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

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BAHIRDAR UNIVERSITY

COLLEGE OF BUSSINESS AND ECONOMICS

DEPARTMENT OF DEVELOPMENT ECONOMICS

Determinants of Soil Fertility enhancing technology adoptionand its effect on households€arm income in Dega Damot district

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July, 2021

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The Thesis Titled determinants of soil fertility enhancing technology adoption and its effect on households€ farm income in Dega DamDistrict, North Western, Ethiopia

It is approved for the Degree of Masters of Science

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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 theses are properly approved

Mulugeta Alemsha

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July, 2021

Bahir Dar

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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 importancethe agricultural sector in Ethiopia is characterized by low productivite to soil nutrient depletion and low external agricultural inputs The main objective of this study wietentifying the key determinants farmes € decision to adopt soil fertility management technology and its effect the adopted technologies on rural households € farm income inof casega Damot district. The study was relying n crosssectional data from 222 randomly selected households from different agregologies and key informant interews. The data were analyzed using Heckman technologies and simple descriptive statistics using STATA software

The first stage of probit regression results **thf**e study show that the adoption decision of soil fetility enhancing technology was deriven by households € ge, farm size, size of family, number **th**e labor force position of land € ducation, accesso credit, livestock, farm experience and wareness 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 **monst** of the study 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, environental degradation and poverty.

The second stage result show the several fertility enhancing technology adoption increases households farm incompeter timad. This implies that farmers should be encouraged to adopt solifertility 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 oil fertility enhancing technology adoption decision and strengthen the leveloption among smallholder farmers.

Key words: Timadsoil fertility, technologyadoption, enhancement

V

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	SubSahar a 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 ion((Debebe, 2019))While agriculture is growing at 1.6% per annum, the population of the country is growing & trate and thus, is expected to double by ever 2020(Debebe, 2019) his indicates the need to increase the productivity of agriculture to keep pace witthe population to ensurean adequate supply of bod in the future. Accordingly, the government has started on a massive agricultural extension program since 1994/Becilia ate the use of improved crop production technologies, keey 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 promotee its

Ethiopia is one of the fastestgrowing economiesfrom developing countries Africa. In the last decade, the EthiopiEnconomyregistered growth of 11 percent per annumon average in Gross Domestic ProduceD(P), (MoFED), 2014) compared to 3.8% for the previous decade (World Bank, 20) as cited in (Biru, 2016). In case, it is rated as one of the fastest growing -rodnexporting economies in the world. Accordingly this growth has beebasically supported by relativelyhigh growth in farming (MoFED, 2012). Hence the role of agriculture the Ethiopianeconomy cannot beunderscoreBut, it is undermined by land degradati(schibiru, 2010)

Land degradation sub-Saharan countries is largely an outcoon the existing agricultural production system which is sources of poor agricultured ctices characterized by incertain rainfall and low inherent land productivity

(Alelgn, 2011) Agriculture-basedlow-income countries reverse the decline of land productivity resulting from environmental degradation, and ensuring used to supplies to the fasgrowing population is adifficult challenge. Agricultural technologies playan immense role in increasing food productivity herefore, agriculture is useful to examine the adopt of technologies among households Agricultural technologies are said to include all kinds of improved techniques

practices which affect the growth bagricultural 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 managementechnology is the best solution to increasing households€ income by improvsoil fertility and to reducinthe use of organic fertilizer(Jain, 2009)The adoption of compost,hemical fertilizer, manure technologies and sustainableagricultural practices that enhance agricultural productivity and improve environmental outcomes remains themost practical option to increasehouseholds€ come food security and poverty alleviation. The adoption of compostand manuretechnology is very important forsmall-holder farmers by reducing theost offertilizers (Biru, 2016) The objective of this study will to assest the determinant of soil fertility managementechnologyadoption behavior of smallholde subsistene farmers and its impact orhouseholds€ income

Dega Damot woreda is a comfortable place and the main source of households€ income is agricultural product. But agricultural productivity is reduced gradually due tobe 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, soeicconomic factor and the like affects agricultural productivity. Despte the achievement in addressing these constraints, fertilizer use among smallholde farmers remained below expectations thus necessitating further investigation into the emerging determinant of fertilizer use among smallholde farmers in the highland of Ethiopia.

1.2 Statementof the problem

In Sub-Sahara Africa (SSA) countries Jow and declining of soil fertility due to net nutrient extraction by crops and soil erosionare responsible for low agricultural productivity and food insecurity (Hassan 2010; Nakhumwa and Hassan 2012). According to Sanchzeet al. (1997) indicated that among other, sthe breakdown of traditional soil nutrient managemenpractices because of population pressures responsible for nutrient depletion in SSA But, different researchersargue that population pressue induce house hold to strengthen agricultural production invest in land improvements and develop land saving innovations eventually resulting in enhanced esource 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 decreasisgil nutrient degradation due to poosoil fertility managementSince the 1970s; the Ethiopian government has intervenedthe agricultural sector to overcome this problem through the promotion of various land ansbil managementechnologies such accompost and manure However soil degradation has continued leading to decline in agricultural productivity (Alelgn, 2011) Low agricultural productivity, poverty and soil erosion areclosely related problems Ethiopia Farm productivity in Ethiopiais very low asa result of lack of agricultural inputs, due to outdated farming, deforestation, overgrazing, declining-oil fertility, and continuous soil erosion, depletion forganic matter, uncertain land tenure and recurrent droughts, all in combination high population pressure (Algh 2011).

West Gojjam is naturally endowed with ample natural resources and good potentialto producæcosystem service 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 a (Sitemane et al 2016). Soil resource under intense pressure from population grownth poor management, and it erosion are very serious and its adverse effect agricultural production has been continuous. As a result, the livelihood of the farming commity faces sever constraints related soil erosion, soil acidity, the decline of soil fertility, water scarcity, and shortage of livestock fodder.

DegaDamot woreda isone of the marginalized woredas found in west Gojjam. The woreda ischaracterized 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 productity of the soil has been abjectly declining the last few decades

and without fertilizer most land does not produce good agricultural products. Moreover, some land giseoff their service to the community. The port of the district agricultural development office showed that fertilizer to be land ratio in the district was 810 kuntal organic fertilizer petimad whereas the recommended level was 1520 kuntalorganic fertilizer and above 100 kg inorganic fertilizer pierrad. This is another reason which has made this arebae chosen for the study to identify constraints of soifertility enhancing technologs doption 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 incomessend the usage and adoption of those technologies are below the recommendation fill this gap this paperwas intending to evaluate which factors affect the adoption of soil fertility management technology and the impact of soil fertility enhancing management technologies households for the impact of soil fertility enhancing management technologies households.

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 watso examine factors affecting the decision to adopt soil fertility enhancing practice and its impact on household €a gricultural incomein Dega Damot district.

1.3.2Specific objective

- ðØ To idertify the factors that affectarmers€decisionto adoptsoil fertility enhancing technologies
- ðØTo evaluate the impact of soil fertility management practiceshoounseholds€ farm

income

ðØ To identify soil fertility managementechnologies used by households€.

1.4 Research question

The main research questions settlecaddressed by this study are;

- ðü Whatare soil fertility technologies used by farmers in Dega Damot district?
- ðü What are theactorsthat affectfarmers€decision to adopof soil fertility management technologies in Dega Damot distract
- ðü To what extentsoil fertility management technologi**es**loption improvehouseholds€ cropincomein Dega Damo?

1.5 Significance of the study

Farmers are not always adopting the newly introduced technologies that come to them from any extensionorganization as it is So understanding **e** factors is important forscientists to develop and generate agricultural **ntelct** gies, which suit the current conditions of farmers. There are several reasons to develop the adoption of soil fertility management technologies. These contain improving the effectiveness of technology generation, to assets effectiveness of technology transfer, understanding the role of policy in the adoption of **rægu** icultural technology, and signifying the impact of investing in technology generation participation of farmers in technology development throut 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 succest the adoption and its impact on agricultural income.

1.6 Scope of the Study

The study wassessed to identify the kelepterminants offarmer€slecisions on theadoption of soil fertility enhancing management technologiese(compos, manure and chemical fertilizers) and impact on households for cultural incomein the rural area of Deca amot district

1.8 Limitation of the study

The researcher had encountered the following limitations:

ðØ The absence of the previous research on related problem on study area. ðØ Thestudy 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, ignificance, scopelimitation 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 arectsonic profile of the study area; research designd 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 researcheeviewsdifferent existing researces 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 exapling in farmers (disa)dopt new practices, there seems to be growing concern suggesting that focus shold 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) naking 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 poputatiosures, a combination of manure application, mulching and intercropping with scientisted approaches to soil fertility management remains plausible.

