of this study is to examine the determinants of soil fertility management technologies and their impact on households€ agricultural income in Dega Damot district. The qualitative and qualitative research design was employ for this study. For the attainment of objectives key informants€ interview, document analysis and observation was used as a source of information as described hereafter.

1.3.1 General objective

The main objective of the study was to examine factors affecting the decision to adopt soil fertility enhancing practices and its impact on household€s agricultural income in Dega Damot district.

1.3.2 Specific objective

ðØ To identify the factors that affect farmers€ decision to adopt soil fertility enhancing technologies

ðØ To evaluate the impact of soil fertility management practices on households€ farm income

ðØ To identify soil fertility management technologies used by households€.

1.4 Research question

The main research questions set to be addressed by this study are;

- What are soil fertility technologies used by farmers in Dega Damot district?
- What are the factors that affect farmers' decision to adopt of soil fertility management technologies in Dega Damot district?
- To what extent soil fertility management technologies adoption improve households' crop income in Dega Damot?

1.5 Significance of the study

Farmers are not always adopting the newly introduced technologies that come to them from any extension organization as it is. So understanding these factors is important for scientists to develop and generate agricultural technologies, which suit the current conditions of farmers. There are several reasons to advance in studying the adoption of soil fertility management technologies. These contain improving the effectiveness of technology generation, to assess the effectiveness of technology transfer, understanding the role of policy in the adoption of new agricultural technology, and signifying the impact of investing in technology generation. The participation of farmers in technology development through the provision of their preference and incorporation of local idea was very limited otherwise existent. Therefore, the study tried to identify important factors which hinder success in the adoption and its impact on agricultural income.

1.6 Scope of the Study

The study was assessed to identify the key determinants of farmer's decisions on the adoption of soil fertility enhancing management technologies (i.e., compost, manure and chemical fertilizers) and its impact on households' agricultural income in the rural area of Dega Damot district.

1.8 Limitation of the study

The researcher had encountered the following limitations:

- The absence of the previous research on related problem on study area.
- The study was faced time and financial constraints.

1.8 Structure of the paper

This study is organized into five chapters. Chapter one is introduction and it comprises the background, statement of the problem, research objectives, research questions, significance, scope, limitation and organization of the study; chapter two about review of related literature. Chapter three tries to introduce description of the area and research methods which discusses location, demographic and socio-economic profile of the study area; research design and approach; types and sources of data; sampling techniques and data collection tools; and techniques of data collection. Chapter four contain with result and discussion. Chapter five consist conclusion and recommendation.

CHAPTER TWO

Theoretical literature Review

2.1 Definition and concepts soil fertility management practice

In this study the researcher reviews different existing researches which are done on the adoption of soil fertility management practices and theories that have been used to know this behavior. While several studies have been conducted to explain why farmers (dis)adopt new practices, there seems to be growing concern suggesting that focus should be tailored towards local contexts that reflective of potential adopters. We review this literature focusing on farmers€ local context regarding their local knowledge; practice characteristics; farm and farmer characteristics and the institutional factors that influence farmer adoption behavior.

Farmers have developed traditional approaches to enhancing soil fertility and conservation such as: the use of organic manure (mainly from livestock and compost); fallowing; mulching;and intercropping (Bwambale, 2015) making their knowledge in soil fertility management a subject of interest. Although practices such as fallowing can no longer be extensively used in many areas due to the competing land use demands as caused by increased industrial growth and population pressures, a combination of manure application, mulching and intercropping with science-based approaches to soil fertility management remains plausible.

Various studies have been conducted to understand factors that motivate farmers to adopt improved soil fertility management practices (Baum-Getz, 2008; Pulido, 2014). In addition, theoretical frameworks have been used to understand and explain the adoption behavior of farmers including the diffusion of innovations (Rogers, 2003), planned behavior and reasoned action (Fishbein, 2010). However, in spite of all these studies and theoretical frameworks used, there remains a lack of consensus on which elements could be the primary drivers of adoption. Besides, efforts to relate farmers€ attitudes and behavior to personal, contextual and farm attributes have largely failed.

Therefore, the study argue that farmer decision-making to adopt new soil fertility management practices is a complex process contingent on multiple factors: biophysical, economic, social and psychological. These can only be understood by using a holistic approach that integrates farmer characteristics, farm attributes, contextual factors and farmer perceptions about the specific practices that they consider adopting.

2.1.1 Definition and concepts of technology adoption

Technology defined as the knowledge that permits some tasks to be accomplished more simply, some service to be rendered or the manufacture of a product. Technology, therefore, is aimed at improving a given situation or changing the status quo to a more desirable level. It assists the applicant to do work easier than he would have in the absence of technology (Bonabana-Wabbi, 2002).

(Bonabana-Wabbi, 2002), defines adoption of technology as the decision to accept that technology i.e. the decision of an end-user to accept an introduced or existing technology. Adoption of an agricultural technology according to (Bonabana-Wabbi, 2002) has two dimensions, thus: adoption intensity and the rate of adoption. Adoption intensity deals with the level of adoption whiles the rate of adoption deals with the number of adopters over a given period. The rate of adoption is the relative speed with which farmers adopt a technology. The technology could be an entirely new idea or an already existing one (Bonabana-Wabbi, 2002).

The concept of technology adoption could be better conceptualized through understanding the difference between technology adoption and diffusion, which are highly interrelated but distinct concepts. Agricultural technology is a specific mechanism intended to facilitate production in agricultural activity. Technology adoption is an action designed to improve pre-existing means of agricultural production. For that reason, agricultural technology is one of the resources in agricultural production. Technology adoption is measured at one point in time while technology diffusion is the spread of new technology across the population over time.

Technology is described as an idea, practice, or object that is perceived as new by an individual or groups of society. Technology adoption is the use or non-use of a new or improved technology by an individual or farmer at a given period (Bonabana-Wabbi, 2002). Additionaly, technology distribution is defined as the process by which a technology is communicated throughout certain channels over time between the members of social systems. It signifies a group of phenomena, which suggests how technology spreads among users. It takes place at the individual level and is the mental process that starts when an individual first hears about the technology and ends with its final adoption or rejection (Biru, 2016)

If the objective of the farming community is to increase agricultural production, it is clear that adoption of agricultural technology is the key instrument instead of simple expansion of agricultural land which might be hazardous to environmental conservation. In support of this, several studies shown that sufficient agricultural technologies are available in developing countries to increase agricultural productivity. Although literature points out to the existence of sufficient agricultural technologies in Sub-Saharan Africa to increase food production, an appropriate policy environment coupled with an active technology transfer program has been lacking (Biru, 2016) To improve this, several studies have been conducted suggesting the importance of agricultural technologies for better agricultural productivity.

2.1.2 Components of technology adoption and Sustainable agriculture

According to Tagel (2018) the definition of technology diffusion summarized by using the following four core elements: The technology that represents the new idea, practice, or object being defused, Communication channels which represent the way information about the new technology flows from change agents suppliers (extension, techmology suppliers) to final users or farmer, The time period over which a social system adopts a technology and the social system. Over all, the technology diffusion process essentially encompasses the adoption process of several individuals or farmers over time. Further, another study by (Tagel, 2018) defined the rate of adoption (speed of adoption) of a given technology. It is the relative speed with which farmers adopt technology; in this definition consideration is given to the element of time in the adoption of a given technology to the farmers.

Sustainable agriculture is an agricultural system involving mixture of sustainable production practices in combination with the discontinuation and the reduced use of production practices which are potentially harmful to the environment (Bhekani, 2020). This idea is concerned with developing agricultural technologies which do not adversely influence the environment, effective and easily accessible to farmers and results in the improvement of food production and has positive effects on the environment (Bhekani, 2020). Sustainable production systems must be developed to meet current food requirements and also preserve the important natural resource base that will ensure that future production is not hazardous and hence, meets future generation€s food demands (Porter, 2011). This generally means that the current generation can meet their needs without compromising the ability of future generations to meet their own needs as well. As noted by Francis and Porter, (2011); sustainability implies that maintaining economic productivity whilst being concerned with natural foundation, social implications, and impacts of farming activity. Thus, this involves developing production systems that are resilient and hence, can continue for the indefinite future.

2.1.3 The use of soil fertility management and its impact on farm income

Fertilizers are inorganic or organic plant food that may be liquid or solid used to amend the soil to improve the quality and/or quantity of crops produced. They are materials that are added to the soil to supply elements needed for plant growth (robert, 2013). They raise soil fertility thus the ability of the soil to provide plant nutrients and resources that support growth by increasing plant nutrients during the cycle of growth and decay. They can also reduce the cost of production since they can raise yield with marginal increases in total cost per hectare (Robert, 2013).

There are two broad groups of fertilizers: 1) organic fertilizers, and 2) inorganic fertilizers. Inorganic fertilizers are from inorganic sources whiles organic fertilizers are mainly from natural organic sources or manufactured using mainly organic materials (Alimi, 2006). The term ƒorganic„ means carbonaceous material or material containing carbon. Fertilizer is defined as any material, organic or inorganic, natural or synthetic, that supplies plants with the necessary nutrients for plant growth and optimum yield (Bhekani, 2020). The use of fertilizer has a significant contribution to enhancing agricultural productivity. Consequently, the demand for fertilizers all over the world continues to grow higher and without fertilizer use, farmers will only be able to produce half of the required staple food crops and as a result, there will not be enough food to feed the growing world population which is anticipated to be more than double by the year 2030 (Robert, 2009). Agricultural productivity can be achieved by producing more per unit of land with agricultural inputs or via expansion of area under cultivation (Hailu, 2014). However, land expansion is less possible given issues involving urbanization, poor infrastructure and technology, environmental concerns, political issues, and increased population pressure and hence, agricultural output increment is expected to emanate from producing more from the less available land through agricultural intensification (Bhekani, 2020).

Agricultural intensification is defined as increased average inputs of labor or capital on a smallholding, either cultivated land alone or on cultivated and grazing land, to increasing the value of output per hectare (Bhekani, 2020). Therefore, agricultural intensification can be defined as an increment in agricultural production per unit of inputs (for example, land, labor, fertilizer, etc.). Practically, intensification is achieved when the total production is increased because of enhanced productivity of inputs or when agricultural production is sustained while other inputs are reduced (FAO, 2004). Agricultural intensification can be achieved through either of the following: a) increased gross output in fixed proportions as a result of a proportional increase of inputs, b) transmission towards more valuable inputs c) technical improvement which enhances land productivity (Carswell, 1997).

According to Alimi (2006), agricultural intensification is a critical way of ensuring sufficient production in smallholder farming. Even though agricultural intensification can be viewed as a tool for simultaneously alleviating poverty and food security, it is also believed to pose severe threats to the environment through natural resource degradation, and hence, agricultural intensification can be viewed as both an opportunity and a threat to the environment (Alimi, 2006).

Even if there are no external inputs apply to repair nutrients consumed by crops and washed away by soil erosion, plots of land require to be rested or left unploughed for longer periods. However, due to increasing demands for food in Africa, this has become more difficult (Bhekani, 2020). As a result, this necessitates the application of mineral fertilization as one of the important inputs in crop production to enhance crop yield and soil fertility. The mineral fertilization process involves the use of manures and inorganic or mineral fertilizers which supplement plant nutrients to soils characterized by low or poor fertility and it began about the year 1880, became practiced commonly in the 1920s and it was adopted largely since 1950 (Roy, 2006).

2.1.4 Implications of using inorganic fertilizer

Inorganic fertilizers are usually processed and produced from mineral deposits (e.g. lime, potash or phosphate rock) or industrially prepared through chemical processes (e.g. urea), (Hussain & Gupta, 2014). Inorganic fertilizers are also known as mineral or chemical fertilizers, and they have relatively high nutrients that are released quickly for plant uptake as compared to organic fertilizers which require time for decomposition before they are consumed by the crop plant (Morris e. a., 2007). Examples of inorganic fertilizers commonly used are straight fertilizers made up of a single nutrient, mostly nitrogen (N), phosphorus (P) or potassium (K) and compound or mixed fertilizers including one or more macronutrients or some traces of zinc and boron elements (Morris e. a., 2007). Inorganic fertilizers require to be applied at least two times within the growing season, either basally during planting or top-dressed at the vegetative growth stage and they are usually available to crops immediately for consumption), (Husain & Gupta, 2014). However, chemical fertilizers are also notorious for their high cost and the negative effect they impose on the environment after some time which often involves the damage of soil structure and texture which consequently leads to soil erosion and nutrient leaching (Morris et al, 2007). Hence, the use of inorganic fertilizer in smallholder farms is low due to poor purchasing power (Husain & Gupta, 2014).

2.1.5 Implications of using organic fertilizer

Organic matter encourages the formation of crumb soil structure thus improving soil drainage, infiltration and aeration. The dark colors€ that form with increasing organic matter content improve soil temperature relations with an effect of boosting important microbial activities and root development. Organic fertilizers include manure and compost. Manure is mainly from farm animals and other livestock. They are the droppings of poultry, ruminants and other animals that are rich in nutrients (Bary, 2004).

Organic materials are decomposed in composting plants under controlled conditions to produce the end product which is used as a fertilizer. Compost can also dissolved into a solution, called compost tea and given to crops. The quality of the compost will depend on the quality of materials used in the process. Compost can be obtained from the market or self-produced by farmers. There are available manuals that farmers can use to make their compost. Composts are quite common and easy to obtain (Bary, 2004).

According to Bary (2004), uncomposted manure is sometimes difficult to spread and has a higher potential to degrade water quality than compost. Manure is more likely to contain weed seeds but requires a lower investment of time and money, manure has the potential for higher pathogen levels but less expensive to purchase or acquire compared to compost, odors€ sometimes pose a problem. Both compost and uncomposted manure improve the tilth of the soil.

Organic fertilizers mainly constitute animal manure, compost, animal waste; crop residues, green manure etc, and they supply nutrients and also add soil quality by enhancing the soil structure, chemistry and biological activity in the soil. Consequently, small-scale farmers who are concerned with ensuring environmental sustainability, use organic fertilizers for sustaining the health of their crops as well (Husain & (Gupta, 2014) (Bhekani, 2020). Organic manure is applied to crops through the following methods: broadcasting, banding, and spot application and consistent application of organic fertilizers improve soil organic matter, reduce soil erosion, and improve soil water holding capacity, increase soil biological activity (Husain

& (Gupta, 2014) Thus, Organic fertilizers enhance long-term productivity and soil biodiversity and thus, environmental sustainability.

Organic fertilizer adoption positively influences agricultural productivity, and those farmers who choose to adopt organic fertilizer obtain higher yields which indirectly result in increased household incomes (Hailu, 2014).

2.1.6 Factors affecting technology adoption

From the extensive review of the literature on technology adoption in developing countries, by (Tagel, 2018) the various factors that influence technology adoption can be grouped into the following three broad categories: factors related to the characteristics of producers; factors related to the characteristics and relative performance of the technology and institutional factors.

