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FACTORS INFLUENCING ADOPTION OF RECOMMENDED SOIL FERTILITY REPLENISHMENT TECHNOLOGIES BY MAIZE FARMERS IN THE NORTH RIFT REGION OF KENYA

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DECLARATION

DECLARATION BY THE STUDENT

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This work is dedicated to my beloved children Flavian and Noela for their encouragement, patience and understanding during the time of writing this thesis. Your prayers, and unwavering support made it possible to complete this study.

ABSTRACT

Adoption of recommended soil fertility replenishment technologies (SFRT), a key component of soil fertility management by farmers in developing countries, particularly sub Saharan African has and continues to be low. This study, through a questionnaire to 384 household heads, investigated factors affecting the adoption of recommended soil fertility replenishment technologies by maize farmers in the Kenya's main maize growing counties of Trans Nzoia and Uasin Gishu. The target population in the study area was maize farmers in Uasin Gishu and Trans Nzoia counties. The study employed multistage, proportionate, systematic and simple random sampling techniques to get a sample size of 384 respondents for the main study. Farm households were used as units for analysis. Data was collected using questionnaires and analyzed using descriptive and inferential statistics. Multinomial logistic model was used to estimate the parameters of the regression model and the Likert Scale was used to measure the perception. Results revealed that, coefficient gender was negative and had significant by -1.844, -2.015 and -1.688 ($p<0.05$, $p<0.05$, $p<0.001$) effect on the adoption of FURP, FURPL and Mavuno technologies, respectively. Age of the househole had a positive significant effect on adoption of FURP, FURP and NAAIAP technologies by 1.960, 1.948 and 1.469 ($p<0.05$), respectively. However, it had negative significant effect on adoption of Mavuno technology by -1.617 ($p<0.001$). Size of land showed a negative and significant effect on the choice of Rutuba by -0.390 ($p<0.05$). Farm income negatively influenced the adoption of FURPL technology by -0.669 ($P<0.05$). The results revealed that the coefficient off- farm income was negative and statistically influenced the adoption of FURP, ½ rate Rutuba plus ½ FURP and NAAIAP technologies by -18.234, -2.364 and -2.515 at ($p<0.001$, $p<0.05$ and $p<0.05$), respectively. Access to credit had a significant negative in influence in the likelihood of adopting FURPL by -0.088 ($p<0.05$) while it was significantly positive in adoption NAAIAP technology by 1.749 ($p<0.1$). Further, the cost of technology had a negative influence on choice of FURP and Rutuba at -4.032 ($p < 0.05$ and -15.688 ($p < 0.001$) significance levels. Farmers had a positive perception of the soil fertility replenishment technologies at a mean score of 3.6. Farmers in Trans Nzoia county identified lack of capital (70.2%) compared to Uasin Gishu (36.9%) as the greatest challenge in the adoption of the recommended SFRT technologies. Credit schemes that are farmer friendly should be established to enable farmers have access to credit. Researchers, development agents and the government ought to implement measures and strategies that will increase access to productive resources by female farmers. The government should device a policy that should encourage the youth involvement in the agricultural activities. Policy makers should also focus on strengthening research/extension/ farmer linkages

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LIST OF ABBREVIATIONS

BNF	Biological Nitrogen Fixation
CAN	Calcium of Ammonium Nitrate
CIDP	County Integrated Development Plan
DAP	Diammonium Phosphate
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Statistics
FGD	Focus Group Discussion
FURP	Fertilizer Use Recommendation Project
FURPL	Fertilizer Use Recommendation Project Plus Lime
FYM	Farm Yard Manure
GTZ	German Agency for Technical Co-operation
GoK	Government of Kenya
IFDC	International Fertilizer Development Center
IMPHOS	World Phosphate Institute
KALRO	Kenya Agricultural Research Institute
KARI	Kenya Agricultural Research Institute
MMT	Million Metric Tonnes
MNL	Multinomial Logistics
MoA	Ministry of Agriculture
MoALF	Ministry of Agriculture Livestock and Fisheries
N	Nitrogen
NAAIAP	National Accelerated Agricultural Input Access Programme
NALEP	National Agricultural and Livestock Extension Program
NCPB	National Cereals and Produce Board
NEAP	National Agricultural Extension Policy
SAPs	Structural Adjustment Programme
S&CM	Soil and Crop Management technologies.
SFET	Soil Fertility Enhancing Technologies
SFMT	Soil Fertility Management Technologies
SFRT	Soil Fertility Replenishment Technologies
SIDA	Swedish International Development Agency
SMP	Soil Management Project

SSA Sub Saharan Africa

SWC Soil and Water Conservation

T Tonnes

SIDA Swedish International Development Agency

TD Transdisciplinary

WASAT West African Semi Arid Tropics

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CHAPTER ONE

INTRODUCTION

1.1 Overview

This chapter contains information on the background of study, statement of the problem, objectives, hypothesis, significance and scope of the study.