Various studies have been conducted to understand factors that motivate farmers to adopt inproved soil fertility management practices (Baum@ærtz, 2008(Pulido, 2014) In addition, theoretical frameworks have been used to understand and explain the adoption behavior of farmers including the diffusion of innowæti (Rogers, 2003), planned behavior and reasoaetior(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 driver fadoption. Besides, efforts to relate farmers€ attitudes and behavior to personal, contextual and farm attributes have largely failed.

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

2.1.1 Definition and concepts of technology adoption

Technology defined as the knowled by at 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 absene of technolog (Bonabana Wabbi, 2002)

(BonabanaWabbi, 2002) defines adoption of technology as the decision to accept that technology i.e. the decision of an-used to accept an introduced or existing technology. Adoption of an agricultural technology accordin(@comabana 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 o(meonabanaWabbi, 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 preexisting 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 we 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 tise use or non-use of a new or improved technology by in individual or farmer at a givenepiod (Bonabana Wabbi, 2002) Additionaly, technology distribution is defined at process by which a technology is communicated iroughout certain channels over timeetween the members of social systems is 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 heating ut the technology and ends with its final adoption or rejectio (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 instrumented of simple expansion of agricultural land which might hazardous toneironmental conservation. In support of this, several studies shown that sufficient agricultural technologies are available in developing countries integrease agricultural productivity. Although literature on to the existence of sufficient agricultural technologies in Subsaharan Africa to increase food production, an appropriate policy environment coupled with an active technology transfer program has been (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 adoptionand Sustainable agriculture

According toTagel (2018)the definition of technology diffusionsummarized 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, technology 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 agel, 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 the telement of time in the adoption of a given technology to the farmers.

Sustainable agriculture is an agricultural system involving maixture of sustainable production practices incombination with the discontinuation attraction enduced use of production practices which are potentially harmful to the environme (Bahekani, 2020) This idea is concerned with developing pricultural technologies which do not adverselyinfluence the environment, effective anetasily accessible to farmers and results in the improvement of food production and hapobsitive 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 hazausdand hence, meets future generation€s food deman(**R**sorter, 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 Portler, (2 sustainability implies that naintaining economic productivity whilst being concerned with natural foundation, social implications, and impacts of farmangivity. Thus, this involves developing production systems that are resilient and hence, can continue for the indefinite future.

2.1.3 The use ofsoil fertility management and its impact onfarm income

Fertilizers are inorganic or organic plant fottbrat may be liquid or solid used to amend the soito improve the quality and/or quantity orfops produced. They are materials that are added to the soil to supply elements needed for plant g(root/ordert, 2013 They raise soil fertility thus theobility of the soil to provide plant nutrients and resources that support growth by creasing plant nutrients during the cycle of growth and decay. They analso reduce the cost of production since they can raise yield with marginal increases in total cost per hec (are bert 2013).

There are two broad groups of fertilizers: 1) organic fertilizers, and 2) **inio**rga 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 *f* organic, 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 ntaritor 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, farmersonally 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 20(Robert, 2009)Agricultural productivity can be achieved by producing more per unit of land with agricultural inputs or via expansion of area under cultivatior(Hailu, 2014) However, land expansion is less possible gisenes involving urbanization, poor infrastructure and technologenvironmentalconcerns, 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 intersificatior(Bhekani, 2020)

Agricultural intensification is defined ascreased average inputs of labor or capital on a smallholding, either cultivated land alone or on cultivated parzing land, to increasing the value of output per hecta (Bahekani, 2020) Therefore, agricultural intensification can be defined as an increment in agricultural production per unit of inputs (for example, land, labor, fertilizer, etc.).cfPrcally, intensification is achieved whethe total production is increased cause f enhanced productivity of inputs or when agridural production is sustained/hile other inputs are reduced (FAO, 2004). Agricultural intensification can be achieved rdbgh either of the following: a) increased gross output in fixed proportions as a result of a proportional increase of inputs, b) transmission wards more valuable inputstechnical improvement which enhances land productiv(@arswell, 1997)

According toAlimi (2006), agricultural intensification is a critical way of ensuring sufficient production in smallholder farming venthough agricultural intensification can be viewed as a tool for simultaneously alleviapiogerty 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 environme(Atlimi, 2006).

Even if there are no external inputs ply to repair nutrients consumed by crops and washed away by soil erosion, plots of land require to be rested unplet ughed for longer periods. However, due to increasing demands for food in Africa, this has become more difficul (Bhekani, 2020) As a result, this necessitates the application of mineral fertilization as one of the important inputs in crop production trancecrop yield and soil fertility. The meral fertilization process involves the use of manures and inorganic or mineral fertilizers which supplement plant nutrients to soils characterized by low ropoor fertility and it begarabout the year 1880, ebame practiced commonly in the 1920s and it was adopted largely since (Re§02006)

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), (Hussaik G& pta, 2014) Inorganic fertilizers are also known as mineral or chemical fertilizers, and they have relative that are released quickly for plant uptake as compared to organic fertilizers which require time for decomposition before they are consumed by the crop (Matotris 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 seascenther basally during planting or toop eased 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 struetoute which consequently leads to soil erosion and nutsideaching (Morris et a2007). 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 encouragetse formation of crumb soil structure thus improving soil drainage, infiltration and aeration. The dark colors€ that form with increasing organic matter content improve soeintperature relations with an effect of boosting important microbial activities and root developmentganic fertilizers include manure and compost. Manure is mainly from farm animals and other livestock. They are the droppings of poultry, ruminants daother animals that are rich in nutrients (Bary, 2004)

Organic materials are decomposed in composting plants under controlled conditions to produce the end product is used as a fertilize Compost canalso 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 septoduced by farmers. There are available manuals that farmers cause to make their compost. Composts are quite common and easy to obtain (Bary, 2004)

According toBary (2004),uncomposted manure is sometimes difficult to spread and has a higher potential to degradater quality than compost. Manure is more likely to contain weed seeds but requires a lower investment of time and money, manure has the potentialrfbigher pathogen levels blatss expensive to purchase or acquire compared to compostdors cometimes pose a problem Both compost and uncomposted manure improve the tilth of the soil.

Organic fertilizers mainly constitutenimal manure, compost, animedaste; 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, smatcale farmers who are concerned with ensuring environmental sustainabity, 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 and ing, 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, Oganic fertilizers enhance lortgrm 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 incor(Hessilu, 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 ca be grouped into the following three broad categories factors related to the characteristics of producer 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 innovationtechnology, its availability and that of complementary inputs, the relative profitability of its adoption compared to substitute technologes, the period of recovery of investment, the susceptibility of the technology to environmental hazards, etc.

Similarly, a study by (Tagel, 2018) dentified assets, volerability, and institutions as the main factors addicting technology adoption. Assets deal with the farmers have the requisite physica (materia) and abstract possessions (e.g. Education) essential for technology adoption. Lack of assets will limit technology adoption and it is recommended that develog countries should promote technologies with low asset requirements as they are likely to have higher adoption eartees appoor farmers. Opennes factors deal with the impact of technologies on the level of exposure of farmers to economic, biophysical area bical risks. Institutions comprise all the services to agricultural development, such as finance, insurfarcities and

mechanisms that enhage farmers access to productive inputs, prod informationspreading, embedded norms, behaviors and practices in society.

According to(Tesfaye, 2008) he Sshaped 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 inform(atiosfraye, 2008) Hypothesized that the Sshaped diffusion curve is meaning of the extent of economicvalue of the original technology, the amount of investment required to adopt the new technology and thevel of ambiguity associated with the new technology (Tesfaye, 2008)

2.1.7 Importance of Agricultural Technology

Agricultural technologyis an action designed to improvexisting meansof agricultural production. Therefore, agricultural technology is one of the resources in agricultural production (Chi and Yamada, 2002) he 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 lo 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 specifictechnology by the same farmer. The extent of adoption is determined by the knowledge on a new technology an ofgioloh @01/2), decision farmers The objective of the farming community is to increase adtigral 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 ufficient agricultural technologies are available in developing puntries to increase agricultural

productivity. Although literature pointsout the existence of sufficient agricultural technologies in SuSaharan Africa to increase fopd duction, an appropriate policy environment coupled with an active technology transfer program has been lacking (Makokhaet al., 2001 as cited inBiru Gelgodube in 2008 To improve this, several studies have been conducted uggesting the importance of agricultural technologies for better agricultural productivity.