The factors related to the characteristics of producers include: education level, experience in the activity, age, sex, household size, level of wealth, farm size, labor availability, risk aversion and capacity to bear risk, etc. The factors related to the characteristics and performance of the technology include food and economic functions of the product, the perception by individuals of the characteristics, complexity and performance of the innovation or technology, its availability and that of complementary inputs, the relative profitability of its adoption compared to substitute technologies, the period of recovery of investment, the susceptibility of the technology to environmental hazards, etc.

Similarly, a study by (Tagel, 2018) identified assets, vulnerability, and institutions as the main factors affecting technology adoption. Assets deal with whether farmers have the requisite physical (material) and abstract possessions (e.g. Education) essential for technology adoption. Lack of assets will limit technology adoption and it is recommended that developing countries should promote technologies with low asset requirements as they are likely to have higher adoption rates among poor farmers. Openness factors deal with the impact of technologies on the level of exposure of farmers to economic, biophysical and social risks. Institutions comprise all the services to agricultural development, such as finance, insurance facilities and mechanisms that enhance farmers access to productive inputs, prod informationspreading, embedded norms, behaviors and practices in society.

According to (Tesfaye, 2008) the S-shaped curve implies that few farmers initially adopt new technologies. However, as time goes, an increasing number of adopters appear. In the end, the trajectory of the diffusion curve slows and begins to level off attaining its apex. Has also a similar idea but he underlined the importance of information. He noted that because of fear of risks associated with the introduction of new technologies, at early stages, few adopters acquire full information (Tesfaye, 2008) Hypothesized that the S-shaped diffusion curve is a meaning of the extent of economic value of the original technology, the amount of investment required to adopt the new technology and the level of ambiguity associated with the new technology (Tesfaye, 2008)

2.1.7 Importance of Agricultural Technology

Agricultural technology is an action designed to improve existing means of agricultural production. Therefore, agricultural technology is one of the resources in agricultural production (Chi and Yamada, 2002). The aim of technological change is to maximize output by increasing agricultural production in order to meet the high food demand. Adoption of new agricultural technology has long been recognized as one of the key factors in increasing productivity in the agricultural sector and therefore farm productivity will tend to remain low for as long as farmers continue to use low yielding-inputs and technology. Adoption of innovations refers to the decision to apply innovation and use it (Oladele 2005). On the other hand, the intensity of adoption refers to the number of technologies practiced or the extent of adopting a specific technology by the same farmer. The extent of adoption is determined by the farmers knowledge on a new technology and the decision (Igido, 2012). The objective of the farming community is to increase agricultural production, it is clear that the adoption of agricultural technology is the key instrument for the improvement agricultural productivity.

In shore up of this, several studies have shown that sufficient agricultural technologies are available in developing countries to increase agricultural productivity. Although literature points out the existence of sufficient agricultural technologies in Sub-Saharan Africa to increase food production, an appropriate policy environment coupled with an active technology transfer program has been lacking (Makokha et al., 2001, as cited in Biru Gelgodube in 2008). To improve this, several studies have been conducted suggesting the importance of agricultural technologies for better agricultural productivity.

According to Uaiene et al. (2009), the issue of improving agricultural productivity can be addressed by the adoption of better agricultural technologies. They argued that unless new technologies are adopted, an increase in production will be slow posing rural poverty to remain widespread. Due to this, in most parts of Ethiopia, intensification of agricultural technologies continues to be necessary to enhance agricultural productivity. To ensure this sustainability, it was important to address core problems related to the availability of agricultural technologies for farmers. This helps to ensure that smallholders have access to the right technologies in the form that is appropriate to their local conditions accompanied with the right information (IFDC, 2012). In Ethiopia farmers have little chance to adopt new agricultural technologies on their farms due to several constraints such as low human capital primarily low level of farmers’ education (Spielman et al., 2010).

2.1.8 Factors influencing the choice of soil fertility enhancing technology

The adoption of soil-fertility enhancing technology has been linked to several factors. These are broadly categorized into economic factors and non-economic factors. Economic factors mainly focus on price, costs and/or returns to factors of production while noneconomic factors include social, cultural, community, institutional and political factors. Few variables consistently explain why farmers adopt (dorthy, 2017). Some variables explain adoption in specific studies. These include concern for environmental threats, the soil erosion rate and income. Others, such as the level of education and steepness of the slope, are frequently found to influence adoption. Some variables, such as farmer age and farm size, are positively correlated with adoption in some studies but negatively correlated in others.

2.1.8.1 Economic factors

Economic factors that influence fertilizer use among others includes the price of fertilizer, price of other inputs that complement (for example, seed) or substitute fertilizer use, price of crop, revenue and opportunity costs related with production and marketing risk. The empirical literature suggests that fertilizer use is sensitive to changes in its price as well as the price of crops to which it is applied. In particular, demand for a particular type/brand of fertilizer (e.g. nitrogen) is derived demand, price elastic and influenced by the price of other types/brands of fertilizer (dorthy, 2017). The price and/or availability of other inputs that complement and enhance fertilizer productivity, for example, hybrid seed and irrigation, also play an important role in farmer…s decision to use fertilizer. Similarly, the price and/or availability of other inputs that substitute a variety/brand of fertilizer as well influence its use (dorthy, 2017). The wedge between the high price of fertilizer on the one hand and the low price of output on the other, especially for farmers in SSA is one of the major factors that make them reluctant to use the input. (Morris M. V., 2007) Observe that demand for fertilizer is often weak in Africa because incentives to use fertilizer are undermined by the low level due to high variability of crop yields and the high level of fertilizer costs relative to crop prices. (Smaling, 2006) Indicate for example that farmers in Africa require 6-11 kg of grain to purchase one kg of nitrogenous fertilizer compared with about 2-3 kg of grain in Asia. High fertilizer prices in SSA are mostly attributed to high transaction costs of fertilizer trade arising from high transportation costs, high interest rates and low volume of purchases (Gregory, 2017)

The decision-making process to adopt new agricultural practices depends on both intrinsic factors such as knowledge, perceptions and attitudes and extrinsic factors such as the characteristics of the farmer (age, education, social networks, farming experience), biophysical characteristics (soil quality, farm size, slope), farm management characteristics (land tenure, labor source, wealth) and the external (contextual) factors (information sources and type, market access, etc.) (dorthy, 2017)

2.1.8.2 Non-economic factors

According to (Langyintuo, 2005), non-economic factors Categorize which are influence farmers decisions to use agricultural improved inputs as farmer characteristics, institutional factors and characteristics of the input. Household and institutional characteristics include sex, age, education, household size, farm size, and farmers€ organization, access to information, access to credit, and access to infrastructures. Characteristics of the factor input relate to the subjective attributes of the input as perceived by the farmer (dorthy, 2017).

Gender of household plays an important role in farmers€ decision on the adoption of soil fertility management technologies. A recent study by (Nayenga, 2008) indicate that use of agricultural inputs including inorganic fertilizer in Uganda, is more prevalent in male than female headed households.

2.1.9 Soil fertility management technology practices

Soil conservation measures have been promoted by researchers and extension agencies in Ethiopia (W/Mariam, 2005). However, technologies have not been practiced by all farmers in different parts of the country with variety of reasons including lack of awareness on the application of technologies, lack of tools or material to practice them (Shibru, 2010). This is true in the study area, during the time of field survey sample households were asked various soil fertility maintenance technologies whether they use or not. The most common practices and the constraints on their implementation are outlined below.

Fallowing: The traditional method of restoring soil productivity is fallowing, or mistigao. According to (Shiferaw, 2010) Farmers said that yields on irrigated land decline if they continuously grow three crops a year without any fallow period. The decision to leave a field fallow is not a matter for an individual farmer to decide on. It is agreed by a group of farmers, who select a site where they want to create a uniform piece of grazing land for the village herds. Fallowing thus also has an important function in the livestock production system. The timespan of fallow period is varied according to the nature of soil. Reguid soils were commonly left fallow for one year, while rekik soils were left for two to three years (Shiferaw, 2010).

Crop rotation: As fallowing, crop rotation is no longer possible they now rotate crops on the fields away from their homesteads, which obtain very little manure. Farmers choose which crops to growing rotation according to how they adapt to the soil and the rainfall pattern. According to (Shiferaw, 2010) the major crop rotations practiced by the farmers we interviewed are, Barley, wheat, barley, Teff, barely/wheat, teff, Teff, vetch, teff, Barley, chickpea, barle.

Most farmers assume that starting the rotation with teff or other cereals and then planting chickpea or vetch improves crop yield more than rotations based solely on cereals. However, crop rotations in the region are dominated by cereals. The choice of crop rotation is mainly influenced by the desire to reduce the need for labor-intensive land preparation or weeding.

Manure: It is practiced in the study area by all local farmers in three selected kebeles. Farmers explain that animal manure is the best form of organic matter when added to the soil. It improves or sustains soil fertility, texture and structure and increases water holding capacity (W/Mariam, 2005). Even those farmers have not livestock they collect dung from communal grazing land and use it on their farm land to increase their land fertility and productivity. However, discussion with key informants revealed that the application of manure on all plots is impossible because of the lack of fodder for animals and decreasing livestock number. Therefore, the production dung is very low. In addition, the majority of the local community uses animal dung for domestic energy.

Livestock has various functions in the production system. Oxen are essential and indispensable for preparing land and threshing grain, and farmers keep cows, sheep and goats as a source of stable income. Poultry provide food and cash, and donkeys are used for transport. The existing livestock management system does not include practices for improving the quality of manure or. Manure is an important input for maintaining and enhancing soil fertility. Farmers distinguish between two types of manure; zikereme dukie or husse and zeykereme dukie or aleba (Shiferaw, 2010). The first type of manure is gathered and allowed to decompose during the rainy season.

The Aleba manure is collected during the dry season and it does not decompose as much as the other type of manure. It has less direct effect on crop yields.

Compost: It is an excellent soil fertility building technology which supplies a wide variety of plant nutrients. It also creates a favorable environment for soil-micro organisms (W/Mariam, 2005). Even though all respondents knowledgeable of this introduced technology as it maintain soil fertility, all farmers did not implement it in their farm field. According to Alelgn (2011), farmers prepare it from livestock dung, plant leaves, various weeds, household waste produces, straw, top soil, water and other organic materials that available in their surroundings. Farmers describe the reasons why all farmers apply it. These are lack of awareness and labor force about preparation system it is a cause of the disease (locally which ena gunifan) since it has high evaporation and bad odor (labote ena kirifat) during its preparation time and compost preparation is taking a long period a minimum three months until it fermented. Compost is prepared above the ground (heap) during the wet season and below the ground (pit) during the dry season (Shelemew, 2005) and (Alelgn, 2011).

2.1.10 Overview of soil degradation in Ethiopia

Ethiopia is one of the least developed countries where agriculture had always played a central role in the country's economy. Even though agriculture has always been the basis of the economy, it is characterized by a stagnant growth rate and a declining trend. This is mainly the result of the low productivity of the sector. The rapidly increasing population has led to a declining availability of cultivable land and a very high rate of soil erosion (Amayehu assefa, 2007). The farmers' perception is not in agreement with scientific knowledge that acknowledges livestock with above carrying capacity of grazing areas and deforestation as major causes of soil erosion. It is also important to discuss various factors causing a difference in perception about causes of soil erosion among local people as this will most likely lead to solving or arresting problems considered not critical with most of the rural community. Education is one factor that appears to influence on local people's perception of the causes of soil erosion. Soil erosion is a major cause of land degradation in Ethiopia (Fikiru, 2009; Fitsum et al., 2002). Soil erosion reduces soil productivity mainly by harmfully affecting soil nutrients, infiltration of water and air into the soil, soil water holding capacity, soil tilts and the surface arrangement of the soil. The amount to which soil losses affects its productivity depends on many factors, among which the most important are the land use type, management and the capacity of remaining soil to support plant growth. Despite variations in such factors, soil erosion generally removes the more fertile portions of the soil as result of the productive capacity of the remaining soil is usually lower than it was before erosion (Abegn, 2011).

To gain further insight in farmers€ knowledge of land productivity and how it was affected by erosion, farmers were interrogated on what criteria they used to determine Good soils. Discussion with key informants proved that farmers in the study area divided their land into several plots for various purposes. Farmers classify fields based on certain critical criteria. In this study only soil fertility enhancement criteria were considered specifically level of soil fertility and crop income. In the study area most field holdings tended to strict (W/Mariam, 2005) in from the very steep hill slope to Gentle slope segments. Therefore farmers were in a position to express their perceptions for each slope position (Ishibiru, 2010). The degradation and loss of soil resulting from soil erosion all over the country was estimated to be about 2 billion tons per year (EHRS, 1986), of which around 45 percent occurs on crop farmlands and 21 percent occurs on overgrazed rangelands (Ishibiru, 2010).

2.1.11 Soil fertility and crop productivity

Soil fertility is a complicated quality of soils that is closest to plant nutrient management. Soil fertility is the component of overall soil productivity that deals with its available nutrient status, and its ability to give nutrients out of its own reserves and through external applications for crop production. It combine a number of soil properties (biological, chemical and physical), all of which affect directly or indirectly nutrient dynamics and accessibility. Soil fertility is a controllable soil property and its management has greatest importance to optimizing crop nutrition on both short-term and long-term source to accomplish sustainable agricultural productivity. Soil productivity is the ability of a soil to support crop production determined by the entire range of its physical, chemical and biological attributes. Soil fertility is only aspect of soil productivity but it is a very important one to increase households€ farm income. For example, a soil may be very fertile, but produce only little vegetation because of a lack of water or unfavorable temperature of a season. Even under appropriate climate conditions, soils vary in their capacity to create a suitable atmosphere for plant roots. For the farmer, the decisive property of soils is their chemical fertility and physical condition, which determines their potential to produce crops. Good natural or improved soil fertility is essential effective agricultural productivity. It is the foundation on which all input-based high-production system can be building. Soil scientists classify soils by different classification systems. In earlier times, the classifications at national level were be based on easily familiar features and relevant soil properties for cropping. Soil-type names were generally well understood by households. Even on a higher classification level, the partition into zonal soils (mainly formed by climate), intra-zonal soils (mainly formed by close relative material or water) and azonal soils (young alluvial soils) was easy to know. Modern and global-scale classification systems are based on developmental aspects and resulting special soil properties. A common one is the system of soil types developed by FAO and the United Nations Educational and Scientific Cooperation Organization (UNESCO) used for the World Soil

2.1.12 Conceptual framework of adoption of agricultural technologies

The adoption of agricultural technologies is influenced by several interrelated components within the decision environment in which farmers operate. For instance, (Kebebe, 2015) identified lack of credit, limited access to information, inadequate farm size, insufficient human capital, tenure arrangements, absence of adequate farm equipment, chaotic supply of complementary inputs and inappropriate transportation infrastructure as key constraints to the rapid adoption of innovations in less developed countries. Farmers with a bigger land holding size are assumed to have the ability to purchase improved technologies and the capacity to bear the risk if the technology fails. Some new technologies are relatively labor-saving and others are labor-using. For those labor using technologies, like improved varieties of seeds compost, manure and fertilizer labor availability plays a significant role in adoption (Kebebe, 2015)