1.2 Background of the Study

There is growing demand for food in the world as a result of increasing human population that is expected to reach 9 billion by 2050 (Alexandratos & Bruinsma, 2012). Further, demand for agricultural produce for industries has also increased (United Nations Global Compact, 2012). Agricultural technologies play a key role in increasing food productivity. New technologies increase output and reduce production cost which in turn results in substantial farm income (Challa, 2013). Agricultural technologies include all kinds of improved techniques and practices which enhance the growth of agricultural output (Ndiritu *et al.*, 2014). Areas of technology development and promotion include improved varieties and management practices, soil fertility management, crops weed and pest management, irrigation and water management (Loevinsohn *et al*., 2013). Successful agricultural transformation, worldwide, has been largely attributed to the use of improved technologies such as fertilizer, improved seeds and soil and water conservation practices (Asfaw *et al*., 2011).

Agricultural productivity can be increased through wider adoption of improved technologies and such measures are known to have positive impacts on income, food security and poverty reduction (Alene *et al*., 2009; Kassie *et al*., 2011; Asfaw *et al*., 2011). The use of improved farming technologies has remained the major strategy used by governments to increase agricultural productivity, promote food and livelihood security (Beshir and Wegary, 2014). In developing countries, the growth of agricultural productivity is considered fundamental for improving the livelihoods of the people (Kassie *et al*., 2011; World Bank, 2008). In this region, agricultural innovations are perceived as significant pathways for poverty eradication (Simtowe *et al.,* 2011; Mwangi *et al.*, 2015).

Adoption of these technologies is an important requirement for the positive transformation of the agriculture sector (Conley & Udry, 2010). Accordind to Ndiritu *et al., (*2014) non-adopters of improved agriculture technologies can hardly maintain their livelihood and are more prone to socio-economic stagnation. On the contrary, adopters of improved technologies increase their productions, leading to socio-economic development. A study by Kariyasa (2011), shows that adoption of improved agricultural technologies can result in higher income and reduced poverty; improved nutritional status; lower food prices; increased employment opportunities and earnings for landless labourers. Adoption of improved technologies is believed to be a major contributing factor to the success of the green revolution experienced by Asian countries (Kariyasa, 2011).

Adoption is a decision made by an individual farmer or a group of farmers to use a technology in a continuous manner. It is a decision to make full use of an innovation or technology as the best course of action available (Rogers, 1995). For the majority of sub-Saharan countries, the adoption of sustainable agricultural practices that enhance agricultural productivity and improve the environment remains the best option for achieving economic growth, food security and poverty alleviation (Challa, 2013). The relationship between technology adoption and agricultural productivity is, however, a complex process that is influenced by farm and farmer characteristics, access to extension and finance, among other factors (Barrett *et al*., 2005; Olwande *et al.,* 2009).

The aim of most countries in sub-Saharan Africa is to increase crop production, however, continuous decline in the production factors especially soil fertility remains a challenge for most farmers (Sanchez *et al*., 2009). Studies of soil nutrient balance in African countries show evidence of widespread nutrient mining leading to nutrient deficiencies across most of the agro- ecological zones. Farming management practices that cause the decline include conventional tillage system that disturbs the soil continuously, leaving the soil surface bare (unprotected) most of the time when not under crop, inappropriate production technologies, and episodes of bad weather have been cited for this phenomenon (Smaling *et al*., 1997). Further, nowadays maize farmers, both large and smallholder, not only harvest the grain but also crop residues (stover) which they sell as livestock feed or overgraze the farm leading to immediate exposure of the soil surface. Without soil and water conservation structures, as is the case in most farms, runoff and winds continuously erode the top soil layer, including plant nutrients from fertilizers held in the layer. The concern for soil nutrient depletion and low soil fertility has led to the development of several soil fertility enhancing technologies (SFETs) by a number of national and international research institutions especially in sub-Sahara Africa (Okalebo *et al*., 2007).

Efforts to restore soil fertility have been enormous over the past century in Kenya and have developed nutrient replenishment technologies which include inorganic and organic fertilizer recommendations. These technologies on soil fertility management practices disseminated to farmers through, trainings, field day and on-farm demonstrations have demonstrated positive crop responses and attractive returns to input investments. These have yielded crop increases, for example in western Kenya, where maize yield increases of 3-5 tonnes per hectare per season are as a result of inorganic fertilizer or with its combinations with organic inputs at on-farm level (Okalebo *et al*., 2007). Despite the potential of these technologies, their adoption by farmers in this region has been dismally low, lagging behind scientific and technological advances thereby reducing their impact (Ajayi *et al.*, 2003; Ajayi *et al.*, 2007).

The factors that influence the adoption of technologies vary from region to region but various reseachers found that socio-economic, institutional and farm characteristics are the main factors influencing adoption of soil fertility management technologies (Lambrecht *et al.*, 2016; Chiputwa *et al.*, 2011). For example, studies on adoption of integrated soil fertility management in Eastern Democratic Republic of Congo found that socio-economic factors generally influenced technology adoption. A study by Lambrecht *et al.,* (2016) recommended more socio-economic research in order to design and implement sustainable soil fertility enhancing technologies that are applicable in the different farming system. Further, Mugwe *et al.*, (2009) also asserted that socio-economic factors play a crucial role in soil fertility technology adoption in Kenya. Therefore, soil fertility and nutrient management are functions of social, economic and its management.