According toUaiene etal. (2009) the issue of improving agricultural productivity can beaddressed by he adoption of better agricultural technologie are adopted in 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 endorance agricultural productivity. To ensure this sustainability was important to address core problems related to availability of agricultural technologies for farmers. This helps to ensure that smallholdershave access to regist technologies in the form that is appropriate to their local conditions accompanied white right information (IFDC, 2012). In Ethiopia farmers have little chance to adopt new agricultural technologies on their farmsdue to several constraints such as low human cappitalarily low level of farmers€ educatio (6 pielman et al., 2010).

2.1.8 Factors influencing the choiceof soil fertility enhancing technology

The adoption of soil fertility enhancing technology has been linked to everal factors. These are broadly categorized into economit to factors and noneconomic factors. Economic factors mainly focus on price, costs and/or returns to factors of production while noneconomic factors include social, cultural, community, institutional and plitical 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 ratein condet. Others, such at the level of education and steepness the slope, are frequently found to influence adopton. Some variables, such as farmer age and farm size, are positively correlated with adoption in some studies but negatively correlated in others.

2.1.81 Economic factors

Economic factors that influence fertilizes among others indesthe price of fertilizer, price of other inputs that complement (for example, seed) or substitute fertilizer use, price of croprevenue and opportunity cost elated with production and marketing risk. The empirical literature suggests that fertilizer use is sensitive to changes in its price as yell as the price of cropts 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 copri of other types/brands of fertilizer (dorthy, 2017) The price and/or availability of other inputs that complement and enhance fertilizeproductivity, for example, hybrides dand irrigation, also play an important role infarmer...s decision to use fertilizer. Similarly, the price and/or availability of other inputs that substitute a variety/brand of fzetilas 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 armers in SSA is one of the major factors that make them reluctant to unseitoput. (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 trigh variability of crop yields and theigh level of fertilizer costsrelative to crop prices(Smaling, 2006) dicate for example that farmers in Africa require 611 kg of grain to purchase one kg of nitrogenous fertilizer compared with about-23 kg of grain in AsiaHigh fertilizer prices in SSA are mostlyattributed to hightransacton costs of fertilizettrade arising from high transportation costs, high interest rates and low volume of purof (assessory, 2017)

The decisiormaking process to adopt new agricultural practices depends on both intrinsic factors such as knowledge, perceptions **autitu**des and extrinsic factors such as the characteristics of the farmerge education, social networks ming 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 (detth), 2017)

2.1.82 Non-economic factors

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

Gender of householplays an important role in farmese decision on the adoption of soil fertility management echnologies. A recent study (Mayenga, 2008) ndicate that use of agricultural inputs including inorganic fertilizer in Uganda is more prevalent in male than female adedhouseholds.

2.1.9 Soil fertility management technologypractices

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 theourtry 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 varisous fertility maintenance technologies whether they use or not be 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 **cide** 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 timespan offallow periodis varied according to the soil. Reguidsoils were commonly left fallow for one year, while rekik soils were left for two to three yea(Shiferaw, 2010)

Crop rotation: As fallowing, crop rotations no longer possible they now rotate crops on the fields away from their homesteads, which ain 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 and arlearley, 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 croppield more than rotations based solely cereals However, crop rotations in the region are dominated by cereaschoice of crop rotation is mainyl influenced by the desire to reduce there d 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 wate 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 withykinformants 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 useiment dung for domestic energy.

Livestock hasvarious functions in the production system. Oxen are essential and indispensable for preparing land and threshing grain, and farmers keep cows, sheep and goatsas a source of stable income. Poultry prevideod and cash, and donkeys are used fortransport. The existing livestock management system does not include practices for improving the quality of manure roManure is an important input for maintaining and enhancing soil fertility. Farmer € distinguish between two types of manure; zikereme dukie or hussend zeykeremetukieor aleba (Shiferaw, 2010) The first type of manure is gathereen allowed to decompose durither rainy season.

The Aleba manure is collected diving the dry season and does not decompose as much as the other type of manure hatsless direct effect on croypields.

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 Alegn (2011), farmers prepare it from livestock dung, plant leaves, various weeds, use hold 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 labtorce about preparation system it is a cause of thisease (locallynich ena gunifa) since it has high evaporation and bad oddat(ote ena kirifat) during its preparation time and compost preparation is taking a long period a minimum threetmsountil it fermented. Compost is prepared above ground (heap) during thewet season and below the ground (pit) during the dry season (Shelemew, 2005) and (Alelgn, 2011).

2.1.10 Overview of soil degradationin Ethiopia

Ethiopia isone of the least developed countries where agriculture had always played a central role in the country€s econd Enven though agriculture has always been the basis of the economy, its characterized by stagnant growth rate and a declining trend. Thiss 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 assef 2007) The farmers€ perception is not in agreement in scientific knowledge that acknowledges livestock vait babove carrying capacity ograzing areas and deforestation as major causes of soil erosion. is also important to discuss various factocausing a difference perceptionabout causes of soil erosion among locape ople as this will most likely lead to solving or arresting problems considered not critical withmost of the rural community. Education is one fact that appears to fully environ of the rural community. Education is one fact that appears to fully environ and degradation in Ethiopia (Fikiru, 2009; Fitsum et al., 2002\$oil erosion reduces soil productivity mainly by

harmfully affecting soil nutrients, infiltration of water and air into the soil, soil water holding capaity, 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 plantgrowth. 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 ero(sitering, 2011)

To gain further insight infarmers€ knowledge of landoductivity and how it was affected by erosionfarmers wereinterrogatedon what criteria they used to determineGoodsoils. Discussion with key informants proved that farmers in the study area divided their land into several plots for various purpo fearmers classify fields based on certain critical criteria. In this study osoby fertility enhancementriteria were considered specifically level of soil fertility and crop income in the study area most field holdings tended to the territe (W/Mariam, 2005) from the very steep hill slope to Gentle slope segments. Therefore farmers were in a position express their perceptions for each slope position adver the country was estimated to be ab20 to be ab20 to to specifically level of percent occurs on crop farmlands and 21 percent occurs on vergrazed rangelan (#shibiru, 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 **vits** ceserves and through external applications for crop production. It combine a number of soil properties (biological, chemical and physicalall of which affect directly orindirectly nutrient dynamics and accessibility. Soil fertility is a controllabaeil property and its management has greatest importance to optimizing crop nutrition on bothteshoatnd long-term source to accomplish sustainable agricultural productivity. Soil productivity is the ability of a soil to support crop production deterned 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 on the live getation 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 eith 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 ibased high-production systems can be building. Soil scientists classify soils by different classification systems earlier times, the classifications at national level were be based on easily familiar features and relevant soil properties for cropping ty Beilnames were generally well understood by households€. Even on a higher classification level, the partition into zonal soils (mainly formed by climate), intranal soils (mainly formed by close relativematerial or water) and onal soils (young alluvial soils) was easy tookin Modern and globascale 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 Organizatio (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 farmepærate. 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 completentry inputs and inappropriate transportation infrastructure as key constraintsheorapid adoption of innovations in less developed countries armers with bigger land holding size are assumed to have the ability to purchase improved technologies the capacity to be the risk if the technology fails Some new technologies are relatively desaving and others are labor-using. For those labor using technologies, like improved varieties of seeds compost, manure and fertilizer labor availability yslæsignificant role in adoption (Kebebe, 2015)





2.2 Empirical literature review

2.2.1 Soil fertility management technologypractice

Soil fertility is declining in many parts of sußbaharan Africa (SSA) (Mitiku, 2010) One of the major constraints to crop production faced by smallholder subsistence farmeris the inadequte supply of nutrient (Mitiku, 2010). The use of mineral fertilizers is declining as they are increasingly beyond them snef most small-scale farmers (Mitiku, 2010). Erosion and scere runoff are extra depleting existing soil nutrient reserves, while levels of societanic matter is declining when, land is subject to overuse. Sustaining soil fertility has become a major issue for agricultural research and development (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 specifice anglogical

locations. Sincehen, 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 biologicprocesses of SFM and aims to promote options that make the besste of locally available inputs.