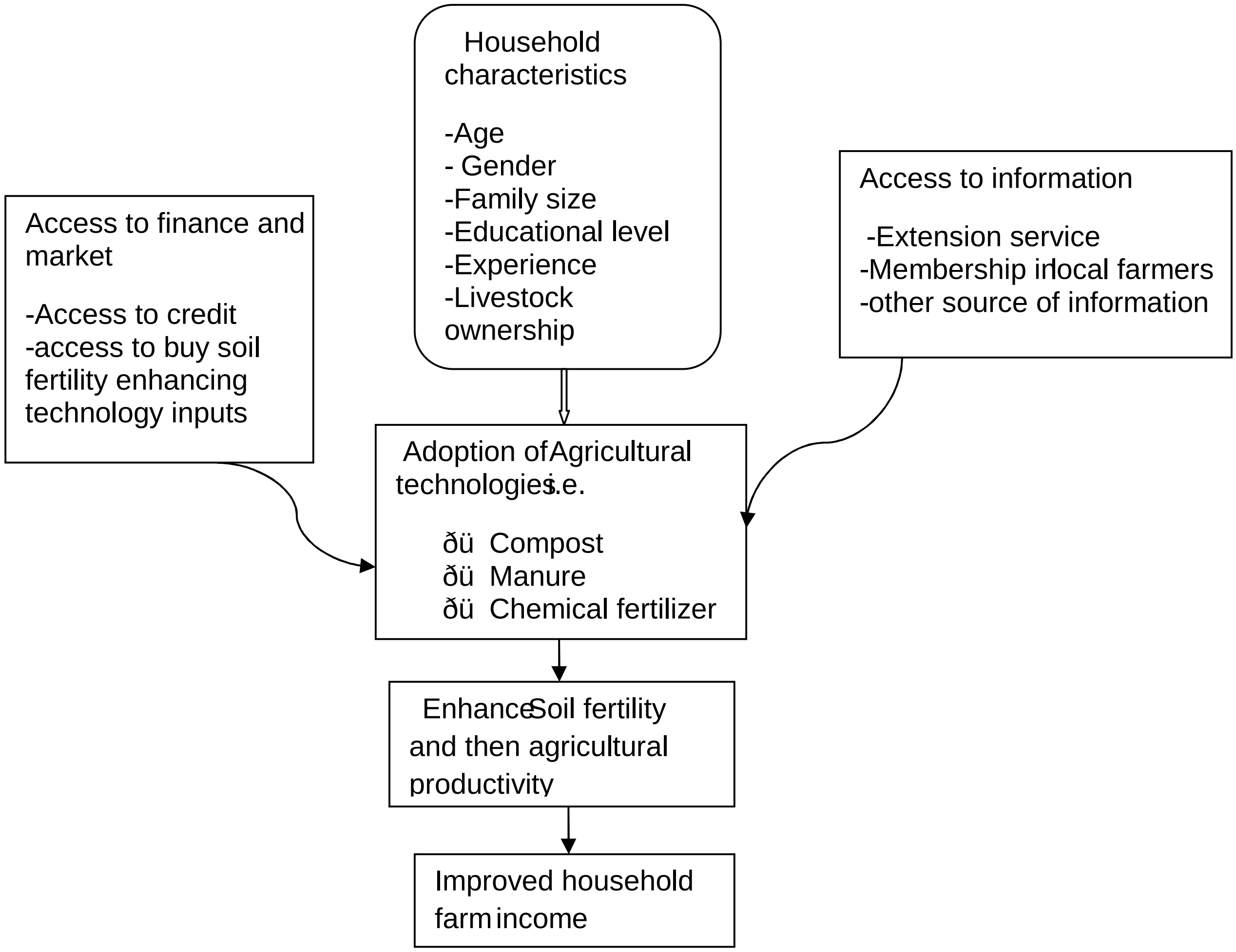


Figure 3. 1 conceptual framework of the study adapted from (Tagel.2018) and (Kebebe.2015)

2.2 Empirical literature review

2.2.1 Soil fertility management technology practice

Soil fertility is declining in many parts of sub-Saharan Africa (SSA) (Mitiku, 2010). One of the major constraints to crop production faced by smallholder subsistence farmer is the inadequate supply of nutrients (Mitiku, 2010). The use of mineral fertilizers is declining as they are increasingly beyond the means of most small-scale farmers (Mitiku, 2010). Erosion and severe run-off are extra depleting existing soil nutrient reserves, while levels of soil organic matter is declining when, land is subject to over use. Sustaining soil fertility has become a major issue for agricultural research and development in Ethiopia (Mitiku, 2010). In the past, most research consisted of trials to determine the appropriate amount and type of fertilizer needed to obtain the best yields for particular soil types and specific agro-ecological locations. Since then, research has gradually shifted towards an approach based on Soil Fertility Management (SFM), which combines various existing soil fertility management techniques. This approach is based on a thorough scientific understanding of the underlying biological processes of SFM and aims to promote options that make the best use of locally available inputs.

2.2.2 Agricultural income measurement

Agricultural income is a measure of the efficiency with which inputs are used in agriculture to produce an optimal output (EEA 2002, Ruttan 2002). Crop income is said to be optimal when the combination of inputs produces a maximum output. Its measurement is an important tool for planning and development decisions (endalew, 2011). Increased production is important if it is a result of improved productivity. The most conventional measure of productivity is to divide total output by a composite index of all inputs used in the production process (EEA 2002, Daya Ruttan 2002, cited in (endalew, 2011). However, it is difficult to aggregate variety of outputs and inputs into a single index to measure productivity. This approach also overstates or understates the productivity of inputs when input ratios change without a technology change (Gebreeyesus 2006, cited as (endalew, 2011)

2.2.3 Factors affecting farmer€s knowledge and perceptions on soil fertility management technologies in Ethiopia

There are different literatures in Ethiopia about determinants of farmers€ adoption of soil fertility management technology in different parts of the country written by different research organizations. As different literature reveals that, there are different factors that affect farmers€ soil fertility management technology adoption decision Some of the factors that affect farmers€ decision on soil fertility management technology practice are explained bellow.

Awareness about the soil fertility enhancing technology adoption is often influenced by farmers€ access to information (Baumgart-Getz, et al. 2012; Lambrecht, Vanlauwe, Merckx, &Maertens, 2014; Prokopy, et al. 2008) and social networks within which the farmers interact (Greiner, et al., 2009; Knowler & Bradshaw, 2007; Pannell, et al., 2006). Access to information increases farmers€ awareness (Lambrecht, Vanlauwe, Merckx, et al. 2014) and evaluative capacity of existing soil management practices (Prokopy et al. 2008, cited as (Naboth, 2015). This in turn influences farmers€ views about the practices (perceptions) based on their felt needs and prior experience. Besides technology attributes, studies suggest that farmers€ perceptions towards adoption of soil fertility management practices are strongly linked to their experiences and knowledge about the practices in question (Meijer, et al. 2015; Reimer, et al. 2012). For instance, (Meijer, et al. 2015) argue that the knowledge farmers have about a new practice closely relates to their perceptions towards such a practice which together frame the farmers€ attitude as whether to adopt the practice or not.

Farmers€ perception about the performance of agricultural technologies significantly influences the decision to adopt them (Mwangi M. a., 2015). Farmers might identify that the performance of the technology being introduced is better than the earlier technologies. However, though they have a positive perception about the specific technology, they may not adopt it because of a lack of know-how to use the technology, financial shortage or other constraints. Thus, positive perception is not a guarantee for a farmer to adopt a given technology. The results of a study conducted in shashemeni on adoption of agricultural technology showed that a farmer with low plot fertility has a positive perception toward adoption of farm technology. This might be due to farmers€ expectation of better returns from the adoption of this technology. However, in Ethiopia, specifically in Dega Damot woreda, though the plots of some farmers are not fertile they have never adopted soil fertility enhancing technology.

In all these studies there is a consensus that farmers€ perceptions towards technology attributes influence their adoption behavior of those technologies. Farmers€ perceived characteristics of the conservation practices were a powerful prediction of adoption within two watersheds in the United States Midwest region (Naboth, 2015).

Livestock: The results of a study conducted in shashemeni on adoption of agricultural technology showed that increase the availability of manure, which may be applied to the soil to increase soil fertility. However, specialization on livestock rather than cropping may reduce investment in crops in terms of soil management (Ememtetu, 2011). In different studies livestock, ownership was assumed to increase the availability of manure and Hypothesized that ownership of cattle increases the likelihood of adoption of manure and its integration with inorganic fertilizers. Income from off-farm labor (Off-incomes) may compensate for missing and imperfect credit markets by providing ready cash for input purchases as well as for other household needs thus increasing the probability of adoption. In addition, off-farm income may increase the ability of households to bear the risk associated with technology adoption.

The major constraint to the adoption of organic fertilizer was found to be low livestock holding. This was reported by about 26.58 percent of the manure fertilizer non-adopters. They reported that they do not own enough livestock which may provide them manure. This shows the importance of livestock holding in organic fertilizer adoption where the low livestock ownership could be the cause of the low adoption rate of organic fertilizer.

Lack of adequate labor was the second constraint to the adoption of organic fertilizer. Organic fertilizer adoption is relatively labor-intensive requiring more labor both for its preparation and application on the farm compared to chemical fertilizer. Thus, lack of adequate labor for its preparation could decrease its adoption rate.

Inadequate knowledge related to organic fertilizer adoption in terms of compost preparation was another constraint to the adoption of organic fertilizer. This was reported by about 69.68 percent of the non-adopter households. (Biru, 2016) noted that the preparation of organic fertilizer is knowledge-intensive. This implies that low skills related to the adoption of organic fertilizer could limit adoption of organic fertilizer as farmers may face difficulty in preparing this fertilizer, specially, composting which has been commonly used in the study area. High transaction costs associated with the adoption of organic fertilizer were also one of the reasons reported as constraints of organic fertilizer adoption. This was primarily for those farmers who lack livestock and tend to find this fertilizer from other sources. For such farmers, high transaction costs coupled with their low capacity to provide finance could limit the adoption of this fertilizer.

Education: of the farmer is considered to positively influence the farmer's likelihood of adopting a new technology or practice because farmers with better education have more exposure to new ideas and information, and thus have better knowledge to effectively analyze and use available information (Naboth, 2015). While most studies consider education in terms of several years of formal education, the categorization of education by (Baumgart-Getz et al. 2012) seems more appropriate. In contrast to formal education, it reflects knowledge farmers attain through other means such as extension programs, workshops, and field days. Meijer et al. (2015) consider farmers€ perceptions as their views of a given technology in terms of their felt needs and prior experiences. In relation to land degradation, Pulido and Bocco (2014) define farmers€ perceptions as the causes and status of land degradation as detected and expressed by farmers on their lands.

The decision of farmers to adopt soil conservation practices begins with their perception of erosion as a problem. These perceptions are shaped by farmers€ personal characteristics (e.g., age, education, conservation attitude, norms beliefs) and the physical characteristics of the land (e.g. slope). Most of the studies have evaluated the household heads€ education level as the main determinant of soil fertility management technology adoption. However, even though the household head is not educated, if the education level of any of family member is higher than that of the household head, this may affect their decision to adopt new technology (Alelign, 2011). Thus, there is a need to evaluate technology adoption based on the highest level of education of any of the household€s family members. In contrast, (Bisu, 2016) stated that providing a platform for regular interaction of agricultural experts with farmers could enable farmers to adopt new technologies to boost their production. He explained that this is valuable as it helps in gaining insights and sharing experiences amongst farmers and experts.

Farmers€ personal characteristics such as age and education also play a critical role in framing their perceptions towards adoption. Although this aspect of perceptions towards technology adoption has been widely studied, there is a dearth of literature about the influence of farmer perceptions towards adoption of soil fertility practices, thus warranting further investigation (Tsehaye T. , 2008)

Most researchers believe a priori that education of the household head is positively related to technology adoption. Many studies report that education has a positive impact in the adoption of improved natural resource conservation technologies (Alelegn, 2011). Education was measured as years of formal schooling of the household head. Because the surveyed technologies are knowledge-intensive, higher education is expected to increase the probability of the adoption of soil fertility enhancing technology practices.

Age: Other investigations done by Biru (2016), on farmers€ decision to wards adoption of technology show that age of the household head (Age) in explaining technology adoption is somewhat controversial in the literature. Older people are thought to be reluctant to change their old ways of doing things. The influence of age was analyzed from perspectives of risk aversion rather than time lag (planning horizon) because the technologies under the study yield benefits in the relatively short-term. Therefore, because the use of inorganic fertilizers and combination of inorganic and organic fertilizers is a relatively new phenomenon, the age of the household head is expected to be negatively associated with the adoptions. However, age is expected to be positively correlated with the relatively traditional practices such as manure and compost, which are used to increase soil fertility as a result of agricultural income.

Off-farm income: as Alelgn (2011) suggested that off-farm income is positively associated with the adoption of soil fertility management technology. According to Tagel (2008) off-farm income is a dummy variable that denotes whether or not off farm income was the main source during two crop growing seasons before the 2006 long rain season. Because all the surveyed inputs either require cash for purchase (inorganic fertilizers) or for hiring labor to apply the inputs, it was hypothesized that off-farm income would be positively associated with the adoption of inorganic fertilizers, manure, compost and their combinations.

Most studies agree that labor scarcity (Labor) is often an operative constraint in farming systems. The effect of the labor availability often depends on whether the new technology is labor-saving or labor-using. When facing labor shortages, farmers may be less likely to adopt labor-increasing technologies and the converse would apply to adopt labor-saving technologies (Katz, ET. al. (2003). He states that Kenyan dairy farmers, who face labor shortages, were unlikely to adopt dairy technologies that require more labor. Labor availability was measured as the proportion of household members who contribute to farm work. The practices studied here are labor intensive and high availability of labor whether household or hired labor is hypothesized to increase the probability of the adoption of all the studied SFMT practices.

Extension service: several adoption studies have shown the significance of extension education on the adoption of land-improving technologies (Pattanayak et al. 2003). According to (Bonabona et al, 2006 Information is important for the adoption of complex innovations such as Integrated Pest Management (IPM). Access to extension is indexed as a dummy denoting whether or not the household access to extension services within five years before the study. This variable was hypothesized to be positively associated with the adoption of the relatively …new€ practices such as inorganic fertilizers and a combination of inorganic with organic fertilizer.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the study area

The study area is drained by both temporal and permanent rivers. It is the sources of many rivers and streams. As it is the high land relative to its neighboring District this makes its rivers are outflow into its neighboring Districts. The major permanent rivers are Gimbara, Gumara, Fendika and Kechem. These and other rivers and streams are used for both human domestic and livestock consumption. To some extent rivers and springs are used for irrigation (Alelgn, 2011)

Figure 3. 2 Map of the study area (prepared from Ethio-GIS database)

3.1.1 Soil

As it has been explained by the District rural development experts (2011) well-known type of soil found in the study area include, nitosols (locally known as key shekilama afer) which typically found in highland of the District and the other soil types is camisoles (borebor afer) this kind of soil also by and large found in woina dega and in steep slope areas it is not as much of fertile. The other familiar soil type is vertisoil (locally merery or walika afer) this soil type mostly covered the low land region in the vast kolla agro-climatic zone. This soil property is quick drying and logging by its nature.