To understand the farmer’s role in soil fertility and nutrient management it is important to understand the factors that influence their decision making. While findings of low levels of soil fertility management practices adoption are well documented, few studies have attempted to explain the reasons for the slow rate of adoption, particularly in the maize producing counties of Uasin Gishu and Trans Nzoia where substantial amount of maize is produced (Uaiene *et al.*, 2009). This necessitates a thorough analysis of the economic-social constraints which have been barriers to using soil fertility enhancing technologies. Better knowledge of how characteristics of individual farmers and their farming practices affect adoption will help researchers in formulating more effective technologies that are tailored to the needs of the farmers.

1.3 Statement of the Problem

Continuous cropping, removal of field crop residues for livestock feed and overgrazing between cropping seasons with minimal or no external inputs, have reduced the productive capacity of arable lands and threatened the sustainability of crop production systems in sub Saharan Africa (Hudgens,1996), Kenya included.

To reverse this trend, scientists have developed and introduced several soil nutrient replenishment technologies that integrate nutrient management which encompasses organic materials and inorganic fertilizers. However, soil fertility and crop yields have declined as farmers continue to ignore these technological packages (Okalebo *et al*., 2007). The maize crop yield for example has remained at an average of 2 tonnes per hectare below the possible 6 to 8 tonnes per hectare a situation attributed to low absorption of modern production technologies (Republic of Kenya, 1997; Kang'ethe, 2004). These technologies are developed at the research centres, Schools/Faculties of Agriculture of the universities and disseminated to farmers mainly through extension services using various extension methods such on-farm demonstrations and trainings.

Farmers' integration of these agricultural technologies into their field is greatly influenced by social, economic, institutional and perceived technology attributes factors (An, 2008). Therefore, it is important to evaluate and understand the factors affecting adoption of soil fertility replenishment technologies by maize farmers as this will help to improve the design and transfer of recommended practices.

1.4 Objectives

1.4.1 General Objective

To determine factors influencing adoption of soil fertility replenishment technologies (SFRT) by maize farmers, in the North Rift region of Kenya.

1.4.2 Specific Objectives

This study was guided by the following specific objectives:

i. To evaluate the effect of social factors that contribute to adoption of SFRT by maize farmers in the North Rift region of Kenya.

ii. To assess the effect of economic factors that contribute to adoption of SFRT by maize farmers in the North Rift region of Kenya.

iii. To establish the awareness level of maize farmers on SFRT in the North Rift region of Kenya.

iv. To establish the perception of maize farmers on SFRT in the North Rift region of Kenya.

v. To establish the challenges maize farmers face in the use of SFRT in the North Rift region of Kenya.

1.5 Hypotheses

i. Ho_1: Social factors do not significantly influence the adoption of SFRT by maize farmers in the North Rift region of Kenya

ii. Ho_2: Economic factors do not significantly influence the adoption of SFRT by maize farmers in the North Rift region of Kenya.

1.6 Justification of the Study

Efforts to increase maize production are enormous and have been adopted by a number of farmers in Kenya, for example breeders have developed high yielding maize varieties such as H6213 for the high potential areas. However, the maize grain yield is still below the potential. Although, this scenario may be caused by various factors, lack or low adoption of soil fertility replenishing technologies is one key factor. Soil fertility replenishment technologies have been known to enhance production of food and are therefore critical for sustainable food security and economic development (Loevisohn *et al*., 2013).

Over the years many studies have been conducted on the adoption of modern technologies in developing countries. In addition, the process of adoption and the impact of adopting new technology by farmers have been studied. However, new agricultural technologies are often adopted slowly and several aspects of adoption remain poorly understood despite being recognized as important factors of alleviating poverty in most African countries (Simtowe *et al.*, 2011). Therefore, in order to scale up the use and promote wider adoption of improved soil fertility enhancing technologies, it is important to identify factors that influence adoption and use of these promising technologies by farmers. It is also important to establish the various constraints regarding the use of a particular technology.

Understanding these factors, will provide insights for designing appropriate strategies, policies and programs that will promote adoption of soil fertility improvement technologies. The added knowledge on which factors have the greatest influence on soil fertility replenishment technologies adoption will help researchers make more informed decisions on how to promote these technologies. Further, this research will give provision of an explanation of the current state of technologies used by farmers.

1.7 Scope of the Study and Limitations

The study was carried out in Trans Nzoia and Uasin Gishu counties instead of the whole North Rift region of Kenya. The study was limited in terms of the unwillingness of the respondents to respond to some questions effectively. They viewed the intentions of the research with a lot of suspicion. The researcher therefore, had to assure the respondents that the data being collected was confidential and for academic purposes only. There was also a tendency among few farmers to give answers aimed to please the researcher rather than engage into objective discussions. In order to overcome the above limitations, in depth Focus Group Discussions were carried out with the most knowledgeable farmers to gain more insight into the reality and to make clear any inconsistencies. The study was also limited by adequate resources and time to reach the whole population. However, this limitation was solved by scientifically using a representative sample for the study which reduced the time that could have been taken to interview the whole population. This implies that the results in this study may be biased in terms of the characteristics of individual farmers. Further, the respondents were dispersed and the researcher had to walk long distances to access them. The researcher therefore would have taken a longer time in data collection than anticipated. To overcome this problem the researcher had to hire a motorbike at some point. The use of the Ministry extension staff is normally problematic as they tend to exaggerate results to show them in a positive light. This problem was solved by selecting very reliable officers by the help of the County Directors of Agriculture. They were further informed that the data was only meant for study purposes and the outcome would not affect the career.