2.2.2 Agricultural income measurement

Agricultural incomeis a measure of the efficiency with which inputs are used in agriculture to produce anoptimal output (EEA 2002, Ruttan 2002), Crop incomeis said to be optimal when the combination of inputs produces a maximum output. Its measurement is an important tool for planning and developmentiates (endalew, 2011). Increased production is important if it is a result of impropresed uctivity. The most conventional measure of productivity is to divide total output by a composite index of all inputs used in the production process (EEØ22, DayaRuttan 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 inputatios change value v

2.2.3 Factors affecting farmer€sknowledge and perceptions orsoil fertility managementtechnologies Ethiopia

There are different literatures Ethiopia about determinants of farmers€ adoption of soil fertility management technology in different parts lose to country written by different research organization as different literature reveals that, there are different factors that affect farmes€soil fertility management technology adoption decision Some of the factors that affect farmers€ decision on soil fertility management technologypractice are explained bellow.

Awareness about the soil fertility enhancing technology adoption is often influenced by farmers€ access to information (Bauth@etz, et al2012 Lambrecht, Vanlauwe, Merckx, &Maertens, 2014; Prokopy, et a2008) and social networks within which the farmers interact (Greiner, et al., 2009; Knowler & Bradshaw, 2007; Pannell, et al., 2006). Access to information increases farmers€ awarenessed(htamb Vanlauwe, Merckx, et a2014) and evaluative capacity of existing soil mamagnt practices (Prokopy et a2008, cited as(Naboth, 2015) This in turn influences
farmers€ views about the practices (perceptions) based on their felt needs and prior experienceBesides technology attributes, studies suggest that farmers€ perceptions towards adoption of soil fertility management practices **arreng**ly linked to their experiences and knowledge about the practices in question (Meijer, et al. 2015; Reimer, et al. 201)2 For instance, (Meijer, et al. 2015) argue that the knowledge farmers have about a new practice closely relates to their perceptionards 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 th**(M** wangi M. a., 2015) Farmers might identify that the performance of the technology being introduced is better than the earlier technologies. However, though they happensitive perception about the specific technology, the may not adopt ibecause of a lack of know 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 coinducted shashemenoin adoption 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 filteradoption of this technology. However, in Ethiopia, specifically iDegaDamot 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**hers€ 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 Stateidwest region (Naboth, 2015)

Livestock: The results of a study conducted in shashemeni on adoption of agricultural technology showed thistcrease he availability of manure, which may be applied to the soil to increase if fertility. However, specialization on livestock rather than cropping may reduce investment in crops in terms of soil managementetu, 2011) In different studies livestock, ownership was assumed to increase availability of manure and Hypothesized that ownership of cattle increases

likelihood of adoption of manure and its integration with inorganic fertilizers. Income from off-farm labor (Offincomes) may compensate for missing and imperfect credit markets by poviding ready cash for input purchases as well as for other household needs thus increasing probability of adoption. In addition, offarm income may increase the ability of households to bear the risk associated with technology adoption.

The major constraint to be adoption of organic fertilizer was found to be low livestock holding. This was reported by about 26.58 percent of management 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 w adoption rate of organic fertilizer.

Lack of adequate labor was the second constraint **the** adoption of organic fertilizer. Organic fertilizer adoption is relatively labor tensive 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 **ptison** decrease.

Inadequate knowledge related to organic fertilizer adoption in terms of compost preparation was another constraint the adoption of organic fertilizer. This was reported by about 69.68 percent of the **-radio**pter household (Biru, 2016) noted that the preparation of organic fetizitier is knowledgeintensive. This implies that low skills related to the adoption of organic fertilizer could limit adoption of organic fertilizer as farmers may face difficulty inpreparing this fertilizer, specially, composting which has been commonly used in the study area. High transaction costs associated with adoption of organic fertilizer were so one of the reasons reported as constraints of organic fertilizer adoption this fertilizer from other sources. For such farmers, high transaction costs coupled with their low capacity to provide finance could the it adoption of this fertilizer.

Education: of the farmer is considered 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 informatio(Naboth, 2015) While most studies consider education in terms seeveralyears of formal education, the categorization of education by (Baumgat6etz et al. 2012) seems more appropriate. Intrest 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 meeds 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 so**d**inservation practices begins with their perception of erosion as a problem. These perceptions are shaped by **faemsers** fill characteristics (e.gage, education, conservation attitude, norms beliefs) and the physical characteristics of the la(**red**g.slope). Most of the studies have valuated he household heads € education level as the main determinant **ca** foil fertility managementechnology adoption. However, even though the household head is not educated, if the education level of any of family **mbe** r is higher than that of the household head, this may affect their decision to adopt new tech **(Nelegyg**n, 2011) Thus, there is a need to evaluate technology adoption based on the highest level of education of any of **t** household €s family members. In cont**(Haist**u, 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.

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

Most researchers believe a priori theaducation of the household head positively related to technology adoption Many studies report that education has a

positive impact in the adoption of impored natural resource conservation technologies (Alelegn, 2011.) Education was measured as years of formal schooling of the household head. Because the survety explinition of a knowled gretensive, higher education is prected to increase probability of the adoption of soil fertility enhancing technology ractices.

Age: Other investigations done by Biru (20,160)n farmers€decision to wards adoption of technology show that ge of the household head (Age) in explaining technology adoption is somewhat orconversial in the literatureOlder people are thought to be reluctant to change their old ways of doing things. The influence of age was analyzed from perspectives of risk version rather than time lag (planning horizon) because the technologies under the study yield beinetfites relatively short term. Therefore, because the use of inorganic fertilizers and oftsbination of inorganic andorganic fertilizers is a relative new phenomenonthe 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, whicting used to increase soil fertility as result of agricultural income

Off-farm income: as Alelgn(2011)suggested thatff-farm incomes positively associated with adoption of soilfertility management technology According to Tagel (2008) offfarm income is a dummy variable that denotes whether or net off farm income was the main source during two crop growing sease the 2006 long rain season. Because all the surveyed inputs either require cash for purchase (inorganic fertilizers) or for ming 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 the implications.

Most studies agree thatabor scarcity (Labor) is often an operative constraint in farming systems. The effect of thatbor availability often depends on whether the new technology islabor-saving orlabor-using. When facing abor shortages, farmers may be less likely to adopt abor-increasing technologies and there would apply to adopt labor-saving technologies E(atz, ET. al. (2003) He states that Kenyan dairy

farmers, who faceabor shortages, were unlikely to adopt dairy technologies that require morelabor. Labor availability was measured as the proportion of household members who contribute to farm work. The practices studied he**tebane**intensive and high availability of labor whether household or hireleabor is hypothesized increase the probability of the adoption of all the studie **G**FMT practices.

Extension service several adoption studies have shown the significance of extension education dhe adoption of landmproving technologies (Pattanayak et al. 2003). According to (Bonabona et al, 2006 Informatisnimportant forthe adoption of complex innovations such as Integerat Pest Management (IPM) Access to extension is indexed as a dummy denoting whether or not the household access to extension services with five yearsbefore the study. This variable wate ypothesized to be positively associated with the adoption of the relatively …new€ practices such as inorganic fertilizers and a combination of ingenic with organic fertilizer.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Description of the study area

The study area is drained by boothing poral and permanent rivertisis 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 areGimbara, GumaraFendika andKechem These and otherivers and streams are used for both human domiestand livestock consumption. Tooome extent rivers and springs are used for irrigati(Alelgn, 2011)

Figure 3. 2 Map of the studyarea (preparetion Ethio-GIS database)

As it has been explained by the District ruddelvelopment experts (2011) well known type of soil found in the study area include, nitosols (locally known as key shekilama afe) which typically found inhighland of the District and the other soil types is camisoles (rebor afe) this kind of soil also by and large found winona degaand in steep slope areas it is not as much of fertile. The other familiar soil type is vertisoil (locally merery orwalika afer) this soil type mostly covered the low land region in the vast kolla agro-climatic zone. This soil property is quied trying and logging by its nature.