3.1.2 Climate

Climate is one of the major physical factor that shape the human way of living, human activities, human settlement pattern and type or species and distribution of animals and plants. The major climatic factors that affect environmental phenomena are rainfall and temperature. As the study area has great area variation topography its climatic zone also different in altitude such that the major agro-climatic zones of the study are 75 percent Dega(Temperate), 20 percent Woina Dega(Sub Tropical) and the remaining 50 percent Kolla(Tropical) (DDDRDO, 2013).

According to natural resource expertise (2011) temperature is decreasing when altitude increase within the District. The maximum temperature is occurring from mid-March to mid-April where as the coldest temperature is on the other hand occurs in July and August because the sky is covered by clouds throughout the day. Dega Damot District has a unimodal form of rainfall distribution. This means that the rainy season ranges from June to September or it has one rainy season in a year. Sometimes it may be extended to October and December. From June to September for the study area is summer (kiremit) season and the main agricultural activities take place during that time. The average maximum annual rainfall occurs in July with the amount of 25.3 mm and the minimum annual rainfall also occurs in February with the amount of 0.13 mm from 2016 to 2020. The rainfall distribution is diverse with in different agro-ecological zone so that Dega part has better rainfall than Woina Dega and in a similar way Woina Dega is also better than Kola region.

Table 3. 1: Average maximum and minimum monthly rainfall distribution of Feres Bet Town from 2016-2020 in mm

Month	Sep	Oct	Nov	Dec	Jan	Feb	Mar	April	May	Jun	July	Aug
Min ava	3.38	0.92	1.08	0.08	1.42	0.13	0.86	0.82	0.72	4.43	11.66	9.51
Max ave	8.83	4.64	3.85	1.42	0.08	1.13	7.09	10.22	10.22	14.4	25.3	14.2

Sources: District municipal office, 2021

3.1.3 Natural Vegetation

The study area has dissimilar agro-ecologic climate and topography there are a variety of vegetations that covered landforms. However, the extent of natural vegetation has been much reducing, due to expansion of agricultural land; overgrazing and cutting of trees for construction and domestic fuel consumption. As a result, land cover change is increasing and natural vegetation is becoming reducing in number and species.

The indigenous natural plants in Dega Damote District include Bamboo (Kerkeha), Scheflera (Getem), Acacia (Girar), Ficusvasfa (worka), Ficus (Sholla), Oliva (woira), Haginia (Kosso), Polystcha (Anfar), Bersama (Azamera), Fobia (Korich), juniprus (Tid), Albniza (Sesa), Mesozoygia (Injori), Rosa Abyssina (kega) and other shrubs and grass vegetation are found in the study area by scattering in different places. Especially, indigenous trees are mostly concentrated in churches and river banks and some trees also are found on farm lands and communal grazing lands. Bamboo forests are the dominant indigenous forest that plays great role for financial sources for the District because it is exported to other cities and regions. Kosso is rare spices among the most endangered spices trees in the study area, which is becoming extinct now form different places. Eucalyptus forests have been the dominant introduce trees for the last three decades because it can adapt almost all agro-ecological zones and by its nature is fast growing and multiplying easily (Animal dung and crop residuals are the major sources of domestic energy next to fuel wood. No other alternative source in all rural kebeles even urban has got electric power since 2011(DDDRDO, 2021).

3.1.4 Land Use Pattern

The land use pattern in Dega Damot District is dividing into several functions. These include: crop land constituted 38.4 percent, uncultivated land also accounts 10.5 percent, Settlement (for housing and institution constriction) share 10.5 percent, forest cover 11.5 percent, bush land also contains 5.9 percent pasture land constitute 18.5 percent and other like road, water and swamp lands cover 2.9 percent. This figure shows crop land share large amount of land area and forest cover is also relatively better than the national forest coverage because countries forest cover accounts from total land only 3 percent.

Table3. 2 Dega Damot land coverage

Land use	Area in hectare	percent
Uncultivated land	6876.4	10.5
Crop land	25262	38.4
For housing	6883.3	10.5
For institution	1093	1.7
Grazing land	12179	18.5
Forest land	7581	11.5
Bush land	3912	5.9
Other like road, Water,swamps land•..	1940	2.9
Total land	65726.7	100

Source: Dega Damot district agriculture office.2021

3.1.5 Population and Settlement Pattern

According to DDDRDO the total population of the District is 101, 236. From this total population 99.95 percent Amhara ethnic group, 99.97 Amharic speakers and 99.95 percent of inhabitants practiced Ethiopian Orthodox Christianity. Among the entire population 98.23% are rural and (1.76 percent) urban dweller. Of the total rural dweller, (49.9 percent) are male and (50.1 percent) are female where as from the total urban 3351 people 1482 (44.23 percent) male and 1869 (55.79 percent) are female. From the above figure it can conclude that the sex ratio is proportionate, meaning the number of male and female almost equal. Total male 49.81 % and female 50.23%. Total household head also 39726 and average house hold size is 6.38. The proportion of urban and rural population proportion has great difference. This indicates that most the populations found in Dega Damot District are rural dwellers. Population settlement in Dega Damot District is scattered and dispersed. The majority of the population is settled in foot hill side by forming small village with a small number of people and the average population density is 27 person per ha.

3.1.6 Economic Activity

Agriculture is merely economic activity except for urban dwellers. Almost all people depend on intensive agricultural activities. Even though the majority of the population depends on this sector, the production level is very low. Due to back ward agricultural activity, low technology, soil erosion, deforestation and alarming population growth. As a result of this the per capita income of the people is very low and decreasing an alarming rate (DDDRDO, 2021).

Agricultural production system in the study area is crop and livestock. These systems are the predominant activities that exist in all over the district (DDDRDO, 2013). Different types of crops are producing in a great extent in the study district but vegetation and fruits are producing in some amount. Some of the dominant crops that are producing include, cereals (wheat, barley, teff, and maize--), pulses (bean, Pea--), and oil seeds (nug, "teliba", Cabage--

3.2 Data types and source

Both primary and secondary data sources were used to get relevant information for the study. The primary data from field observation was collected to answer the research questions which are close-ended and open-ended items and achieve the objectives of this study. The primary source of data could be the number of rural farmers engaged in farm activity and who reside in Dega Damot woreda at the time of the survey. And secondary data source was any published and unpublished written materials such as report, journals, articles' and papers as well as internet sources that contain available information about the determinants of soil fertility management and its impact on households' income for the study used.

3.2.1 Sample size and Sampling procedures

For this study the researcher were used multistage sampling procedure sampling technique to select the sample households. In the first step purposively sampling technique was used to select the study area. In the second stage stratifying sampling technique used by stratifying degadamot woreda in three agro ecology criteria and then select the three kebele from each and after this sample households was select by using the formula which is raised below from the three stratum kebele, determine the total sample size from each kebele stratum and then finally used random sampling to interviewed by giving equal chance because of household homogeneous characteristics by any aspect. As suggested by Yamane (1967), since the population number (number of targeted population) is known in the study area.

Table 3.3 total sample size of the household

The selected kebeles	Target population in each sample selected kebele	Sample size of the household
Zikuala wogem	192	85
Fenkatit	174	77
Arefa medehani alem	136	60
Total	502	222

The following formula can best provide the required sample size for this study.

$$= \frac{\quad}{\quad} = \frac{\quad}{(\ .\ )} = n = 222$$

Where; n is sample size, N is the population size (total number of the households in the three kebeles), e is allowable margin of error (level of precision) ranging from 0.05 to 0.1. Margin of error shows the percentage at which the behavior of the sample deviates from the total population. The smaller the margin of error the more the sample is representative to the population at a given confidence level. Therefore, for this study, allowing the smallest possible margin of error (e = 0.05), the total sample size was 222 households.

To calculate the sample size of the three kebele

For Zikuala wogem $\frac{\times}{\quad} = 85$

For Fenkatit $\frac{\times}{\quad} = 77$

For Arefa medehanialem $\frac{\times}{\quad} = 60$

3.2.2 Data Gathering Instruments

3. 2.2.1 Questionnaire

An appropriate objective and subjective type questions were prepared for farmers to collect data. Detail discussion was made with my advisor regarding the relevance and clarity of questionnaires before filed survey. The respondents€ in the study area are Amharic speakers. Thus the questionnaires were translated in to Amharic. As it is estimated majority of farmers€ in the study area cannot read and understand the design questionnaire and appropriately put their idea. So, enumerators will be needed to forward them. Therefore, three enumerators were hired to administer questionnaire for the sample household heads, for enumerators training was given. This training was helped them to aware of the content of the questioners. Methods of data collection and recording system and in addition how to approaching the household heads peacefully to made them willing for the reasons. The questioner were administered by the enumerators to household heads at each selected kebeles€ village (gots) in different place such as at farm filed, bund construction place, church, and at their home. When the household head was not willing to answer the questioner, they were shifted to the next household head. In the three selected kebeles, enumerators and the researcher were collected data simultaneously.

3.2.2.2 Key informant Interview

Detailed interview was made with key informants. The key informants were including leaders of religious and community, aged persons, DAs and their supervisors, and female household heads, natural resource experts of the district were also the interviewees. The interview was forwarded by the researcher at different places such as church, tea house, and orientation (meeting) centers and farmers house.

3.3 Method of Data Analysis

The data collected from the field were summarized and organized by different methods. Quantitative data were analyzed using descriptive statistical methods such as frequency distribution, mean, and the econometrics model and percentage with different Tables while data gathered from interviews and observation were analyzed and described qualitatively.

3.3.1 Analytical framework

To select the appropriate analytical model that considers the inter-relationship between the three inputs, it is necessary to start with one basic assumption about the inputs. The assumption was the interdependence of the decision to use chemical fertilizer on the decision to use manure or the decision to use manure on the decision to use compost or the decision to use chemical fertilizer on the decision to use compost and vice versa. This means that there is reciprocal causation between the three variables in affecting one another, and are also being affected by other factors like farm characteristics, household characteristics Distance of farm from farmers homestead (km), farm land size, household size and others.

3.4 Methods of data analysis and model specification

In this study, both descriptive statistics and econometric model were used to analyze the data.

3.4.1 Descriptive statistics

In this study descriptive statistics such as mean, standard deviation, percentages, frequency, t-test, Chi-square and were used to analyze the data and to compare adopters and non-adopters in terms of explanatory variables.

3.4.2 Econometric mode

The dependent variable in this model is a dummy consisting of two outcomes, yes or no and continuous. In this case, the use of the Ordinary Least Square/OLS technique for such variables show inference problems, and thus not appropriate for investigating dichotomous dependent variables. In this condition, maximum likelihood estimation procedures such as either logit/probit model are more efficient (Gujarati, 1995).

Several investigators used different models for analyzing the determinants of technology adoption at the agricultural farm level. Various adoption studies used Tobit model to estimate adoption relationships with limited dependent variables while, others used the double-hurdle model. However, it is possible to use Heckman€s (1979) two-stage procedure in case of the anticipated problem of selection bias in the sample. In one study Sample selection bias might arise in practice for two reasons. First, there may be self-selection by the individuals or data units being investigated. Second, sample selection decisions occurred, by data processors work in the same manner as self-selection. Selection bias was expected in this study because among the representative not all households are believed to participate soil fertility enhancing technology adoption due to individual problems. The Heckman two-step selection model allows for separation between the decision to adopt technology and the level of their application. The model uses in the first step a probit regression to analyze factors that affect the soil fertility enhancing technology adoption decision and in the second step uses Heckman two-step sample selection model to determine the impact of soil fertility enhancing technology on farmers€ agricultural income (Greene, 2007) and the method correct sample selection bias.

The fundamental assumption of this study was to concentrate on farmers€ choice on the adoption of agricultural technologies to improve households€ agricultural income by improving soil fertility management. This implies that households€ agricultural income is a function of determinants of soil fertility enhancing technology adoption decision.

$Y_i^{*}k = \dagger_i x_{ik} + \ddagger_i k$, y= {k=1, 2, 3}•••••••••••••••• (1)

$Y_{ik=}$ {1 if Y^{*}_{ik} >0 and 0 otherwise

Y^{*}= latent variables which are not observable,

i=the number of farmers who live in the district

k= the number of technologies which are adopted or adopted by i^{th} farmers who lived in the district those technologies are (1, 2, 3; 1=compost, 2=manure and 3=chemical fertilizer)

ˆ i=are parameters of the model, ($\dagger_1$, $\dagger_2$ $\dagger_3$ ..... $\dagger_{i)}$ are the coefficients associated with each explanatory variables (X_1, X_2,••$x_{i\,)}$

e= the disturbance term which is unobserved

Xi = a vector of exogenous variables which affects the i[th] farmers€ choice to adopt or not adopt from the three technologies to increase their income by improving soil fertility in the district.

In the first stage of the model deals with the adoption decision equation which can be expressed or the probit equations as:

$d_i^* = †_i x_i + ‡_i$ --- (2)

Where; d_i^* is an unobservable choice of adoption decision and also known as latent variable, x_i is a vector of explanatory variables hypothesized that affect soil fertility enhancing technology adoption decision, and u_i is normally distributed error term with zero mean and constant variance. Then, the observed soil fertility enhancing technology adoption decision is:

Di = {1 if d_i^* >0 and 0 if d_i^* <0}••••••••••. (3)`

Where; d_i^* is unobservable choice of the technology by the i[th] household, and D_i represents observable i[th] household decision to participate in technology adoption; 1 if a respondent describe soil fertility enhancing technology use and 0 otherwise.

3.4.3 Heckman sample selection model

James Heckman has proposed an alternative to maximum likelihood method which is comparatively easy. Heckman procedure yields consistent estimates of the parameters but they are not as efficient as ML estimates.

Heckman model uses the following assumptions:

That is both error terms are normally distributed with mean 0, variances as indicated and the error terms are correlated where •‰u indicates the correlation coefficient.

(‰, u) ~ N (0,0,Š²‰ Š²u,•‰u),

The error terms are independent of explanatory variables.

(‰, u) is independent of X

Variance of the error term in the population and the correlation coefficient between the error terms are equal to one.

$Var(u) = \sigma^2_u = 1$

Sample selection problem: The key problem is that in regressing adoption on characteristics for those in farm activity we are not observing the equation for the population as a whole. Those in farm activity were tending to have higher income than those not in the adopters would have (that is why they are adopting soil fertility enhancing technology). Hence the results were tend to be biased (sample selection bias) .rho = estimate of ρ_{eu} indicates the correlation coefficient between error terms as in equation. The Heckman selection equation should contain at least one variable which is not in the outcome equation. This variable is an instrumental variable. Therefore, were ensuring that coefficients in the Agricultural income equation are identified. His method consists of a two-step estimating procedure.