1.8 Operational Definition of Key Concepts

Adoption: - refers to the decisions that individuals make each time that they consider taking up an innovation or decision of an individual to make use of an innovation as the best course of action available.

Recommended Technology: This refers to methods, systems and devices which are the result of scientific research being used for changing the exiting practices.

Soil fertility: - Ability of the soil to sustain plant growth and optimize crop yield

On – farm demonstration: - This is a farm which used to demonstrate various agricultural including the recommended technologies as means dissemination agricultural innovations creating positive changes in farmer perceptions and hence

Households: This is the composition of adults and children where the head of the house is male or female operating under one common goal of keeping the family united.

Perception: -Perception is the process by which people receive information or stimuli from the environment and transforms it into psychological awareness (Ndiema, 2010).

North Rift region: This is the geographical area within former Rift Valley province. The area is well endowed with agricultural farming activities. The study mainly concentrated in Uasin Gish and Trans Nzoia counties.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter reviews issues of declining soil fertility, adoption, and factors affecting adoption of technologies, perception of farmers, challenges facing farmers in adoption of SFRT, and analytical methods, and conceptual framework.

2.2 Declining Soil Fertility

Soil nutrient depletion in agricultural lands and their subsequent degradation have become serious threats to agricultural productivity in sub-Saharan Africa. According to (Ayaga, 2003) most arable lands have been affected by degradation thereby reducing agricultural productivity resulting in food insecurity and poor economic growth of most of the developing countries. Decline in soil fertility is one of the important factors limiting food production in sub-Saharan Africa (SSA) (Bationo *et al*., 2006). In Kenya, there has been a net nutrient loss of soils mainly due to crop harvests, removal of crop residues, leaching, denitrification, erosion and inadequate nutrient replenishment (Otinga, 2012). In every cropping season, plant nutrients are withdrawn from the soil through crop harvest, overgrazing and soil erosion at higher rates than they are replaced through organic and inorganic fertilizer application (Woomer *et al*., 1997). With the high population growth rate in Kenya of about 3% per annum and the shrinking farm size per head, improved agricultural innovation/technology is required to increase land productivity to generate income and enhance food security (Okalebo *et al*., 2007). Some of the tools available to provide the boost in production include the use of soil fertility enhancing strategies for example application of organic, inorganic fertilizers and control of land degradation through enactment and enforcement of soil and water conservation policies at both county and national levels.

2.3 Soil fertility Management Technologies Used by Farmers

Per capita food production in Africa has been declining over the past two decades, contrary to the global trend. The increase in production for cereal grain is about 1% while population growth is about 3% (Bationo *et al*., 2004). The average annual maize production for SSA of 1.6/t ha falls far below the expected yield potential of 6 to 8 t/ha depending on maize variety (Otinga, 2012). Researchers have attributed food reduction mainly to soil fertility decline. The magnitude of nutrient depletion in agricultural land in sub Saharan Africa is enormous, as is indicated by negative nutrient balances. There are many measures that have been used by farmers in Kenya to maintain soil fertility status. These include among others, shifting cultivation, use of inorganic fertilizers, application of farm yard and compost manures, use of nitrogen-fixing legumes and incorporation of crop residues into the soil, conservation agriculture and soil conservation measures among others.

Shifting cultivation involves cultivation of a piece of fallow land for 2 to 3 years after which it is left fallow for 2 to 10 years. This method is outdated in many areas due to population pressure. However, it is still used in the semi-arid areas of Eastern Kenya particularly in Tharaka, Mbere, and parts of Machakos and Kitui counties. With the population pressure increases the practice has no future even in the marginal areas (MoA, 2007). The other method used in restoring soil fertility is the use of legumes to incorporate N into the soil via biological N_2-fixation (BNF) and residue incorporation. This requires an integrated soil fertility management (ISFM) strategy since phosphorus (P) which is important for effective N_2-fixation through promotion of nodulation has to be applied (Giller, 2001). Another limitation to this practice is that the current knowledge on N_2-fixation performance under the non-ideal conditions encountered in African smallholder farming systems is low. Further, N_2-fixation is a high energy and water requiring process for the fixing plant which may be a challenge to the many farmers (Schulze, 2004).

Farm yard manure (FYM) is an organic by-product derived from either purely animal droppings or mixed with plant residues. However, just like in many parts of sub-Saharan Africa, the use of animal manure in Kenya is limited by the large quantities needed to provide adequate plant nutrient (Jama *et al*., 1997). Further, its nutrients composition remains low and very variable due to the materials used for feeding and animal beddings. The use of inorganic fertilizers is another option used for replenishing soil fertility for increased agriculture production. However, the replenishment of soil fertility with inorganic fertilizers at the recommended rate and appropriate time is constrained by lack of knowledge (on type of fertilizer and rate), high price of fertilizer and delivery delays (Donovan, 1996).