3.1.2 Climate

Climate is one of the major physical factor that shappeehuman 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 aretionariatopography its climatic zone also different altitude such that the major agotimatic zones of the study are 75 percent Dega(Temperate), 20 percent Woina Dega(pittal) 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 anximum temperature is occurring from mid March to midApril where as the coldest temperature is on the other hand occurs in July and August because the skips covered by clouds throughout the dagega Damot District has a unimodatorm 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 summerk (remit) season and the imagricultural activities takeplace during that time. The average maximum annual fall occurs in July with the amount of 25.3 mm and the minimum annual rainfall distribution is before with in different agro ecological zone so that Dega part has better rainfall **Main** a Dega and in asimilar way Woina Dega's also better thak on region.

Table3. 1: Average maximum and minimum monthapinfall distribution of Feresett 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 agencologic climate and topography there are a variety of vegetations that covered landorms. 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 reducing reducing in number and species.

The indigenous natural plants in Dega Damote District include abmoo (Kerkeha), Scheflera Getem), Acacia (Gira), Ficusvasfa (worka), Ficus Sholla), Oliva (woira), Haginia (Kosso), Polystcha (Anfar), Bensa (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 traces mostly concentrate in churches and river banks and some trees also famend on farm lands and communal grazlagds. Bamboo forests are the dominant indigenous forest that playeat role for financial sources for the District because it is exported to other cities seguing his. Kossois rare spices among the most endangered spices trees in the study area, which is becoming extinct now form different places. Eucalyptutsprests have been the dominant introducetrees for the last three decades because it can adapt almadistaging ecological zones and by its nature is fast growing and multiplying easily (Animal dung and crop residuals are the major sourcestomestic energy next to fuel wood. No other alternative source in all rukaebeleseven urban has got ecliectpower since 2011(DDDRDO, 202)1.

3.1.4 Land Use Pattern

The land use pattern in Dega Damot District is dividing inseveral functions. These include: crop land constituted 38.4 percent, uncultivated land also

accounts10.5percent, Settlement (for housing and institution constriction)1shāre percent, forest cover 11.5 percent, bush land also contains 5.9 tperassiure land constitute 18.5percent and other like road, water and swamp lands 2o9eprerceth This figure shows crop land share large amount of land area and forcest is calso 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 nectare	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,	1940	2.9
Water,swamps land		
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 ofnihabitants practiced Ethiopianttodox 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 theabove figure it can conclude that 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 ner population proportion has greatfelifence. This indicates theretost the populations found in Dega Damot District are rural dwelleropulation settlement in Dega Damot District is scattered and dispersed. The majority of the population is settled infoot hill side by forming small village with small number of people and the average population density is 27 person per ha.

3.1.6 Economic Activity

Agriculture is merely economic activity exceptor urban dwellers. Almost all people depend on themsive agricultural activities. Everthough the majority of the population depends on this sector, threeduction level is very low. Due to back ward agricultural activity, low technology, soil erosion, deforestation anærmaing population growth. As æsult of this the per capita income of the plecip very low and decreasing an alarming rate (DDDRDO, 2021)

Agricultural production system in the usely area is crop and livestock these systems are the predominant activities that exist inoveder 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 amoon the dominant crops that are producing includecereals (wheat, barley, teffand maize-), pulses (bean, Pea--), and oil seets (nug, *f* teliba,, Cabage

3.2 Data types and source

Both primary and secondary data sources were toosgedt relevant information for the study. The primary datafrom field observation was collected to answer the research questions which are clesseded and opeended items and achieve the objectives of this study. The primary source of data could be the number of rural farmers engaged in farm activity anvolto reside irDega Damot woredaat the time of the survey. And secondary data sources any published and unpublished written materials such as report, journals, articles€ appaipers a well as internet sources that contain available information about he determinants of soil fertily imanagementand its impact on households€ income for the study used.

3.2.1 Sample size and Sampling procedures

For this studythe researcher were used multistage sampling procedumpling technique to select the sample household and the first steppurposively sampling technique used by tratifying degadamot wored and three agreecology criteria and then select the three belefrom each and after this samplehouseholds as select by using the formula which is raised below moment the three stratum kebele determine the total sample size from each belestratum and then finally used random sampling to interviewed by giving equal chance because of usehold homogeneous characteristics by any aspects suggested by amane (1967), since the population number (number of argeted population) is known in the study area.

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

Table 3.3 total sample size of the household

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

= — = = = = = 222

Where; n is sample size, N is the population size (total number of the households in the threekebeles), 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 behavitbre sample deviates from the totapopulation 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 5),0tbe total sample size wa 222 households

To calculate the sample size of the thkebele

For Zikuala wogem \xrightarrow{x} = 8 5 For Fenkatit \xrightarrow{x} = 7 7

For Arefa medehanailem $\xrightarrow{\times}$ = 60

3.2.2Data Gathering Instruments

3. 2.2.1Questionnaire

An appropriate objectivend subjectively pe questionsvere prepared for farmers to collect dataDetail discussion was made with my advisor regardingrefieevance and clarity of questionnairds afore filed survey. The respondents€ in the study area are Amharic speakers. Thus the estionnaires vere translated in to Amharic. As it is estimated majority offarmers€ in the study area cannot read and under of the design questionnaire and appropriately put their idea. Soumerators will beneeded to forward them. Therefore, three enumerators were hored minister questionnair for the sample householdeads, forenumeratorstraining was given. This training was helped them to aware of the content of due stioners Methodsof data collection and recording system and in addition how to approaching the household heads peacefully to made them willing for the reasons. The estionerwere administered by the enumeratorsto household heads at each selected kebeiltste (gots) in different place such as at farm filebund construction place, hurch, and at their home. When the household head was not willing to answer the questitneer were shifted to the next household headin the three selected kebeles, enumerators and the researcher were collected dataimultaneously

3.2.2.2Key informant Interview

Detailed interview wasmade with keyinformants The keyinformants were including leaders of religious and community, aged persors and their supervisors and femalehousehold heads atural resource experts of the district were also the interviewees. The interview was forwarded by the researcher at different places such as churde a 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 methodass 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 theappropriate analytical model that considers the interrelationship between the threaputs, it is necessary to start with one basic assumption abouts the inputs. The assumption was the interdependence of the decision to use chemical fertilizer on the decision to see 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 versathis means that there is ciprocal causation between the three variables in affecting one another, and are also being affected by other factors like farm characteristics, household characteris Disstance of farm from farmers homestead (km farm land size, household size and ems.

3.4 Methods of data analysis and modelpsecification

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

3.4.1 Descriptive statistics

In this studydescriptive statistics such as mean, standard deviation, percentages, frequency, t test, Chisquare andwere used to analyze the dataand to compare adopters and none adopters in terms of explanatory variables.

3.4.2 Econometric mode

The dependentariable in this model is dummyconsisting of two outcomes, yes or no and continuous In this case, the use offhe Ordinary Least Square/OLS technique for such variables showference problems, and thus not appropriate for investigating dichotomous dependent variables. In this notion, maximum likelihood estimation procedures such either logit/probit model are more efficient (Gujarati, 1995).

Several investigators used different models for analyzing the determinants of technology adption at the agricultural farm level. Valous adoption studiessed Tobit model to estimate adoption relationships with limited dependent variables while, others usedhe 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 studySample selection biansight arise in practice for two as ons. First, there may be selfselection by the individuals or data units being investigated. Second, sampleselection decisionoccurred, by data processon work in the same manneras self-selection. Selection bias was expected in this study because among the representative not all heeholds are believed to participates in fertility enhancing technologyadoption due to individual problem The Heckman twostep selection model allows for separation between the decision dopttechnology and the level their application. The modeses in the first step a probit regressionantalyzefactors that affect thesoil fertility enhancing technology adoptionecision and in the second step usesHeckman twestep sample selection model determine thempact of soil fertility enhancing technology on farmers€ agricultural inc (dareene, 2007) and the method correct sample selection bias.