In Step one in this study estimate the probability of farmers€ soil fertility enhancing technology adoption decision by using probit model. In this stage the study shows the probit regression and marginal effect of probit outcomes of factors which are influence the likelihood of small farmers€ soil fertility enhancing technology adoption decision.

In step two the model estimates the Heckman selection model by adding it a variable (invers mills ratio/ lambda) which is derived from probit estimate.

In this study there are two question which are (1) behavioral (i.e. the respondents€ adoption decision) and (2) selection (if the respondent adopt soil fertility enhancing technology what will happen their agricultural income).

Heckman provide some flexibility by treating these two questions (the mind of the respondent) separately with potentially different set of variables and different set of coefficients€ for predicting these two outcomes behavior Vs selection, (Jones www.bandicam.com) . Heckman two stage regression model become

= + ‹Œ(Z, •) + •••••••••••••••••.. (4)

Where Œ is the inverse mills ratio which is estimated from first stage probit equation? If it is significant it implies that the selection probability term of this study does not work in unconditional expectation.

The second stage deals with the outcome equation which uses a sample selection model. The equation helps to determine the impact of soil fertility enhancing technology adoption on farmer€s farm income. An explained variable that has a zero value for a significant fraction of the observation i.e. a censored regression model (referred to as a modified censored model in this case) because standard OLS results is a biased and inconsistent parameter estimates (Greene, 2002). The censored regression model seems the probit model was used to deal with the impact of soil fertility management technology practices on agricultural income (outcome) equation which can be expressed as follows:

Y_i = †X_i + ‰$_i$ .... (5)

Where, Y_i is adoption, X_i observed variables relating to the i€th person€s adoption decision and ‰$_i$ is an error term in the sample. Y is observed only for adopters, i.e. only people in adopting get higher farm income. Sample selection (i.e. Have higher income so adoption is observed)

The Heckman two-step approach is based on the assumptions that the selection equation and the conditional equations are related to each other through their error term. When there is no relation between the error terms, there is no need to perform a Heckman two-step model as there is no sample selection.

3.5 Definition of variables and their expected hypothesis sign

This study has considered several explanatory variables in modeling of soil fertility enhancing technology adoption behavior of farmers in the study area. The researcher simplifies briefly the variables and suggests the expected effect under this section.

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

Household Age: is the age of the head of the household in years and it is a continuous variable. Though it is empirical question, age in the study area is hypothesized to have a negative coefficient showing that younger head of households have been a higher probability of using soil fertility management technology.

Household educ: in this study education is a dummy variable representing the education level of the head of the household. Where literate household heads represent (1) and otherwise (0). A positive relationship between soil fertility enhancing technology use and education of the head of household is expected

Household size: It refers to the total number of household members within the given household. According to tedla (2013), labor constraints affect household€s ability and willingness to adopt and use a new technology. The larger is the family size, the more labor is expected within that household. Accordingly; though family size is an empirical question, it is hypothesized for this study that it positively affects household€s soil fertility enhancing technology adoption. Additionally, household family size has no impact on the adoption soil fertility enhancing technology (Biru, 2016).

Farm size: This is the total area cropped by the household in timad. This includes plots of the household headed owns & rents in to grow its crops. The relationship between farm size and adoption of agricultural technologies is an empirical question. However; for this study, a positive relationship between farm size and adoption is expected as larger farmers can experiment with new technologies on portion of land without severely risking their minimum subsistence food requirement (Debebe, 2019).

Credit access: dummy variable representing availability of credit to households from credit institutions; where availability of credit. 1=yes and 0=no and positive relationship is expected. As access to credit increases in the rural area, then the cost of transaction reduce. It implies that farmers are motivated to adopt soil fertility enhancing technology in their cultivated land.

Off-farm income: includes earned non-farm activities and unearned (private transfer like remittance and government transfer). It is believed that off-farm income can have a positive impact on the adoption of soil fertility enhancing technology. When household€s income increase, their risk-taking behavior also increase; this may lead to a higher probability of modern agricultural inputs use. Thus, a positive relation is expected.

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

Farming experience: Several studies examined the effect of farming experience on adoption decision of ISFM technologies. Farmers€ Experience in agriculture has an influence on planning horizon. For instance, short planning horizons are equated with older and more experienced farmers who may be reluctant to switch from traditional methods to new practices (Yirga and Hassan, 2008). As farmers€ experience increase, their planning horizons shrink and so the incentives for them to invest in the future productivity of their farms diminish. Moreover, younger farmers may incur lower switching costs in implementing new practices since they only have limited experience and the learning and adjustment costs involved in adopting SFM practices may be lower for them (Marenya and Barrett, 2007). Farming experience was measured as the number of years a farmer has been in farming.

Multicollinearity Problem : To test variance inflation factor (VIF) were employed. VIF greater or equal to 10 is an indicator for the existence of serious problem of multicollinearity.

One of the important parts in this section is to specify and hypothesize the dependent and explanatory variables that were used in the model.

Table 3.3 expected effect of explanatory variables on soil fertility enhancing technology adoption

Variable	Nature of variable	Variable definition and measurement	Expectation
Soil fertility enhancing	Binary	1 If household use soil fertility enhancing technology, 0 otherwise.	

technology adoption decision			
Age of the farm household head	Continuous	Age of the household head in the year	+/-
Farm size	Continuous	Farm land size in hectare	+
Household labor	Continuous	household labor force or number of family in working age	+
Family Size	Continuous	Number of family members	+
Sex of farm head	Dummy	Sex of farm household(if female=1 otherwise,0)	-
Educational status	Dummy	Educational statues of the household head(1=litrate,0=otherwise)	+
Participation in none farm activity	Dummy	Participation in farm activity(if have=1, 0, otherwise)	+/-
Distance from the residence	Continuous	Distance from the residence of household to plot land of the household head in km	-

Source: own expectation 2021

CHAPTER FOUR

4. Results and Discussions

Introduction

This chapter includes analysis of the collected data and interpretation of the findings. As already stated in the objective type close and open ended questionnaires were administered to 222 sample household heads in Dega Damot District in three selected Kebeles and questionnaires were also forwarded to key informants. In addition the results from field observation in the three selected kebeles are interpreted.

4.1. Demographic and Socio-Economic Characteristics of respondents

4.1.1. Demographic Characteristics of respondents on dummy/categorical variables

The demographic characteristic of household head includes, sex, and marital status is illustrated. Table 4.1, Additionally Table 4.1 indicates that from a total of 166 male household heads 74 respondents were Non-adopters soil fertility enhancing technology practices and 119 respondents were implement SFM practices. The results showed that the proportion of male headed households were higher both among the adopters and non-adopters of organic fertilizer compared to that for female headed households. Among the adopters of organic fertilizer, the higher proportion of male headed households could be due to better exposure that the male headed households have to different technologies and trainings delivered by extension agents. Male heads are more likely to attend community meetings and visit demonstration plots or research centers compared to female heads (IFPRI, 2012).

. Additionally from 192 married respondents 111 sample households are adopters of soil fertility enhancing technology and 81 respondents are not adopt soil fertility enhancing technology and from 30 unmarried sample household head 19 respondents are not adopters but the reaming 11 respondents are adopters. The proportion of married household heads was higher among the adopters compared to the non-adopters implying that respondents who are the heads as a result of being married are more likely to adopt organic fertilizer. This could be due to the very concern that the married households have to improve output at minimal possible cost over the limited and competing resources (Martey et ai, 2013) noted that marriage increases farmer€s concern for household welfare thus increasing farmer€s participation in agricultural technology adoption. As Table 4.4, shows, of the total sample household headed in the study area, 74.77 percent were males where as 25.23 percent house hold headed were females. Among the adopters of soil fertility management technology about 20.4 percent of the households were female-headed and 79.6 percent are non adopters from 56 female sample size and 33.9 percent of male-headed are non-adopters and 66.1 percent are adopters from 166 male sample size. The result showed that the proportion of male-headed households was higher both among the adopters and non-adopters of soil fertility management technology compared to that for female-headed households.

Table 4 1. Demographic characteristics of sample household head

Explanatory variables	Category	soil fertility enhancing technologies				
		Non adopters of SFM	Adopters of SFM	Total number	Percentage	p-value chi^2 test
Sex of HHs	Male	47	119	166	74.77	0.000***
	Female	51	5	56	25.23	
	Total	98(44.14)	124(55.86)	222	100.00	
Marital status of HHs	Married	81	111	192		0.03**
	unmarried	19	11	30		

Source: own survey data (2021)

*** And ** indicates that significant level at 1% and 5% level of significance.

4.1.2 Description of the first variable/treatment variable

The researcher€s treatment variable is the adoption of soil fertility enhancing (SFE) technology practices. Specifically focus on the two core practices of soil fertility enhancing technology, i.e. the use of organic and inorganic fertilizers. To account for differences in locally available resources, organic fertilizer refers to having applied animal manure, compost, and manure on crop land. As shown Table 4.2, the three Kebles household respondents apply soil fertility management technology to reclaim soil nutrient degradation. As interviewed the respondent additionally as indicates from the above table the respondents apply different SFMT like intercrop, crop rotation and improved seed in some extent as the researcher interviewed and the respondent most of the time use organic and inorganic fertilizer for soil fertility enhancement.

Compost: farmers have a low perception about compost preparation time, method and place preference. According to a key informant interview, farmers prepare compost in front of their home during sun shine. This might causes, for Varieties of diseases for the people in the study area. In the study area 26.58 percent of the respondent used compost technology.

Chemical fertilizer: This soil fertility maintenance measure is not indigenous and it is practiced by 61.71 percent of the respondents and 38.29 percent of the respondent dose not adopts chemical fertilizer. During the field survey, interviewee farmers explain different reasons why all farmers do not used chemical fertilizer. Some feared that their land may adopt this fertilizer and unable to produce a crop without it. Others also argued that due to increasing its price and lack of money to purchase it hinder them from applying on their cultivated land.

Manure: It is practiced in the study area by the majority of local farmers in three selected kebeles. As the researcher interviewed, most of the respondents who have livestock, use manure more and some extent. Farmers explain that animal manure is the best form of organic matter when added to the soil. It improves or sustains soil fertility, texture and structure and increase water holding capacity (Shelemew, 2005). As Table 4.2 indicates, 30.32 percent of sample household respondents have been using animal manure. Even those farmers have not livestock they collect dung from communal grazing land and use it on their farm land to increase their land fertility and productivity. However, discussion with key informants revealed that the application of manure on all plots is impossible because of the lack of fodder for animals and decreasing livestock number. Therefore, the production of dung is very low. In addition, the majority of the local community uses animal dung for domestic energy. According to key informants, there is additional soil fertility enhancing technology practice listed below.

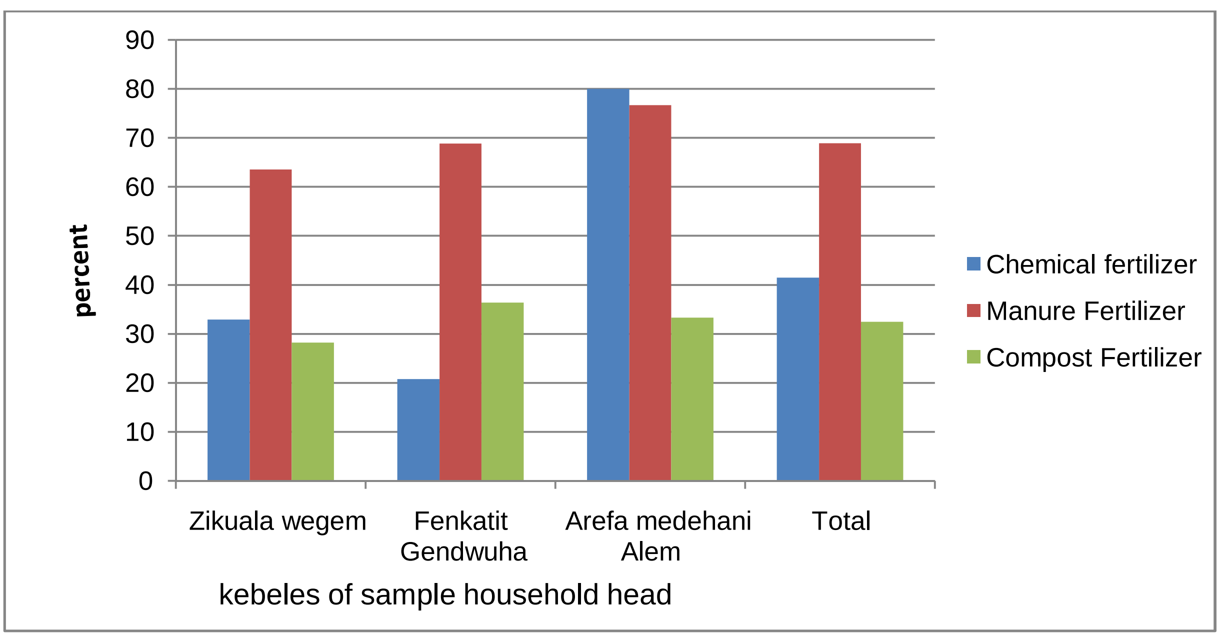
Table 4.2: Type of soil fertility enhancing technology

Type of SFM practice		Category	Frequency	Percent
Compost		Yes	59	26.58
		No	163	73.42
	Total		222	100%
Manure fertilizer		Yes	68	30.32
		No	154	69.68
	Total		222	100%
Chemical fertilizer		Yes	137	61.71
		No	85	38.29
	Total		222	100%

Source: own survey 2021

As hypothesized the researcher shows the adoption level of organic and inorganic soil fertility enhancing technologies in each sample selected kebeles by using chart.

figue17: The adoption level of each fertilizer in the study selected kebe



Source: own survey 2021

From the above chart conclude that sample household head used more manure from soil fertility enhancing technology type. As interviewed the key informants there is additional traditional soil fertility enhancing technology.

Fallowing: It is an important traditional method of land management practice in which land is leaving idle for a certain period until it recovers or restores soil fertility or it can sow with grosses or legumes crops like gito in study area. According to key informants, this technology is abundant except in from of grazing land rather than the aim of maintenance soil fertility because shortage of farming land to produce crops for family feeding.

Crop rotation: It is an indigenous soil fertility maintenance method that is practiced by all respondents widely in the study area. According to key informants in the study area, if they grow cereal type of crops in the first year then they grow legumes crops in the next following year and may return to cereal crops on third year or they continue other like potato. Farmers explain that the choice of crop for rotation depend on food consumption for family and its market prices.

4.1.3 Descriptive statistics of average farm income of household€s

The researcher outcome variable is agricultural income, measured as crop output in the so-called name quintal (100kg) per timad (kg/tim) and it is measured in ETB annually. In this study average agricultural/farm income of adopters from the respondents was about 61294.35 in ETB per annum. Amongst the respondents who have adopted and not-adopted soil fertility management technology practice, the average farm income was about 61294.35 and 28601.02 respectively in ETB. From this finding the researcher concludes that, adopters have higher average farm income than non-adopters. This implies a significant difference between adopters and non-adopters of SFM technology. The majority of sample respondent farmers more depend on agriculture makes them give more concern productivity increasing technology such as organic, inorganic and other mechanisms which enhance soil fertility to increase agricultural productivity. According to Alelgn 2011, a household whose income depends on farm activities does not have enough capital to use chemical fertilizer in Kenya thus they to use manure to compensate outflow of nutrients. Moreover, the difference of the average farm incomes among the adopters and the non-adopters of soil fertility management technology were found to be significant at 1 percent probability level.