2.3.1 Management Practices by Smallholder Farmers

About 95% of the smallholders farmers in the Uasin Gishu and Trans Nzoia counties apply basal and topdressing fertilizers (MoALF, 2016). The majority of these farmers purchase GoK subsidized fertilizer from National Cereal and Produce Board (NCPB). Farmers' choices of types of fertilizer to use is dictated by of their availability at NCPB depots, advice from agricultural staff, what they are used to and advice from other farmers. Such a scenario comprises the use of any fertilizer recommendation. Further, some farmers have developed their own management practices. For example, some of the farmers mix phoshatic fertilizers with nitrogenous fertilizer at the time of planting. Others apply foliar feeds when the crop is at vegetative stage. Some of the farmers in this region have even surpassed the optimum level of inorganic fertilizer recommendations (Sheahan, 2011). In both counties, the rates of inorganic fertilizers used by smallholder farmers are estimated to be between 50 to100 kg N /ha and 26 to 52 kg P /ha for nitrogenous and phosphatic fertilizers, respectively. The main sources of basal fertilizer include DAP, NPK (23.23.0) and Mavuno planting while CAN and UREA are used as topdressing fertilizers (*personal communication*). In addition, farmers in this region often perceive chemical fertilizers as substitutes to additions of soil organic matter rather than as compliments. However, according to William *et al.,* (2012), organic fertilizers are not substitutes because they are not capable of producing benefits associated with organic inputs, such as improving the soil structure, increasing the water holding capacity of soils.

2.4 Efforts to Address Declining Soil Fertility

Efforts to restore soil fertility have been enormous over the past century in Kenya and have provided nutrient replenishment technologies which include organic and inorganic fertilizer recommendations. The technologies include Kenya Fertilizer Recommendation Project (FURP). Based on research by FURP (1994) the adapted recommendation by the Ministry of Agriculture is 75 kg/N ha and 26.4 kg/P ha as diammonium phosphate (DAP) at planting, followed by topdressing of 50 kg/N ha as calcium ammonium nitrate (CAN). Soil Management Project (SMP) phase one (1) which was initiated in 1995 in Trans Nzoia, Uasin Gishu, Keiyo and West Pokot counties in the North Rift region of Kenya, with funding from the Rockefeller Foundation succeeded in developing eight Soil and Crop Management (S&CM) technologies.

These S&CM technologies was disseminated through on-farm demonstration and largely adopted by farmers in the experimental clusters. In the year 2001 (Adolwa *et al*., 2010), these technologies were up scaled beyond the experimental clusters to wider farming communities in within Kenya Agricultural Research Institute (KARI) Kitale mandate region of Trans Nzoia, West Pokot, Uasin Gishu and Keiyo counties. The National Accelerated Agricultural Inputs Access Programme (NAAIAP, 2014), Ministry of Agriculture, Livestock and Fisheries, State Department of Agriculture, provided fertilizer recommendations for various crops for specific counties. Despite the potential of these recommendations, farmers have either partially adopted, adopted followed by disadoption. For example, the current recommended rates of fertilizer application (NAAIAP) of 75 kg/N ha and 25 kg P/ha at 6 t ha of manure at planting time are not fully implemented (NAAIAP, 2014). Farmers instead apply 60 kg/N ha and 15 kg P/ha, which are very low levels for optimum crop production.

Other organizations, for example the International Phosphate Institute (IMPHOS), recommend liming of the soil in combination with conventional diammonium phosphate (DAP) use and manures for improving soil fertility (Ndung'u-Magiroi *et al.,* 2010). In an field experiment established at Kuinet in Uasin Gishu, managed by women groups leaders, positive maize responses to initial lime application at 2, 4 and 6 t/ha and phosphorus at 26 and 52 kg P/ha were observed to increase yield up to six seasons of consecutive maize cropping in all the sites. Further, lime at all rates raised the soil pH and hence the available P in soils resulting in high maize yields.

"Blanket" fertilizer applications have been implemented over time. These are recommendations based on regional soil surveying or on agro-ecological zoning specific to a given crop for nitrogen (N), phosphorus (P), and potassium (K) (FURP

1994). This approach results in varied yields due to differences in field management practices and spatial topsoil heterogeneity (Vanlauwe and Giller, 2006). The varying results have led to farm-specific recommendations coupled with decision-making forums through a transdisciplinary (TD) process. The TD process is an approach which utilizes knowledge from theory and practice to generate socially robust solutions for sustainable development. It complements other forms of science, society cooperation such as contract-based research, public participation, and participatory research (Scholz, 2011). In this context, the aim of this process is to enable a mutual learning process between scientists and farmers (Scholz, 2000). This process brings scientific knowledge to farmers by creating a researcher and farmer-to-farmer network. The extension and fertilizer manufacturer-supplier services play important roles in disseminating information. In addition, the manufacturers have the responsibility of availing the right types of fertilizers to farmer (Scholz *et al*., 2014). The TD approach looks very noble however; most of the farmers have not embraced the idea of individual soil testing.