The fundamentalssumption of this study was concentrate on farmers€ choice on the adoption of agriculturatechnologies to improvehouseholds€ gricultural 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) $Y_{ik=} \{1 \text{ if } Y_{ik}^* > 0 \text{ and } 0 \text{ otherwise}$

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

i=the number of farmers whiove in the district

k= the number of technologies which are adopted oradopted byth farmers who lived in the distict those technologies are (1, 2, 3; 1=compost, 2=manure and 3=chemical fertilizer)

 \hat{i} = are parameters of the model, $(\mathbf{1}_2 \mathbf{1}_3 \dots \mathbf{1}_i)$ are the coefficients associated with each explanatory variables, $X_2, \mathbf{1}_2, \mathbf{1}_3, \dots, \mathbf{1}_i$

e= the disturbance term which is unobserved

Xi = a vector of exogenous variables which affects that imers€ 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 adoptien ision equation which can be expressed of the probite quations as:

Where; \mathbf{d}^{i} is an unobservable choice of adoption decision and also known as latent variable, \mathbf{x} is a vector of explanatory variables hyppesized that affect soil fertility enhancing technology adoption and \mathbf{d}_{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 itheousehold, and D_i representsobservable th household decision to participate in technology adoption; 1 if a respondent describe in fertility enhancing technology se and 0 otherwise.

3.4.3 Heckman sampleselectionmodel

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

Heckman modeluses the following assumptions:

That is both error terms are **mo**ally distributed with mean 0yariances as indicated and the error terms are correlated whereindicates the correlation coefficient.

 $(\% \text{kl}) \sim N \left(0,0, \check{S}^2_{\mbox{\tiny ∞}} \check{S}^2_{\mbox{\tiny u}}, \bullet_{\mbox{\tiny M} \text{kl}}\right),$

The error terms are independent of explanatory variables.

(%ม) is independent oX

Variance of the error term in the population and the correlation ficient between the error are qualto one.

 $Var(u) = \check{S}_{u}^{2} = 1$

Sample selection problem The key problems that in regressing adoption on characteristics for those in farm activity we are not observing the equation for the population as a worker. Those in farm activity were tending to have higher income than those not in the adopters would have (that is why they are drout tingsoil fertility enhancing technology). Hence the results were end to be biase (sample selection bias) .rho = estimate of_{Au} indicates the correlation coefficient to be biase 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 procedure.

In Stepone in this study estimate the probability of farmers€ soil fertility enhancing technology adoptiondecisionby using probit modelIn 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 modelestimatesthe Heckman selection model by adding it a variable (invers mills ratio/ lambd) awhich is derived from probit estimate. In this study there are two question which are b(e) havioral (i.ethe 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 **væsiaa**nd different set of coefficients€ for predicting these two outcomes behavior Vs sele**rctike**,j(ones www.bandicam.com). **E**ckman two stage regression model become

Where E 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 outcompleation which uses sample selection model. The equation helps to determine the impact of soil fertility has no series and the selection which uses sample selection model.

technology adoption on farmerfessm income An explained variable that has a zero value for a significant fraction of the observation inequal accensored egression model (referred to as anodified censored model in this case) because standard OLS results is a biased and inconsistent parameter estimates (Greene, 2002) nsored regression model seems the probit was used to deal with the mpact of soil fertility management technology practices agricultural income (outcome) equation which can be expressed as follows:

Where, Y is adoption,X_i observed variables relating to the i€th person€s adoption decision and_i‰ 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 twostep approach is based on the assumptions theasethection 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 twostep model as there is no sample selection.

3.5 Definition of variables and their expected hypothesis sign This study hasconsidered several explanatory variables in modeling of fertility enhancing technology adoption behavior of farmers in the study area.refstee archer simplifies briefly the variables and uggests he 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 **eigr**ated 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 han 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 the dunger head of households have been been grobability of usingsoil fertility management technology.

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

Household size It refers to the total number of household members within the given household. According to ted(2013), labor constraints affedhousehold€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€soil fertility enhancing technologyadoption. Additionally, household family size has no impact on the adoption soil fertility enhancing technol(€gyu,(2016))

Farm size: This is the total area **qpp**ed by the household **it**mad This includes plots of the householdheaded owns & rents in to grow its crops. The relationship between farm size anadoption of agricultual technologies is an empirical question. However; for this study, a positive relationship between farm size ampticand is expected as larger farmeors nexperiment with new technologies on portion of land without severely risking their minimum subsistence forced uiremer (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 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 norferm activities and unearred (private transfer like remittance and government transfer). It is beliet/next off-farm income can have

a positive impact on the adoption of soil fertility enhancing technologly/hen househod € sincome increase, their ristlaking behavior also increasten is may lead o a higher probability of modern agricultural inputs use. Thus, a positive teation is expected.

Tropical livestock units: the total tropical livestock unit other than oxen owned by the household obtained by multiplying total number of animalsh weighnversion factors. Though an empiricalueston, a positive relation is expected because of the potential of applying manuae obtainable from the livestock.

Farming experience: Several stdies examined the effect of farming experience on adoption decision of ISFM technologidsarmers€xperience inagriculturehas an influence on planning horizon. For instance, short planning horizons are equated with older and more experienced farmers **wha**y 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. Meover, 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). Fargreixperience 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 specify and hypothesize the dependent and explanatory variables that were used in model.

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

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

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

Source:own€expectatior2021

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 clored appen ended questionnaires were administered to 222 sample household heads in Dega Damot District in three selected Kebeles and questionnaires were all forwarded to key informants. In addition he results from field observation in the three selected selected selected.

4.1. Demographic and Socic Conomic Characteristics of respondents

4.1.1. Demographic Charactersitics of respondents on dummy/categorical variables

The demographic characteristic of householddhiexecludes, sexand marital status isillustrated. Table 4.1, Additionally Table 4.1 indicates that from addotf 166 male household heads 7 4 espondents were Noardopters soil fertility enhancing technology practices and 119 respondents were impliming b FM practices. The results showed that the proportion of male headed households were higher both among the adopters and noardopters of organitertilizer 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 training livered by extension agents. Alle heads are more likely to attend community meetings and visit demonstration plots or research centers compared to female headel h(1668RI, 2012)

. Additionally from 192 married respondentts1 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 darpeteers. 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 theyheencern that the married households have to improve output at minimal possible cost over the limited

and competing resource(Martey et ai, 2013) noted that marriage increases farmer€s concern for household welfare thus increasing farmer€s participation in agricultural technology adoptionAs Table 4.4, shows, of the total sample household headed in the study area, 74.77 percent were males where as participation house hold headed were females. Among the adopters of soil fertility management technology about 20.4 percent of the households were females and 79.6 percent are non adopters from 56 female sample size and 33.9 percent of **rhead** are nonadopters and 66.1 percent are adopters from 166 male sample size. The result showed that the proportion of maleheaded households was higher both among the adopters aradiopters of soil fertility management technology.

Explanatory	Category	soil fertility	soil fertility enhancing technologies			
variables						
		Non	Adopters	Total	Percentage	p-value
		adopters	of SFM	number		chi ² test
		of SFM				
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	Married	81	111	192		0.03**
status of	unmarried	19	11	30		
HHs						

 Table 4 1. Demographic characteristics of sample household head

Source: own survey data (2021)

*** And ** indicates thasignificant level at% and5% level of significance.

4.1.2 Description of the first variable/treatment variable

The researcher€s treatment variable is the adopti**sso**ilofertility enhancing (SFE) technology practices. Specificalligicus 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 maare, compostand manureon 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 respondent **espoil** ferent 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 percepti**ab**out 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 **stude** 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 **em**ical 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 thadue 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 selectedkebeles. As the researcher interviewed, most 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 ding 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 the 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 momental grazing low and the local community uses animal dung for domestic

energy. According to key informants, there is additional soil fertility enhancing technology practice listed below.

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%

Table 4.2: Type of soil fertility enhancing technology

Source: own survey 2021

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



figue174he adoption level of each fertiliziemr tilneesatouhdysealeecated kebe

Source:own survey 2021

From the above chart conclude that sample household head used more manure from soil fertility enhancing echnology typeAs 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 **djike** to 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 meth**iba**t 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 onth**thre** 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.

4.1.3Descriptive statistics of average farm income of household€s

The researcher outime variable is agricultural income, measured as crop output in the secalled name quintal (100kg) ptimad (kg/tim) and it is measured in ETB annually. In this study average agricultural/farm income of adopters from the respondents was about 294.35 in ETB per annumAmongst the respondents who have adopted and noted opted soil fertility management technology practice, the average farm income was about 294.35 and 28601.02 respectively in ETB. From this finding the researcher concludes the tead opters have higher average farm income than nonadopters. This mplies 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 easing 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 chterritiater 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 adopters of

soil fertility management technologywere found to be significant at 1 percent probability level

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

Table 4.3 The descriptive statistics of outcome variables.