Table 4.3 The descriptive statistics of outcome variables.

Average income of HHs	adopter of SFM		Non-adopter of SFM		P-value
	Mean	SD	Mean	SD	
Agricultural income	61294.35	41989.72	28601.02	85736.57	0.00***
Total income	66641.52	49532.28	24450.94	24618.16	0.00***

Note: SD = standard deviation. P-value = statistical significance of differences in means between those who adopt SFM and those who do not at 1% level of significance

4.2 Socio-Economic characteristics of respondents

In this section the researcher describes different socio-economic characteristic of the household head includes Education, off-farm activity, and agricultural income of the household head, land size and livestock holding access to credit. The response of sample household heads has been categorized as continuous/discrete and dummy/categorical variable and summarized in table below.

The age of the household is an important factor that affects respondents€ their use of soil fertility management. The result shows that average sample household age was 59 and the minimum and the maximum age of respondent was 23 and 96 respectively. This implies that household in the study area are middle aged. The mean age of the household heads who don€t adopt SFM land management practices were 57.18 and the mean age of household heads who adopt soil fertility enhancing technology practice were 42.86. The p-value indicates that, there is significant mean difference at a 1% level of significance on age between household heads who implement and who don€t implement SFM technology.

Farm experience is also one of the socio economic factors which affect framers in acquiring information and their skills in their life span as it influences their understanding of farming activities. Farmers can observe success and failure in crop production and other ways. This could help them to weight the performance of modern and indigenous soil fertility management technology measures to develop more confidence to take risk related to farming practice.

The researcher survey result indicates that the average livestock holding was about 6.4 among the adopters and 4.90 among the non-adopters. The fact that the livestock has the potential resources (animal manure) for organic fertilizer preparation could make the number of livestock units to be quite important for adoption of organic fertilizer (Tefera et al 2013). Due to this, the larger average livestock holding shown among the adopters possibly had intensified specially for organic fertilizer adoption compared to low livestock holding farmers. The difference was significant at a 1 percent probability level showing the importance of livestock in the adoption of soil fertility management technology. The number of livestock owned was presented in terms of the tropical livestock unit (TLU) giving different weights for different types of livestock.

According to Runge-metzger (1988), TLU is a unit that represents an animal of 250 kg live weight where, 1 is assigned for cattle, 0.1 for sheep and goat, and 0.04 for chicken. The manure from animals used as sources of organic fertilizer in the study area. During composting, farmers most of the time exclude the manure of animals because these manures cannot be easily decomposed as those obtained from the cattle, sheep, goats and chickens. Due to this, excluding donkeys, horses and mules, other livestock€s such as cattle€s, sheep, goats and chicken were used as the potential sources of organic fertilizer in the study area.

As hypothesized farm size, soil fertility enhancing technology adopters own on average, about 7.8 timad of farm land while the non-adopters own about 6.6 timad of the farm land. The current study had predicted that farmers with relatively larger farm size are likely to adopt soil fertility enhancing technology. This could be primarily due to lower marginal costs associated with the adoption of labor-intensive technology on the larger area of the farm land. The results indicated that the households with larger farm land were adopters of soil fertility management technology possibly due to lower marginal costs. As hypothesized regarding to farm size, there is a significance difference between the adopters and the non-adopters of soil fertility enhancing technology at 1 percent level of significance.

(Martey et ai, 2013) argued that an increase in cultivation plot is associated with financial constraints for smallholder farmers in Ghana thus reducing adoption of chemical fertilizer. Lower use of chemical fertilizer could possibly result in more use of organic fertilizer in Ethiopia. Ketema (2011) claimed that manure use is negatively correlated with application of chemical fertilizer in Tigrai region of Ethiopia as these two types of fertilizers are substitute for each other. Moreover, majority of the households (64.4 percent) own less than or equal to 0.75 hectares of the farm land. About 7.1 percent of the adopters of organic fertilizer own 2 to 3 hectares of the farm land while the corresponding proportionate for non adopters was 2.4 percent showing that adopters own larger farm land than non-adopters.

Education enables farmers to engage in land management practice using various ways of maintenance and adopting techniques with both traditional and introduced soil fertility enhancing technologies. Education is the potential source of knowledge which enables one to understand instructions access and comprehend information about the new technology (Biru, 2016) Farmers€ educational level increases the awareness, perception, knowledge and skill about the causes, severity, indicators and consequences of land degradation. Education enables farmers to engage in land management practice using various ways of maintenance and adopting techniques with both traditional and introduced soil conservation technologies (Alelgn, 2011). As the above table indicates that the majority of the three kebele respondents€ about 45.5% percent of the sample household head were totally illiterate and 55.5% percent of the respondents were attended education either formally or informally. Majority of the respondents€ from literate sample household headed were educated formally.

Table 4.4: Socio-economic characteristics of the sample HHs continuous/discrete variables

Variable€s name			Soil fertility management practices			
			Adopter	Nob-Adopter	P-value	t-value
	Min	Max	Mean	Mean		
Age of HHs	23	96	42.86	57.18	0.00***	6.46
Educational status	1	12	6.00	4.00	0.03**	-1.80
Number of labor force	1	8	3.36	2.98	0.01***	2.27
Family size	1	9	5.02	5	0.15	1.01
Agricultural income	0	160000	32315.57	18244.45	0.00***	-4.5200
Off farm income	500	30000	8930.56	8681.82	0.43	-0.18
Total income	1000	160000	40457.29	31969.03	0.00***	-3.53
Farm experience	2	58	19.77	20.96	0.82	0.93
Own land size	0	16	7.82	6.65	0.00***	-2.80
own livestock€s	0	16	6.4	4.52	0.00***	-7.23
Number of percales used for crop production	0	12	5.38	4.18	0.00***	-3.04
fragmented plots	1	2	.51	.41	0.05**	-1.59

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

4.2.1 Awareness of farmers€ about SFM

According to these study farmers who are included in the sample size in the study areas of the three kebeles, they have a good awareness about the use of SFM technology adoption. In the three kebele as the researcher interviewed as compared as the previous time awareness of farmers€ about SFM technology adoption now a day€s awareness is a better because farmers know about SFM technology adoption Practices and which practices is better for which landform and soil type and also which practice is good to produce more crop. Farmers€ who is not practice SFM technology adoption are minimum because of different problems like small size land, farm experience of farmers€ and low level of livestock.

Table 5, shows that farmers€ awareness level on the benefit of the of SFM technology adoption. From the table 66.67 percent of the respondents have awareness about the use of SFM technology adoption to the enhancement of soil fertility to increase agricultural income and in the contrast 33.33 percent of the household headed have not awareness. This implies that the majority of household headed respondents€ have a good awareness about the use of soil fertility management technology adoption practice for the enhancement of soil fertility of farm land.

Table 4.5 the awareness level of farmers€ about benefit of adopting SFM practice

Explanatory variable	Category	Total number	Percent
Benefit of SFM	Yes	148	66.67
	No	74	33.33

Source: own survey data (2021)

4.2.2 Major crop type

Table 6 indicates that each crop type and productivity of the crop. The result indicates that average productivity of adopters and non adopters. As indicated from the above table there is a significance difference on production of crop between adopters and non adopters of soil fertility management technology practice.

Table 4.6: The major crop types cultivated in each kebeles

Major crop types	Ziqual	Fenkatit	Arefa	Adopters	Non-adopters
	%	%	%	average Yield in	average Yield in (Qt/ti)

	(Qt/ti)				
Wheat	68.02	34.23	25.50	8.46	6.35
Barley	59.91	42.11	8.27	6.86	5.99
Teff	17.43	26.61	55.96	6.33	5.11
Maize	26.28	32.12	41.61	12.57	11.17
Potato	69.37	29.22	26.62	8.46	7.95
Legumes	45.95	35.14	18.92	2.76	2.36

Source: own survey 2020/2021

4.2.3 Farm Fertility

According to this study, farm fertility represents the households' opinion about the level of fertility of their farm land. The results presented in Table 7 show that about 3.3 percent of the adopters believed that their farms were not fertile. In comparison, the corresponding figure for non-adopters was about 96.7 percent. Relatively higher proportion of households who perceived that their plots are not fertile were found to be adopters of organic fertilizer. Low farm fertility has been reported to be a major constraint to agricultural production by an increasing number of farmers in Ethiopia (Biru, 2016) This shows that low fertility of the farm could be one of the reasons for adoption of soil fertility management technology. The survey results of this study further revealed that about 58.06 and 65.62 percent of the adopter households perceived that their farms were fertile and medium respectively. On the contrary, about 41.9 percent and 34.38 percent of the non-adopters were believed that their farms were medium and fertile respectively. From 222 respondents 0.9 percent of the sample size dose not describe their fertility level of their farm land.

Table 4.7 farm land fertility level

Characteristic	Adopters		Non-adopters		Test statistics Chi^2
Level of fertility	Freq.	%	Freq.	%	
Infertile	1	3.3	29	96.7	34.57
Medium	84	65.62	44	34.8	

Fertile	36	58.06	26	41.9

Source: own survey 2021

4.2.4 Group membership, Access to credit, Extension service, and Distance from home to the land

Table 8 show that 0.84 percent of the sampled respondents were members of farmers based associations while the remaining nearly 0.16 percent was not. As a result of key informants, majority of adopters were members of at least one farmer based organization. The majority members of farmers based organizations and they are adopters. Farmer based organizations are the potential sources of information. Contrasting that of information media such as television and radio, the information obtained through membership in a given farmer group involves two way discussions which can be easily understood by the farmers. Due to this, availability of such organizations may increase frequency of discussion among the member farmers therefore enhancing communication for development (Berhe, 2014). Households belonging to farmers group such as associations and cooperatives can easily access fertilizer technology ((Martey et ai, 2013). As such, existence of farmers based organizations could possibly increase the adoption rate of SFM. The mean difference of membership in different farmers based organizations between the adopters and the non-adopters of SFM was insignificant.

Credit is an essential source of funding in agricultural technology adoption. The major sources of credit in Degadamot district include-amhara credit and saving institution and farmer based informal associations such as Idir, Ekub, Mahiber and Debo (wonfel). It was found that about 74 percent of the sampled respondents had accessed and used credit while about 26 percent of them did not access credit due to different reasons such as high interest rate. The result of credit access and use among the respondents was high. The difference was significant at 1% percent probability level.

Extension service refers to demonstration, training and advice delivered to farmers mainly by development agents and other agricultural experts. Extension service was measured in terms of the frequency of farmers meeting with extension workers during the previous agricultural season. The results indicated that the overall average frequency of extension contact was about 2.5. In comparison, it was found that the average frequency of extension contact was about 3 times per season among the adopters of organic fertilizer while that of non-adopters was about. The difference in the average extension contacts between the adopters and non-adopters of organic fertilizer was significant at 1 percent probability level. The results show that the adopters of organic fertilizer had better access to extension services on average compared to non-adopters justifying that the higher frequency of extension visits may have contributed toward adoption of organic fertilizer.

Table 4.1 The results on Group membership, Access to credit, Extension service, and Distance from home to the land

Characteristics	Adopters		Non-adopters		Test statistics
	Mean	SD	Mean	SD	t-value
Member of organization	0.84	0.39	0.16	0.36	0.7
Access to credit	0.74	0.33	0.26	0.05	-5.55***
Extension service	0.025	0.43	0.44	0.49	-5.03
Average walking time	1	60	13.63	15.88	0.91

Source: own survey 2021

4.3 Empirical results of Factors that determine the Adoption of SFM technology and Its Impact on Households’ Farm income

Heckman two stage selection analyses is executed to identify the household level demographic, socio-economic and institutional factors that determine the decision of smallholder farmers to adopt or not to adopt soil fertility enhancing (SFE) technology in the first stage by applying probit model.

In the first stage the probit model was used to examine factors that influence the level of soil fertility enhancing technology adoption decision. However, before running the regression analysis, the diagnostic tests, such that, the existence of multicollinearity problem of variables included in the model are needed to be checked both for the continuous and discrete explanatory variables. According to Gujarat (2004), when the values of VIF approach to infinitive there is serious problem of multicollinearity between the independent variable, while if VIF is below 10 there is no much problem. In this study all the computed value of VIF for explanatory variable was blow five. As a result, there is no evidence of multicollinearity problem between the explanatory variable in this study.

4.3.1 Factors that determining smallholder farmers€ soil fertility enhancing technology adoption decision

The models constructed with 15 independent variables and out of these 9 variables are significantly determining the adoption decision with hypothesized sign and the impact on adoption. These variables include age, livestock, awareness of farmers about the benefit of soil fertility enhancing technology adoption, farm experience of the household head, size of farm land, Position of land, education status of household head, accessibility of credit service are significantly affect farmers€ soil fertility enhancing technology adoption decision. Whereas; participation in off-farm activity; fertility of land, fragmented plots, number of labor force, membership to farm cooperative and access to agricultural extension service insignificantly but all other variables with expected sign influence the technology adoption decision.

As specified in Table 4.9. The marginal effect report of the probit regression provides the probability that a farm household able to adopt a soil fertility enhancing technology in their agricultural crop production (see Appendix 5). As hypothesized from the above regression the arable farm size of the respondent was positive and had statistically significant influence at a 5% level of significance on the adoption of soil fertility enhancing technology. The marginal effect result indicates that a farmer, who has one additional timad of arable land, would increase the likelihood of farmers€ soil fertility enhancing technology adoption by 3% statistically significance level. This result is in line with the argument of Nowak (1987) and Alelgn(2011), which claimed that larger arable land ownership enable farmers to have more flexibility in their decision making, greater access to a unrestricted resource, and give more opportunity to adopt new farm technology practice. This is because availability of more arable land enable farmers€ to allocate more land to produce more crop leading increment in output and the rise in output widen the chance of farmers€ more income and the increment in family income enable farmers to widen the understanding and the use of new soil fertility enhancing technology.

As hypothesize, the position of land was found to be negatively and significantly influenced the probability of soil fertility enhancing technology adoption decision of small holder farmers€ at 1% level of significance. Other variables€ constant, if the position of land is steeper, the likelihood adoption of soil fertility enhancing technology decrease by 3.8 percent on crop cultivation at 1% level of significance. This finding is similar to (Susie, 2017) Bessir (2014) and Debelo (2015.

Additionally, the number of livestock has positive effect on households€ soil fertility enhancing technology adoption decision. Holding other variables constant, the numbers of livestock increase by one unit, the likelihood of soil fertility enhancing technology adoption decision of farmers€ increase by 68 percent at 1% level of significance holding other variables constant.