Soil conservation technologies are known to play an important role in improving soil fertility. In Kenya soil and water erosion was first identified as a major environmental problem in 1935 and in the 1940's. The colonial government then introduced the first soil and water conservation techniques in the country (Khisa *et al*., 2002; Gachene *et al*., 2004). However, the approaches used then did not bear much impact. In 1988 "catchment" approach funded by Swedish International Development Agency (SIDA) through the Ministry of Agriculture was initiated. It used participatory approach whereby farmers participated indentifying the areas affected by soil erosion. Farmers took part in analyzing degradation problems and in recommending soil conservation options. Swedish International Development Agency through GoK provided financial and technical support to farmers in catchment areas. Soil conservation technologies in the study area promoted include terraces, cutoff drains, drainage ditch, grass strips, unplugged strips and agro forestry (Pretty *et al*., 1995). Although, this approach was perceived to be superior compared to the previous ones, the soil and water conservation structures constructed were destroyed by the very farmers involved in the implementation process. This is probably because most farmers have not embraced the importance of conserving the soil coupled with sub division of land due increase in population.

2.5 Knowledge of Soil Fertility Replenishment Technology

The first prerequisite for a farmer to apply a new technology is to have knowledge regarding the existence of the technology. At this stage an individual farmer gathers information about the technology forms an attitude and finally makes decision on whether accept or reject. Knowledge about a technology is often influenced by farmers' access to information (Greiner *et al*., 2009; Baumgart-Getz, *et al*., 2012; Lambrecht, *et al*., 2014) and social networks within which the farmers interact (Greiner, *et al*., 2009; Knowler & Bradshaw, 2007). Access to information increases farmers' awareness (Lambrecht *et al*., 2014). Further, it enhances the capacity of the farmers to evaluate the existing technologies (Prokopy *et al*., 2008). Awareness is "the first stage of adoption process" of agricultural technology (Ekong, 2003). Once the farmers are aware about the existence of a new technology they may consider using it or not. The supply and diffusion of information about a technology by extension personnel are crucial for increasing awareness. Literature shows that, lack of Knowledge by farmers on issues related to agricultural production led to the increased establishment of awareness programs especially in developing countries.

However, awareness level of farmers about agricultural technologies that can increase production still remains low.

2.6 Technology Adoption

Adoption is an integration of a new technology into existing practice and is usually preceded by a period of 'trying' and some degree of adaptation (Loevinsohn *et al*., 2013). Citing the works of Jabbar *et al*., (1998); Tura *et al*., (2010); Kalinda *et al*., (2014) adoption is the stage in which a technology is selected for use by an individual or organization. Further, Feder, *et al*., (1985), Bonabana-Wabbi, (2002) defines adoption as a mental process an individual passes from first hearing about an innovation to final utilization of it. Adoption is in two categories; rate of adoption and intensity of adoption. The former is the relative speed with which farmers adopt an innovation, has as one of its pillars, the element of 'time'. On the other hand, intensity of adoption refers to the level of use of a given technology in any time period (Bonabana-Wabbi, 2002).

The technology adoption decision process is a dynamic sequence of actions and interactions through which individuals evaluate a technological innovation and decide upon whether or not to incorporate it into the on-going practice. Farmers make decisions about adopting new technologies as part of the overall strategy for ensuring subsistence and cash income needs. Further, farmers invest in improving land and fertility if it is a critical part of their livelihood strategy. The different livelihood strategies pursued by farmers have significant implications for the types of technologies they adopt (Thangata *et al.,* 2001). Adoption potential, from farmer's perspective can be considered to have three components: feasibility, profitability and acceptability (Swinkles and Frazzle, 1997). Feasibility is the capacity of the farmer to manage technology. The farmer should have the required information and resource to maintain the soil fertility improvement technology. Technologies that are promoted should therefore take into account the resource limited farm households. Technology characteristics plays a role in influencing diffusion process and farmers decision making on adoption of technologies (Vedeld and Krogh, 2001), as regards to farmers resources and capability to manage the technology. The economic constraints of a household to access resources influence the ability and willingness to adopt technological innovations (Vedeld 1990).

2.7 Factors Determining Adoption

There exist vast literatures on factors that determine agricultural technology adoption. Farmers' decisions about whether and how to adopt new technology are conditioned by the dynamic interaction between characteristics of the technology itself, farm and farmer characteristics (Loevinsohn *et al.*, 2013). Diffusion itself results from a series of individual decisions to begin using the new technology, decisions which are often the result of a comparison of the uncertain benefits of the new innovation with the uncertain costs of adopting it (Hall and Khan, 2002).