<u>Note</u> SD = standard deviation.-VPalue =statistical significance of differences in means between those who adopt SFM and those who doatnot% level of significance

4.2 Socio Economic characteristics of respondents

In this section the researcher describes ifferent socie conomic characteristic of the household head includes Education, for a ctivity, and agricultural income of the household head, land size aives 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 af**fesp**ondents€ their use of soil fertility management[he 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 **a**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 **tegl**ynpractice were 42.86. The palue indicates that, there **a**ssignificant mean difference ata 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 socion nomic factors which affect framers in acquiring information and their skills in their life spass 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 measurescadevelop 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 theadoppters. Thefact that the livestock has the optential resources (animal manure) for organic fertilizer preparation could make the number of livestock units to be quite important for adoptiong antior fertilizer (Tefera et al2013). 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 Rungemetzger (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 7.20 mad of farm land while the nonadopters own about 610 mad of the farm land. The current study had predicted 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 lighten sive technology on the larger area of the farm land. Thesults 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 them-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 fertilizerin 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 peent) 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 owharger farm land than nemadopters.

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 technologie € ducation is the potential source of knowledge which enables one tounderstand instructions access and comprehend information about the new technology (Biru, 2016) Farmers € educational level increases the awareness, perception, knowledge na 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 consection technologies (Alelgn, 2011) As the above table indicates that the majority of the theese lerespondents € about 45.5% percent of the sample household head were totally illiterate and 55.5% percent of the respondents € from literate sample household headed were educated formally.

Variable €s ame			Soil managem	fertility ent practice:		
			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 percale	0	12	5.38	4.18	0.00***	-3.04
used for crop production						
fragmented plots	1	2	.51	.41	0.05**	-1.59

Table 4.4: Socioeconomic characteristics of the sample HHs continuous/discrete variables

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 threacebeles, 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 farmerwisenabout 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 problerings 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 respondentsahave awarenessabout 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€ the agrood awareness about the use of soil fertility management technology adoption practice for the enhancement of soil fertility and.

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

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

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 **a** fdopters 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 cro	p types cultivated in	eakaebeles
--------------------------	-----------------------	------------

	Ziqual	Fenkatit	Arefa	Adopters	Non-adopters
Major	%	%	%	average	average Yield in
crop types				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

4.2.3Farm Fertility

According tothis study, farm fertility represents the household the sign about the level of fertility of their farm land. The results presented in Tab/Ieshow that about 3.3 percent of the adopters believed that their farms were not fertile. In comparison, the corresponding figure for noard opters was about 96.7 percent. Relativelyighed 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 farmershiop Fet (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 prefroef 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 adopters were believed that their farms were medium and fertile respectively. From 222 respondence of the sample size dose not describe theil fey revealed of their farm land.

Characteristic	Adopte	ers	Non-a	dopters	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	

Table 4.7 farm landfertility level

-						
Fertile	36	58.06	26	41.9		

Source: own survey 2021

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

Table 8 show hat 0.84 percent of the sampled respondents were members of farmers based association while the remaining nearly 0.16 percentwas not. As a result of key informants, majority outdopters were members of at lease farmer based organization. The majority members of armers 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 angiven 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 developm (Beerhe, 2014). Households belonging to farmers group such as associations and cooperatives can easily access fertilizer technology (Martey et ai, 2013) is such, existence of farmers based organizations could possibly increative 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 anessentialsource offunding in agricultural technology adoption. The major sources of credit in Degadamot district includer mhara credit and saving institution and farmer based informal associations such diasEkub, Mahiber and Debo (wonfe). It was found that about 7percent of the sampled respondents had accesse and used credit while about 2percent 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 the monstration, training and advice delivere that moners mainly by development agenteend other agricultural expert 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 the sper season among the adopters of organic fertilizer while that of nonadopters was about. The difference in the average extension contacts between the adopters anadopters of organic fertilizer was significant at 1 percent probability level. The results show that the adopters of organidertilizer had better access to extension services on average compared to nonadopters justifying that the higher frequency of extension visits may have contributed towaradoption of organic fertilizer.

Table 4.1 The resultson 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

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

Heckman two stage selection analyses iscreted to identify the householdvel demographic, socieconomic and institutional factors that determine the decision of smallholder farmers to adopt or not to adopt soil fertility enhat(Sing) technology in the first stage by applying probit model.

In the firststage theorobit modelwas used to examine factors hat influence the level of soil fertility enhancing technologo doption decision. However, before running the regression analysis, to tests, such that, the existerof 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 indinitive there is serious problem of multicollinearity between the independent variable, while if VIF is below 10 there is

no much poblem. 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 Factorsthat determining smallholder farmers€ soil fertility enhancing technology adoption decision

The models constructed with **in***f***u**dependent variables and out of these/**a***r*iables 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 teohorgy adoption, farm experience of the household headedizes of farm land, Position of land, education status of household head, accessibility of credit seevaresignificantly affect farmers€ soil fertility enhancing technology adoption decision. Whereas; participation **ifaroff** activity; fertility of land, fragmented plotsnumber of labor forcemembership to farm cooperative and access to agricultural externsiervice insignificantly but abther variableswith 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 abledtopta 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 **sifgra**nce on the adoption of soil fertility enhancing technology. The marginal effect result indicates that a farmer, who has one additionatimad of arable landwould increase the likelihoot farmers€ soil fertility enhancing technologyadoption 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 unrestrictedurce, 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 new farm 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 porbability of soil fertility enhancing technology adoption decision small holder farmers at 1% levelof significance Other variables € constant, if the position of land is steeper, the likelihood adoption of soil fertility enhancing technology decreasely 3.8 percent on crop cultivation 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 incæse by one unit, the likelihood of soil fertility enhancing technology adoption decision darmers€ increase by 68 percent at 1% level of significanceholding 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 cuttion. As compared to illiterate farmers the probability of adoption of soil fertility enhancing technology input in crop production for literate farmers wouldbe higher This implies that the educational level of a household headed increase by one yetate, Itkelihood adoption of soil fertility enhancing technology input in the educated farmers are more confident to adopt soil fertility enhancing technology input in their cultivation than those 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 decisionaking 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/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 significanceThis result is consistent with the **r** factor 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 paribusavailability of credit service encoura**ge** 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 toh**passe** relatively more expensive technol**izes** 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) **he** 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. Thereforen**fers** who have the availability of credit services are more likely to ado**p** bil fertility enhancing technology thanvithout credit.

Old household heads€ are less likely to adopt soil fertility enhancing technology than adult household stolding other variable € constant the age of a household increase by one year, the likelihood of soil for the hancing technology adoption becrease by 22.5% t 1% level of significance.

Generally the pvalue in the regression indicates that the probit segme model is highly significant.

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***

Table 4 2 Factors that determine farmer€s soil fertility enhancing technology adoption decisionprobit model result
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***
Extensionservice	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 tatistically significant at %, 5% and 10% respectively. Number of obs=222, Prob-chi2=0.000 pseude0.756

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

4.3.2.1 Heckmantwo-stage model

The Heckman model in the second stage estimation identifies the effect of the adoption f soil fertility enhancing technology on farm inconTeable4.10, shows that impact of variables which affects soil fertility enhancing technology adoptior fsmallholder farmers on the marm income Out of 16 explanatory variables age size of a family member access to credite ducational status of house holded awareness, farm experience number of livestock. Position of land, significantly influence the households€ soil fertility enhancite phology adoption 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 he remaining variabes€ 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 applyingleckman twestage models due to its ability to handle the selectionbiasproblem.

Table 4.10 shows that ambda 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 the 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 laboforce, position of land gender affect adoption decision significantly with expected sing. Moreover, household heads education level, awareness and availability of livestockand access to credit, age ave the expected positive effect on the level of solifertility-enhancing adoption in 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 twestage regressionesult which implies the effect of soil fertility enhanoing technology adoption on households€ farm income, age and household family size have negative influence on agricultural income.

As hypothesized, **a**ne additional person in the family deteriorate agricultural income by 6386.97 in ETBat 1% level of significanceThis implies that when family size of ahouseholdheaded increase, then ann**eal**rningincome from agricultural crop decrease holding other **stell** tility 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 **&** 1/89.48 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 indicates that higher land

holding size increaskeouseholds€ annual farm income age of the household head has negatively and signitiantly affected agricultural income of the household headed. This finding shows that being older for the household headeds to agricultural incomedecreaseby 1118.81 ETBat 1% level of statistical significance his finding is consistent with (Alelgn2011).