As hypothesized, the education level of the household head was found to be positively and significantly influenced the probability of adoption of soil fertility enhancing technology in crop land cultivation. As compared to illiterate farmers the probability of adoption of soil fertility enhancing technology input in crop production for literate farmers would be higher. This implies that the educational level of a household headed increase by one year, the likelihood adoption of soil fertility enhancing technology increase by 3.6% holding other variables constant. This indicates that the educated farmers are more confident to adopt soil fertility enhancing technology input in their cultivation than those who are less illiterate or completely illiterate. Farmer with formal education has better ability to obtain information€s about productive input and new technology of production relative to uneducated one. Education also increases the decision making abilty of farmers based on identified information of cost and benefit. This result is consistent with the work of Bayissa (2014) and Leake & Adam (2015), who forwarded that having education increases the probability of adoption of new agricultural technology by farmers.

Holding other variable constant, if farm experience of farmers€ increase by one year, the probability technology adoption decision of farmers€ increase by 15 percent at 10% level of significance. This result is consistent with the work of Alelgn(2011).

Access to credit service also positively determines the probability of farmers€ decision on soil fertility enhancing technology adoption at 1% level of significance. Citreous paribus, availability of credit service encourage the likelihood of household fertilizer technology adoption decision by 61 %. This result was consistent with the finding of Ogada (2013), which reason out that accessible credit solve the smallholders problem created due to their low saving ability to purchase relatively more expensive technologies like inorganic fertilizer. Hence, the accessibility of credit enables farmers to purchase inputs like improved seed, fertilizer, which increase output through productivity increment. According to Alelgn (2011), on the other hand, accessibility of credit solves farmers€ cash problem that hinders farmers to purchase chemical fertilizer at an early period of crop collection in which there was no sufficient market or low price for agricultural output. Therefore, farmers who have the availability of credit services are more likely to adopt soil fertility enhancing technology than without credit.

Old household heads€ are less likely to adopt soil fertility enhancing technology than adult households€. Holding other variables€ constant, the age of a household increase by one year, the likelihood of soil fertility enhancing technology adoption decrease by 22.5% at 1% level of significance.

Generally the p-value in the regression indicates that the probit regression model is highly significant.

Table 4 2 Factors that determine farmer€s soil fertility enhancing technology adoption decision probit model result

SFM	Coef.	Std. Err.	Z	Mariginal effect
Age	-.0563627	.0165251	-3.41	-.0224629***
Gender	.7651959	.5707345	1.34	.2950233
Education	.0912022	.0517363	1.76	.0363479*
Family size	.3618669	.1707307	2.12	.1442192
Number of labor force	.2938709	.2134821	-1.38	.11712
Fragmented plots	.1935787	.170343	1.14	.0771493
Positionof land	-.9703738	.4061	-2.39	-.3867349***

Awarenes	1.944726	.7691653	2.53	.6505155***
Fertility of land	.3699828	.3904134	0.95	.1474538
Livestock	.1719775	.0558872	3.08	.0685403***
Access to credit	1.753344	.5265933	3.33	.6106031***
Extension service	-.8814073	.6592244	-1.34	-.3309547
Farm expriance	.0400703	.0238025	1.68	.0159697*
Size of land	-.0266216	.067767	-0.39	.0306098*
Off-farm income	.0000181	.0000262	0.71	7.4506
_cons	.5481786	1.127909	-0.02	-

Sorce:own 2021

***, ** and * indicates that statistically significant at 1%, 5% and 10% respectively.

Number of obs=222, Prob>chi2=0.000, pseudo=0.756

4.3.2 The effect of soil fertility enhancing technology adoption on farmer€s crop income

4.3.2.1 Heckman two-stage model

The Heckman model in the second stage estimation identifies the effect of the adoption of soil fertility enhancing technology on farm income. Table 4.10, shows that impact of variables which affects soil fertility enhancing technology adoption of smallholder farmers on their farm income. Out of 16 explanatory variables, age, size of a family member, access to credit, educational status of house hold head, awareness, farm experience, number of livestock, Position of land, significantly influence the households€ soil fertility enhancing technology adoption decision, while membership to cooperative, sex, participation in off farm activity, insignificant to influence the level of adoption. Accordingly, age, education, family size, number of labor force, livestock, farm size, farm experience, and awareness are significantly affect households€ crop income. From those variables age and family size have negative significance impact and the remaining variables€ affect households€ farm income positively and significantly.

The coefficient of inverse Mill€s ratio /Lambda is significant at 5% level. The significance of Mill€s ratio discloses the presence of selection bias and the effectiveness of applying Heckman two-stage models due to its ability to handle the selection bias problem.

Table 4.10 shows that lambda term is significance and positively signed. If there is no correlation between the error terms, there is no need to perform Heckman two-stage approach. The positive sign of rho reflects that the error terms in the adoption decision model and selection equations are positively correlated. if there is no correlation, the applying of Heckman two-stage model is not necessary.

Therefore, (unseen) factors that makes soil fertility enhancing technology more likely tend to be associated with higher farm income.

Corresponding to the first stage result, age, education, livestock, awareness, access to credit, number of labor force, position of land gender affect adoption decision significantly with expected sing. Moreover, household heads education level, awareness and availability of livestock and access to credit, age, have the expected positive effect on the level of soil fertility-enhancing adoption in a statistical significance level. The sizes of family and age determine soil fertility enhancing technology adoption decision of sample household by 1% significance level and have expected negative influence on adoption.

In Heckman two-stage regression result which implies the effect of soil fertility enhancing technology adoption on households€ farm income, age and household family size have negative influence on agricultural income.

As hypothesized, an one additional person in the family deteriorate agricultural income by 6386.97 in ETB at 1% level of significance. This implies that when family size of a household headed increase, then annual earning income from agricultural crop decrease holding other soil fertility enhancing technology constant.

Additionally, number of household headed labor force has positive statistical effect on farm income. This implies that, one more active labor force of a household headed increase agricultural income by 8189.48 ETB at 5% level of significance, holding all other variables constant. Size of land holding also found positive and significant influence on the level farm productivity at 5% level of significance.

At a one timad increase in land size, increase households agricultural income by 2736.872 ETB, keeping other variables constant. This indicates that higher land holding size increase households€ annual farm income. The age of the household head has negatively and significantly affected agricultural income of the household headed. This finding shows that being older for the household head, leads to agricultural income decrease by 1118.81 ETB at 1% level of statistical significance. This finding is consistent with (Alelgn, 2011).

Number of livestock also found positive and significant influence on the level farm income at 1% level of significance. At one unit increase in livestock, increase households€ agricultural income by 664.05 ETB, keeping other variables constant.

As expected, Access to credit is also shown expected sign and statistically significant at the 1% level as indicated in stage one. This suggests that households, who had access credit, are more likely to adopt soil fertility enhancing technology on their crop cultivation than without and increase farmers€ annual farm income in the finding of (Alelgn, 2011). This finding is the same result as (Biru, 2016) on adoption rather than income. As hypothesized other variables stated in Heckman two-stage regression result like access to credit, marital status, fertility of land, have not a significance effect on households€ agricultural income.

Generally, in this regression the instrumental variable (IV) which is used to identify the Heckman two-stage selection equation are farmers€ organization and marital status. This implies that the selection equation (if the respondents adopt soil fertility enhancing technology, what will be households€ agricultural income) is identified by the behavioral equation (the respondents€ soil fertility enhancing management technology adoption decision) and as indicated the p-value of the regression result, Heckman two-step regression model is significance.

Table 4.10 The results of Heckman two-stage selection estimation (impacts of soil fertility technology adoption on farmer€s farm income).

Agricultural income	Coef.	Std. Err.	Z	P>|z|
Age	-1118.81	447.7562	-2.50	0.012***
Gender	-21402.92	20467.11	-1.05	0.296
Maritalstatus	-5134.409	3201.229	-1.60	0.109

Edustatus	3465.925	1291.659	2.68	0.007***
familysize.	-6386.971	3631.127	-1.76	0.079*
Nooflaborforce	8189.485	4169.859	1.96	0.050**
Livstockown	664.0472	1279.995	0.52	0.020**
Size of land	2736.872	1184.765	2.31	0.021**
Fertilityoflan	-5122.184	7411.477	-0.69	0.489
Awernessofsfm	11242.7	6763.41	2.38	0.017***
Acestocredit	6911.49	41352.86	0.65	0.515
Farm expriance	1225.27	414.4612	2.96	0.003***
_cons	162929.8	70359.81	2.32	0.021
SFM				
Age	-.0481842	.0178788	-2.70	0.007***
Gender	1.083716	.6613468	1.64	0.001
Maritalstatus	.1053786	.1031476	1.02	0.307
Edustatus	.0923784	.0526069	1.76	0.079*
familysize.	-.3687676	.1734889	2.13	0.034**
Nooflaborforce	.0000123	.0000269	0.46	0.046**
Farmexprance	.0399175	.0251471	1.59	0.031**
Sizeofland	.0663785	.0909538	0.73	0.466
Fragmetland	-.5806221	.4511233	-1.290	0.198
Positionofland	-1.048252	.4005602	-2.62	0.009***
Awernessofsfm	.730355	.7777667	2.220	0.026**
Fertilityoflan	.2745827	.3953669	0.69	0.487
Livstockown	.1640941	.0561082	2.92	0.003***
Acestocredit	1.570713	.536052	2.930	0.003***
Exteserv	-.768847	.6664695	-1.15	0.249
Off-farm icome	-1.753282	1.168474	-1.5	00.133
Farm organization	2.117534	1.064581	-1.99	.6311692**
_cons	-.44752	1.402034	-0.320	0.750
Mills				
Lambda	14194.08	24441.49	0.28	0.026**

rho	0.38640
sigma	36734.619

***, ** and * imply statistically significant at 1, 5 and 10% respectively. Number of obs = 222, Censored obs = 98, Uncensored obs = 124, Wald chi2(11) = 35.77, Prob > chi2 = 0.0004

4.3.2.2 Heckman two-stage endogenous treatment effect on households Farm Income between adopters and non-adopters

Table 4.11 indicates that significance difference between adopters and non adopters of agricultural income. The impact of soil fertility enhancing technology adoption on households€ farm income difference per timad was estimated between adopters and non-adopters in this section. However, according to (Biru, 2016), Propensity Score Matching methods were employed to compare the difference of average farm income between the samples of adopters and non-adopters of agricultural technology adoption. In this study Heckman two steps with endogenous treatment method were employed. Accordingly, the results indicated that the households who adopted soil fertility enhancing technology adoption had earned income from 6144.966 ETB to 11919.2 ETB more average farm income per timad compared to non-adopters of soil fertility enhancing technology. As hypothesized, the mean annual agricultural income of adopters is higher than non-adopters of soil fertility enhancing technology by 32,693.33 ETB. This implies that adoption of soil fertility enhancing technology is crucial to increase farmer€s farm income.

Table 4.11 the result of Heckman two-stage endogenous treatment result

Variables	Coef.	Std.Err.	P>|z|	[95% Conf. Interval]	
Age	3.943852	244.8863	0.987	-476.0245	483.9122
Gender	1961.157	11213.32	0.861	-20016.54	23938.86
No of labor force	5043.098	4307.606	0.242	-3399.655	13485.85
Education	2199.773	1124.236	0.050**	-3.689218	4403.236

	FarmExperience	-448.1133	372.6484	0.229	-1178.491	282.264
	Size ofland	4946.39	1152.865	0.000***	2686.816	7205.964
	Awareness	8283.471	14976.91	0.580	-21070.73	37637.67
	Livestock	344.756	1174.107	0.769	-1956.452	2645.964
	fertility of land	-6633.523	7647.994	0.386	-21623.32	8356.27
	Access to credit	-18423.78	13270.24	0.165	-44432.98	7585.415
	SFMT					
	Yes	11919.52	17402.92	0.493	-22189.57	46028.62
	No	6144.966	10952.19	0.575	-15320.94	27610.87
	_cons	16600.04	21027.74	0.430	-57813.66	24613.58
SFM	Mean income					
Yes	61294.35					
No	28601.02					
p-value	0.0001					

** And * imply statistically significant at 1 and 5% respectively

CHAPTER FIVE

5.1 CONCLUSION AND POLICY IMPLICATION

5.1.1 Conclusion

A remarkable improvement in agricultural Productivity in majority of developing countries in the late 1960s resulted from agricultural Transformation agenda including agricultural research, extension services and rural infrastructural developments that underline the role of technology adoption among smallholder's farmers in increasing production was vital. Technological change in agriculture comprises the introduction of a high-yielding variety of seeds, fertilizers and irrigation. These changes in the agricultural sector augment the productivity per unit of land and bring about rapid increase in production to tackle the severe problem of poverty. Even though, some progress has been recorded over time, the use of agricultural technology is found at its low level in Ethiopia

To this end, this study was conducted to investigate the institutional, demographic and socioeconomic factors that influence soil fertility enhancing technology adoption decision and the extent the impact of soil fertility enhancing technology among smallholder farmers farm income. Accordingly, descriptive statistics and Heckman's two-stage econometric methods were employed to analyze data collected from sampled household. The significance coefficient of inverse Mill's ratio indicates the presence of selection bias and the effectiveness of applying Heckman two-stage models.

The result shows that the adoption decision of soil fertility enhancing technology use was driven by factors such as the size of farm land, size of family, age, availability of family labor force, education status of household head, accessibility of credit service, farm experience, and number of livestock. An increase in the household size discouraged adoption of soil fertility enhancing technology showing that per se does not necessarily mean that farmers have enough labor supply for their farm work. Households who owned large number of livestock are likely to get more manure and those they are likely to adopt soil fertility enhancing technology. Access to credit and better information through information media also motivate to adopt soil fertility enhancing technology.

Additionally, farmers€ who adopt soil fertility enhancing technology earned better average annual farm income per timad compared to non-adopters. This shows that the adoption of soil fertility enhancing technology had positive impact on households€ farm income. Hence farmers should be motivated to use soil fertility enhancing technologies which are organic and inorganic fertilizer and another traditional mechanism to increase soil fertility.

5.1.2 Recommendation

Based on the finding of this study, the researcher proposed the following recommendations

Most farmers have good perception than real implementation is not the same as their perception due to lack of awareness about preparation and application of different soil fertility enhancing technologies like compost. Therefore, concerned body should create good awareness for farmers when, where and how soil fertility enhancing technologies are prepared and used. Although the development agents are available in all kebeles of the district and should be give attention more on sustainable implementation of soil fertility enhancing technology rather than giving awareness only, it was not all farmers who have had extension services and the frequency of contact was low for those who already had the services. Access to credit plays crucial role in enhancing technology adoption. Credit can be obtained from different organizations. Based on the results, having low access to credit on time could result in low adoption of soil fertility enhancing technology adoption. To counter this, the policy makers should target at enabling farmers to get access to credit with low annual interest rate.