Traditionally, economic analysis of technology adoption has sought to explain adoption behavior in relation to personal characteristics and endowments, imperfect of information, risk, uncertainty, institutional constraints, input availability, and infrastructure (Rogers, 2003; Uaiene *et al.*, 2009). A more recent strand of literature has included social networks and learning in the categories of factors determining adoption of technology (Uaiene *et al.*, 2009). Some studies classify these factors into different categories. For example, according to Akudugu *et al.*, (2012) determinant of agricultural technology adoption can be grouped into three categories namely;

economic, social and institutional factors. Further, Lavison, (2013) broadly categorized the factors that influence adoption of technologies into social, economic and physical categories. Although, there are many categories for grouping determinants of technology adoption, currently there is no clear distinguishing feature between variables in each category. Some factors can be correctly placed in either category. For instance, experience as a factor in adoption is categorized under 'farmer characteristics' or under 'social factors' (Kebede *et al.,* 1990) or under 'human capital characteristics' (Caswell *et al.,* 2001). The level of education of a farmer has been classified as a human capital by some researchers while others classifies it as a household specific factor. Categorization is done to suit the current technology being investigated, the location, and the researcher's preference and to suit client needs (Bonabana- Wabbi, 2002). This study will review the factors determining adoption of agricultural technology by categorizing them into economic and social factors. This will enable a depth review of how each factor influences adoption.

2.7.1 Economic Factors

Economic factors are aspects that relate to economic conditions in communities and less to the social and biophysical environment. These include: farm size, farm income off farm income, credit availability and cost of technology. These factors adversely influence the adoption of agricultural technologies among farmers (Binod, 2010).

2.7.1.1 Farm Size

Farm size plays a critical role in adoption process of a new technology. It forms an important determinant of technology adoption. Most of empirical adoption studies focus on farm size as the first and most important determinant (Baidu-Forson, 1999). This is because farm size can affect and in turn be affected by the other factors influencing adoption process (Lavison, 2013). Some technologies are termed by researchers as scale-dependant because of the great importance of farm size in their adoption (Bonabana- Wabbi, 2002). Studies by Ahmed, (2004); Uaiene *et al.*, (2009); Mignouna *et al*., (2011) have reported a positive relation between farm size and adoption of agricultural technology. Farmers with large farm size are likely to adopt a new technology as they can afford to devote part of their land to try new technology unlike those with small farm size (Uaiene *et al*., 2009). Some studies have shown a negative influence of farm size on adoption of new agricultural technology for example, a study by Samiee *et al*., (2009) reported a negative relationship between farm size and adoption with adoption.

A small farm size may provide an incentive to adopt a technology, especially in the case of an input-intensive innovation such as a labor-intensive or land-saving technology. Farmers with small land may adopt land-saving technologies such as green house technology, zero grazing among others as an alternative to increased agricultural production (Harper *et al.*, 1990; Yaron *et al*., 1992). Other studies have reported insignificant or neutral relationship with adoption. For instance a study by Bonabana- Wabbi (2002) concluded that size of farm did not affect Integrated Pest Management (IPM) adoption implying that IPM dissemination may take place regardless of farmers' scale of operation. The impact of farm size on adoption and intensity of use agricultural technologies on the other hand, is not consistently similar in various adoption studies. Some of the studies showed a positive influence of the variable on adoption decision. For instance, studied determinants of adoption and intensity of use of improved Maize varieties in the Central Highlands of Ethiopia and found a significant positive effect. Similar, results by other researchers such as

(Ogada *et al*., 2014) also found a reverse effect of land size on the joint adoption of inorganic and improved maize varieties.

2.7.1.2 Cost of Technology

The decision to adopt a technology is normally an investment decision. This decision presents a shift in farmers' investment options (Caswell *et al*., 2001). Therefore, adoption of a technology is dependent on its cost and on whether farmers possess the required resources. Technologies that are capital-intensive are only affordable to wealthier farmers and hence the adoption of such technologies may be limited to large scale farmers who have the resources (Khanna, 2001). The cost of adopting agricultural technology has been found to be a constraint to adoption in the developing countries. In sub-Saharan Africa the situation has been made worse by elimination of subsidies on prices of seed and fertilizers due to the World Bank-sponsored structural adjustment programs which started in the 1990s (Muzari *et al*., 2013). For instance, in Embu county, Kenya, the cost of hired labor is one among other factors constraining adoption of fertilizer and hybrid seed (Ouma *et al.*, 2012). Further, Wekesa *et al*., (2003) when analyzing determinants of adoption of improved maize variety in coastal lowlands of Kenya found high cost and unavailability of seeds as one of factors responsible for low rate of adoption.

2.7.1.3 Off - Farm Income

Off-farm labour has become a significant source of income for farm families. According to Diiro *et al*., (2013), off farm income received by farmers had risen steadily over recent decades. Off-farm income has been shown to have a positive impact on technology adoption. This is probably because off-farm income acts as a strategy for overcoming credit constraints faced by farmers in many developing countries (Reardon *et al*., 2007). It provides ready cash for purchasing inputs and could also be used to spread the risk of using improved technologies (Reardon *et al*., 2007). Off-farm income acts as a substitute for borrowed capital in rural economies where credit markets are either missing or dysfunctional (Ellis *et al*., 2004; Diiro, 2013). Off-farm income provides farmers with liquid capital for purchasing productivity enhancing inputs such as improved seed and fertilizers (Diiro, 2013). However, not all technologies have shown positive relationship between off-farm income and their adoption. Some studies on technologies that are labour intensive have shown negative relationship between off-farm income and adoption. Further, the pursuit of off-farm income by farmers may undermine their adoption of modern technologies by reducing the amount of household labour allocated to farming enterprises and time for searching for information regarding the new technology (Goodwin and Mishra, 2002).