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 incomet 4.05 ETB keeping other variables stant.

As expected, Access to credit is also shown expected sign and statistically significant at the 1% level as indicated in stægge. This suggests that households, who had access credit, are more likely to adopt soil fertility enhancingotlecty non their crop cultivation than without increase farmers€ annual farm incommente finding of (Alelgn, 2011.) This finding is the same result as (Biru,2016) adoption rather than incomeAs hypothesized other variables stated in Heckman strage 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 varia(bWe) which is used to identify the Heckman two stage selection equationare farmers€ organization and marital status This implies that the selection equation (if the respondents adopstoil fertility enhancing technology, what will be households € agricultural income) is identified by the behavioral equation (the respondents € oil fertility enhancing management technology adoption decisionam) as indicated the volume of the regression result, Heckman two the progression model is significance.

Table 4.10 The results of Heckman two tage selections timation (impacts of fertility technology adoption on farmer € arm income).

	Coef.	Std. Err.	Z	P> z
Agricultural income				
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 umber of obs = 222Censored obs = 98, Uncensored obs 124Wald chi2(11) = 35.7, Prob > chi2 = 0.0004

4.3.2.2Heckman two-stage endogenous treatment effect orobseholds Farm Income betweenadopters and non-adopters

Table 4.11 indicates that significance difference between adopters and non adopters of agricultural incomeThe impact of soil fertility enhancing technology adoption on households€ farm incomeEfference per timad was estimatedbetween adopters and newadopters in this section. However, according to (Biru, 2016), Propensity Score Matching methods wereemployed to compare the difference of averagefarm income between the samples of adopters anetadopters agricultural technology adoptionIn this study Heckman twostepswith endogenous treatment method were employed. AccordingNe results indiced that the households who adopted soil fertility enhancing technology adoption had earriedome from 6144.966 ETB to 119192 ETB more averagefarm incomeper timad compared to non-adopters of adopters is higher than -adopters of soil fertility enhancing technologyAs hypothesized, the rate annual agricultural income of adopters is higher than -adopters of soil fertility enhancing technology by 32,693.33 ETET.his implies that adoption of soil fertility enhancing technology is crucial to increase farmer€s farm income.

	Coef.	Std.Err.	P> z	[95% Conf. Interval]
Variables				
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

Table 4.11 the result of Heckman twestage endogenous treatment result

	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-valu	e 0.0001					

** And * imply statistically significant at 1 and % 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 ansformation agenda including agricultural esearch, extension services and rum far astructual developments that underline role of technology adoption among smallholder€s farmes in increasing production was vital. Technological change in agriculture comprises the introduction of a higheding variety of seeds, feritizers and irrigation. These changes the agricultural sector augment the productivity per unit of land and bring about rapid increase in purction 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 condexite investigate 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 armersfarm income. Accordingly, descriptive statistics and Heckmass 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 eivectess of applying Heckmarwo-stage models.

The result shows that the adoption decision of soil fertility enhancing technologyuse was driven by factors such the size of farm lad, size of family age, availability of family labor force education status of household edad, accessility of credit service farm experience and number of livestock An increase in the household size discouraged adoption of soil fertility enhancing technology showing thrase does not necessarily mean that farmers have enlabgh 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 adopt soil fertility

enhancing technology.

Additionally, farmers€ who adopt soil fertility enhancing technology earned better average annufælrm income pertimad compared to nomadopters. This shows that the adoption of soil fertility enhaing technology had positivempact on households€ farm income. Hence farmers should be motivated to use soil fertility enhancing technologies which areorganic and inorganic fertilizer and another traditionalmechanism to increase soil fertility.

5.1.2Recommendation

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 putidation 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 us Authough 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 thosewho already had the services. Access to crediplays crucial role in enhancing technology adoption. Credit can be obtained from different organizations. Based on the results, having low access to credit on timeuld result in low adoption of soil fertility enhancing technology adoption fo 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 fertilityenhancing 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 technologyab the potential to increæe farmers€farm income. As such, the smallhoder farmers should be encouraged to adopt technologyto increæe theirfarm incomeand improve their livelihood

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BAHIRDAR UNIVERISTY

COLLEGE OF BUSSENECE AND ECONOMICS

DEPARTMENT OF ECONOMICS

QUETIONAIRS RESPONDEDBY HOUSHOLD HEADS

General direction

Dear respondent,

This questionnaire is prepared to find out *f* Determinants of soil fer**tility**ancing management technologies by smallholder farmers and its effect on households€ agricultural income in Dega Damot districHowever, 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 otherlybby 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 responsible space provided.

March 2021

SECTION A: HOUSEHOLD CHARACTERISTICS

- 1. Age _____
- 2. Gender _____
- 3. Maritalstatus. 1 = Single 2 = Married = Divorced 4 = Widowed
- 4. Educational status in year

Your household composition:

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

"d14				
years				
14-65				
years				
"е				
65years				

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

6. basedon 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, **s**ecify_____

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?

SECTION B: FARM LAND CHARACTERISTICS

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 accentrated 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

your locality? 1. Yes 0. No

23. Which types of crops are you growing? _____, ____,

24. How do you rate your plots fertility? = 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 <u>p</u> 27 is yes, which type of technology do you used?

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

29. If question <u>o</u> 27 is no, what makes you those 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 yourchoice 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 dain 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 pl**pt**oductivity 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 ma	any quintals of the	following crops	s do you harvest per h	ectare in 2019/20
	When youuse 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?

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. Whois/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? _____

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 orgic fertilizer? 1 = every production season 2 = per two season

- 37. Do you have access to TV, radio or any other social media? 2= mes
- 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 douyget it? 1 = Market, 2 = from government,
- 3 = Farmerassociation
- 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 marketes),1⊕¥ 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 organidizent, what do you use \mathcal{M} (ore 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 coofsbargaining 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 54si 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 nonadopters 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 followingrops do you harvest per Timad	Productivity/ti	Income/quntal
Wheat		
Barley		
Maize		
Teff		
Bean		
Pea		
Potato		
If other		

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 advantagets and antages 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? Wehindoner 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 bot 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
	-	

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

Drahit regression			Nuumaha	w of obo	222		
Probit regression			Number of tobs 222				
				LR chi2 (16	5) =	230.63	
				Prob > chi	2 =	0.0000	
Log likelih	nood =-37.03679	98		PseuddR2	=	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	2938709	.2134821	-1.38	0.169	7122881	.1245462
	labor force						
	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		.0000262	0.71	0.476	0000327	.0000701
income						
_cons		1.127909	-0.02	0.983	-2.235045	2.186276

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	11712	.08506	0.169
labor force			
Fragmented	.0771493	.06789	0.256
plots			
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	3309547	.22496	0.141
service			
Farm expriance	.0159697	.0095	0.093
Size of land	0106098	.02701	0.694
Off-farm	7.45e06	.00001	0.476
income			

Appendix 6

Heckman selection model two-stepestimates

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	3 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	2.379932
Maritalstatus	.1053786	.1031476	1.02	0.307	0967869	.3075441
Edustatus	.0923784	.0526069	1.76	0.079*	0107292	.195486
familysize.	.3687676	.1734889	2.13	0.034**	.0287356	.7087996
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	.2446447
	I					

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	.274064
Acestocredit	1.570713	.536052	2.930	0.003***	.52007	2.621355
Exteserv	768847	.6664695	-1.15	0.249	-2.075103	3 .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					

Linearregression with endogenous treatment	Number of obs $=$ 222	
Estimator: maximum likelihood	Wałkóż (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	5043.098	4307.606	0.242	-3399.655	13485.85
labor force					
Education	2199.773	1124.236	0.050	-3.689218	4403.236
Farm	-448.1133	372.6484	0.229	-1178.491	282.264
experience					
Size of	4946.39	1152.865	0.000	2686.816	7205.964
land					

	Awareness	8283.471	14976.91	0.580	-21070.73	37637.67
	Livestock	344.756	1174.107	0.769	-1956.452	2645.964
	fertility of	-6633.523	7647.994	0.386	-21623.32	8356.27
	land					
	Access to	-18423.78	13270.24	0.165	-44432.98	7585.415
	credit					
	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					