Households with more livestock are more likely to adopt soil fertility-enhancing technology. This shows that households with less or no livestock are less likely to adopt soil fertility-enhancing technology. To enable such households to have access to soil fertility enhancing technology especially organic fertilizer, the government and other development partners should encourage commercialization of the organic and inorganic fertilizers. About the farm size, large scale farming should be encouraged. This could be supported through providing training to the farmers which is aimed at the use of soil fertility enhancing technology adoption.

Generally, soil fertility enhancing technology has the potential to increase farmers€ farm income. As such, the smallholder farmers should be encouraged to adopt technology to increase their farm income and improve their livelihood.

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Appendix 1

BAHIRDAR UNIVERISTY

COLLEGE OF BUSSENECE AND ECONOMICS

DEPARTMENT OF ECONOMICS

QUETIONAIRS RESPONDED BY HOUSHOLD HEADS

General direction

Dear respondent,

This questionnaire is prepared to find out ƒDeterminants of soil fertility enhancing management technologies by smallholder farmers and its effect on households€ agricultural income in Dega Damot district„ However, the success of this study highly depends on your genuine and honest response. Thus, the information you provide is highly valuable for the finding of this study. We assure that your information confidentially never disseminates to any other body by any means. Hence, you are kindly requested to answer all items. Thank you for your cooperation!

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

March 2021

SECTION A: HOUSEHOLD CHARACTERISTICS

1. Age ______________
2. Gender ____________
3. Marital status. 1 = Single 2 = Married 3 = Divorced 4 = Widowed
4. Educational status in year

Your household composition:

Age category	Gender		Education (use number)				
	Male	Female	Illiterate	Write and read	Elementary(1-8)	Secondary(9-12)	Tertiary

"d14 years								
14-65 years								
"e 65years								

5. based on question 4, how many of them are females?

6. based on question 4, how many of them are males?

7. What is the number of working (18 years and above) family members in your home?

______

8. What is the major source of your income?

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

4 = if other, specify_________

9. Based on your choice for question 10, what is the state of your employment for the choice you made?

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

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

11. If your answer for question 10 is not agriculture, what is the level of your income per month? Or year in ETB? ______________

12. What is your total income per month/year in ETB irrespective of its source?

____

13. For how long have you been practiced farming? ___________________________

<u>SECTION B: FARM LAND CHARACTERISTICS</u>

14. Do you own cultivated land? 1 = Yes 0 = No

15. If question 14 is yes, what is the size of your land in timad? __________________

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

____

18. Is your cultivated land fragmented?

1. Yes 2. No

19. If your answer is yes, how many plots do you have? ______________________

20. If your cultivated land is not concentrated in homestead, how much time you need to reach

The last plot in minute? ____________________________________

21. What is the position of most your cultivated land?
1. Steeper slope 2. Moderately steeper slope 3. Plain

22. Do you perceive land degradation is one of the major environmental problems in your locality? 1. Yes 0. No

23. Which types of crops are you growing? _________, ______________, ____________,

____

24. How do you rate your plots fertility? 1= infertile 2 = Medium 3 = Fertile

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

26. If question 25 is yes, how many animals? Cattles_____, Sheep_______,

Goats______, Others_______

SECTION C: USE OF SOIL FERTILITY ENHANCING TECHNOLOGY

27. Do you use land management technology? 1= Yes 0 = No

28. If question no 27 is yes, which type of technology do you used?

1=compost, 2=manure, 3= chemical fertilizer

29. If question no 27 is no, what makes you not to use land management technology?

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

3 = Low talent of know how to prepare 4 = Shortage of finance

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

30. If your choice for question 29 is 1 or 4, based on your choice, how much would you have been spending to get organic or inorganic fertilizer for one hectare of your plot in ETB? ____________

31. If question 27 is yes, answer the questions (a-d) in the following table.

a. Which type of fertilizer do you use? 1= Manure, 2 = Compost, 3= chemical fertilizer

4 = other, specify________

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

How many quintals of the following crops do you harvest per hectare in 2019/20				
	When you use compost and manure		When you don€t use compost and manure.	
	Productivity/hec	Income/ha	Productivity/quntal	Income/ha
Wheat				
Maize				
Teff				
Beans				
potato				

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

____

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

d. How frequent do you apply organic fertilizer? 1 = every production season 2 = per two season

3 = per three season

SECTION D: INSTITUTIONAL FACTORS

32. Do you have access to credit? 1=yes 0= no

33. If question 32 is yes, how much did you get last season? _______________________

34. Who is/are the sources of credit?

35. Do you get extension services? 1=yes 0 = no

36. If question 35 is yes, how many times did you meet extension workers in the last season? _________

37. Do you have access to TV, radio or any other social media? 1= yes 2= no

38. is there any farmer€s organizations in your village? 1= yes 2= no

39. If question 38 is yes, how many organizations are available?

____

40. Based on question 38, are you a member of that organization/s 1= yes 2= no

41. If question 38 is yes, to how many organizations are you a member in?

____

42. How many hours does it take to you to reach the nearest market from your village?

____

43. Did you get information about market prices of agricultural inputs and out puts?

1. Yes 2.No

SECTION E: TRANSACTION COSTS

44. Do you produce your own organic fertilizer? 1 = Yes, 2 = No

45. If question 44 is no, from where do you get it? 1 = Market, 2 = from government, 3 = Farmer association

46. If question 44 is not a market, can you get organic fertilizer from the nearest market? 1= yes 2= no

47. Is there any other sources to buy organic fertilizer? (Other than markets) 1= yes, 0 = No

48. If question 47 is yes, how far are these sources from your village in km?

____

4. How long does it take to identify the sources of organic fertilizer in days?

____

49. When you search for the sources of organic fertilizer, what do you use? (More than one option Is possible) 1= Phone call, 2 = SMS, 3 = Internet, 4 = Transportation, 5=others,

50. Based on question 49, how much does it cost in ETB when you use;

a. Phone call __________ b. SMS______________ c. Transport _____________

51. How long does it usually take from searching for to getting the organic fertilizer in days?

____

52. Do you bargain when buying organic fertilizer? 1 = Yes 0 = No

53. If question 52 is yes, what is the cost of bargaining in ETB and how long does it take in time?

54. In trying to get this fertilizer do you forgo any benefit? 1 = Yes 0 = No

55. If question 54 is yes, what is the amount of the benefit you forgo in ETB?

____

56. If question 54 is yes and the total amount of the benefit is unknown, list the benefits you would have obtain.________, ______________, _____________, ______

SECTION F: FARM PRODUCTIVITY FOR SELECTED CROPS

Only by non-adopters of any fertilizer)

57. Fill the following table based on your plot productivity. Your answer should only include those crops you have been producing from the listed crops in 2019/2020

How many quintals of the following crops do you harvest per Timad?	Productivity/ti	Income/quntal
Wheat		
Barley		
Maize		
Teff		
Bean		
Pea		
Potato		
If other		

Appendix 2

For key informants

1. Do you perceive the current available land is enough to the community to produces yield for feed households?

2. For what purpose you utilize your land?

3. Most lands in your locality are fragmented? What are advantages and disadvantages of fragmented land? Explain in detail.

4. Do you perceive the reduction of soil fertility is the major environmental problem in your locality?

5. Do you perceive soil erosion can be prevented? How to control it? What are the methods that you perceive for soil erosion control? What are the measures currently you apply?

6. Do you use both traditional and modern soil conservation measures? Which one more effective to prevent soil erosion?

7. Do you perceive soil fertility can be maintained? What are the measures that maintain soil fertility according to your perception? What are the methods that use to increase soil fertility?

8. Do you apply both chemical and organic fertilizer? Which is more effect according to your view to enhance soil fertility?

Appendix 3

Variable	VIF	1/VIF
Awareness	4.89	0.204686
Farmer organization	3.98	0.251092
Family size	3.9	0.256170
Number of labor force	3.65	0.274130
Access to credit	3.58	0.279118
Fertility of land	3.02	0.331566
Age	2.82	0.355131
Gender	2.33	0.428890
Extension service	2.32	0.431000
Educational status	2.11	0.473489
Position of land	1.93	0.517827

Farm experience	1.85	0.539204
Size of land	1.84	0.543945
Livestock	1.82	0.548829
Fragment land	1.5	0.665927
Off-farm income	1.2	0.833018
Marital status	1.08	0.923590
Mean VIF	2.58	

Appendix 4

Probit regression   Number of obs = 222

LR chi2 (16) = 230.63

Prob > chi2 = 0.0000

Log likelihood =-37.036798   Pseudo R2 = 0.7569

SFM	Coef.	Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Age	-.0563627	.0165251	-3.41	0.001	-.0887512	-.0239741
Gender	.7651959	.5707345	1.34	0.180	-.3534232	1.883815
Education	.0912022	.0517363	1.76	0.078	-.0101991	.1926036
Family size	.3618669	.1707307	2.12	0.034	.0272409	.696493
Number of labor force	-.2938709	.2134821	-1.38	0.169	-.7122881	.1245462
Fragmented plots	.1935787	.170343	1.14	0.256	-.1402874	.527444
Position of land	-.9703738	.4061	-2.39	0.017	-1.766315	-.1744324
Awarenes	1.944726	.7691653	2.53	0.011	.4371894	3.452262
Fertility of land	.3699828	.3904134	0.95	0.343	-.3952133	1.135179
Livestock	.1719775	.0558872	3.08	0.002	.0624407	.2815144
Access to credit	1.753344	.5265933	3.33	0.001	.7212403	2.785448
Extension service	-.8814073	.6592244	-1.34	0.181	-2.173463	.4106487
Farm organization	-2.117534	1.064581	-1.99	0.047	-4.204074	-.0309933
Farm expriance	.0400703	.0238025	1.68	0.092	-.0065817	.0867224

Size of land	-.0266216	.067767	-0.39	0.694	-.1594425	.1061993
Off-farm income		.0000262	0.71	0.476	-.0000327	.0000701
_cons		1.127909	-0.02	0.983	-2.235045	2.186276

Appendix 5

Marginal effects after probit

y = Pr(SFM) (predict)

= .5178656

Variable	dy/dx	Std. Err.	P>|z|
Age	-.0224629	.00664	0.001
Gender	.2950233	.20149	0.143
Education	.0363479	.02061	0.078
Family size	.1442192	.06793	0.034
Number of labor force	-.11712	.08506	0.169
Fragmented plots	.0771493	.06789	0.256
Position of land	-.3867349	.16139	0.017
Awarenes	.6505155	.17102	0.000
Fertility of land	.1474538	.15538	0.343
Livestock	.0685403	.02223	0.002
Access to credit	.6106031	.13617	0.000
Extension service	-.3309547	.22496	0.141
Farm expriance	.0159697	.0095	0.093
Size of land	-.0106098	.02701	0.694
Off-farm income	7.45e06	.00001	0.476

Appendix 6

Heckman selection model -- two-step estimates Number of obs = 222

(regression model with sample selection)

Censored obs = 98

Uncensored obs = 124

Wald chi2(11) = 35.77

Prob > chi2 = 0.0004

	Coef.	Std. Err.	Z	P>|z|	[95% Conf.	Interval]
Level of agricultural income						
Age	-1118.81	447.7562	-2.50	0.012***	-1996.396	-241.2238
Gender	-21402.92	20467.11	-1.05	0.296	-61517.72	18711.88
Maritalstatus	-5134.409	3201.229	-1.60	0.109	-11408.7	1139.885
Edustatus	3465.925	1291.659	2.68	0.007***	934.3205	5997.529
familysize.	-6386.971	3631.127	-1.76	0.079*	-13503.85	729.9077
Nooflaborforce	8189.485	4169.859	1.96	0.050**	16.71222	16362.26
Livstockown	664.0472	1279.995	0.52	0.020***	1844.697	3172.791
Size of land	2736.872	1184.765	2.31	0.021***	414.7746	5058.969
Fertilityoflan	-5122.184	7411.477	-0.69	0.489	-19648.41	9404.044
Awernessofsfm	111242.7	46763.41	2.38	0.017***	202897.3	19588.0
Acestocredit	26911.49	41352.86	0.65	0.515	-54138.62	107961.6
Farm expriance	1225.27	414.4612	2.96	0.003***	412.9413	2037.59
_cons	162929.8	70359.81	2.32	0.021	25027.12	300832.
SFM						
Age	-.0481842	.0178788	-2.70	0.007***	-.083226	-.0131424
Gender	1.083716	.6613468	1.64	0.101	-.2124995	2.37993
Maritalstatus	.1053786	.1031476	1.02	0.307	-.0967869	.307544
Edustatus	.0923784	.0526069	1.76	0.079*	-.0107292	.195486
familysize.	.3687676	.1734889	2.13	0.034**	.0287356	.708799
Nooflaborforce	.0000123	.0000269	0.46	0.646	-.0000403	.000065
Farmexprance	.0399175	.0251471	1.59	0.031**	-.00937	.089205
Sizeofland	.0663785	.0909538	0.73	0.466	-.1118877	.244644

Fragmetland	-.5806221	.4511233	-1.290	0.198	-1.464807	.3035633
Positionofland	-1.048252	.4005602	-2.62	0.009***	-1.833336	-.2631689
Awernessofsfm	.730355	.7777667	2.220	0.026**	.2059603	3.25475
Fertilityoflan	.2745827	.3953669	0.69	0.487	-.5003222	1.049488
Livstockown	.1640941	.0561082	2.92	0.003***	.0541241	.2740641
Acestocredit	1.570713	.536052	2.930	0.003***	.52007	2.621355
Exteserv	-.768847	.6664695	-1.15	0.249	-2.075103	.5374093
Farmorganaz	-1.753282	1.168474	-1.5	00.133	-4.04345	.5368861
_cons	-.44752	1.402034	-0.320	0.750	-3.195456	2.300416
Mills						
Lambda	14194.08	24441.49	0.28	0.026	62098.52	33710.36
rho	0.38640					
sigma	36734.619					

Linear regression with endogenous treatment Number of obs = 222

Estimator: maximum likelihood Wald chi2 (13) = 65.18

Log likelihood =-2760.9586 Prob > chi2 = 0.0000

	Coef.	Std.Err.	P>|z|	[95% Conf. Interval]	
Level of agricultural income					
Age	3.943852	244.8863	0.987	-476.0245	483.9122
Gender	1961.157	11213.32	0.861	-20016.54	23938.86
No of labor force	5043.098	4307.606	0.242	-3399.655	13485.85
Education	2199.773	1124.236	0.050	-3.689218	4403.236
Farm experience	-448.1133	372.6484	0.229	-1178.491	282.264
Size of land	4946.39	1152.865	0.000	2686.816	7205.964

	Awareness	8283.471	14976.91	0.580	-21070.73	37637.67
	Livestock	344.756	1174.107	0.769	-1956.452	2645.964
	fertility of land	-6633.523	7647.994	0.386	-21623.32	8356.27
	Access to credit	-18423.78	13270.24	0.165	-44432.98	7585.415
	SFM					
	yes	11919.52	17402.92	0.493	-22189.57	46028.62
	no	6144.966	10952.19	0.575	-15320.94	27610.87
	_cons	16600.04	21027.74	0.430	-57813.66	24613.58
SFMT	Mean income					
yes	61294.35					
no	28601.02					