2.7.1.4 Access to Credit

A positive relationship exists between the level of adoption and the availability of credit. This is probably because credit eases the cash constraints and allows farmers to purchase inputs such as fertilizer, improved crop varieties and chemicals used to control pest and diseases (Yirga, 2007). Access to credit stimulates technology adoption (Mohamed & Temu, 2008). It promotes the adoption of risky technologies through relaxation of the liquidity constraint as well as boosting household's-risk bearing ability (Simtowe & Zeller, 2006). With an option of borrowing, a household can do away with risk reducing but inefficient income diversification strategies and concentrate on more risky but efficient investments (Simtowe & Zeller, 2006). On the contrary, the study of Wollni and Andersson (2014) found it to have a negative influence of credit access on the adoption. This is probably because the income is diverted to other activities other than farming. Further, at times access to credit is gender biased in some countries where female-headed households are discriminated against by credit lending institutions, and as such they are unable to finance yield-raising technologies, leading to low adoption rates (Muzari *et al*., 2013). There is therefore, need for policy makers to improve current smallholder credit lending institutions to ensure that a wider spectrum of smallholder farmers are able to have access credit, especially female-headed households (Simtowe & Zeller, 2006). This may, in certain cases, necessitate designing credit packages that are tailored to meet the needs of specific target groups (Muzari *et al*., 2012). For instance in Kenya, the government has started a program that offer free interest loans to youths and women (UWEZO fund). This will help empower women and enable them to adopt agricultural technologies hence enhancing economic growth.

2.7.1.5 Farm Income

Increased income from the sales of farm produce can contribute to greater adoption of SFRTs. This is because it provides farmers with liquid capital to purchase inputs required for crop production. Shiferaw *et al*., (2014) asserted that annual farm income had a significant positive relationship with the adoption of recommended technologies in Bangladesh. Accordingly, a study by (Diiro, 2013) indicated that increased annual farm income significantly influenced the adoption of maize, wheat, barley and sorghum technology packages.

A study by (Olumba and Rahji, 2014) revealed that farmers' income showed a significant relationship with the farmers' level of adoption of the technologies. Further, the proportion of income received from banana significantly influenced the adoption of Tissue Culture Banana (TCB), implying that income from banana sales allow farmers to grow TCB in Uganda(Olumba and Rahji, 2014). This implies that, the higher the proportion of banana revenue at the household level, the higher the adoption of innovation. According to Lee, (2005) economic incentives play an important role in the adoption of improved agricultural technologies. Smallholder farmers in sub Saharan Africa are characterized by widespread failure to adopt/invest on soil fertility replenishment technologies in order to sustain the productivity of their farmland (Barrett *et al*., 2002; World Bank, 2003). In such cases high farm income can enhance technology adoption. This can increase the ability of the farmer to purchase the necessary required inputs for the implementation of the technology.

2.7.2 Social Factors

There is a large literature on the adoption of agricultural technology (Rogers, 2003). Further, there is agreement that the adoption of agricultural technology is affected by social factors such as age, education, gender, access to extension services and household size (Pannel *et al*., 2006)**.**

2.7.2.1 Age

Age is an essential factor that influences the probability of adopting new technologies (Emmanuel *et al*., 2016). The age of a farmer may positively or negatively influence the decision to adopt a new technology (Gbegeh and Akubuilo, 2013). Older farmers have acquired more experience in farming and are better able to assess the characteristics of a new technology than younger farmers, and hence a higher probability of adopting the practice. On the other hand, older farmers are more risk-averse, less flexible than younger farmers and thus have a lesser likelihood of adopting new technologies (Mignouna *et al*., 2011; Kariyasa and Dewi, 2011).

Younger farmers are likely to incur lower switching costs in implementing new farming practices since they have limited experience and therefore, adjustment costs involved in adopting new technologies may be lower for them (Marenya and Barrett, 2007). For instance, Alexander and Van Mellor (2005) found that adoption of genetically modified maize increased with age for younger farmers as they gain experience but declines with age for those farmers closer to retirement. Other studies revealed that age of individuals affect their mental attitude to a new technology and hence influence adoption in a number of ways. Young farmers have been found to be more knowledgeable about new practices and may be more willing to take the risk and adopt or invest than the older farmers. This implies that farmer's age and technology adoption are inversely related (Akinola *et al*., 2011). Therefore, it is hypothesized that farmer's age and investment decisions are expected to relate negatively.

2.7.2.2 Education

Education measures the literacy level of an individual farmer. Education level of the farmer has been assumed to have a positive influence on farmers' decision to adopt new technology. Studies by Mignouna *et al*., (2011); Lavison (2013); Namara *et al*., (2013); Gbegeh & Akubuilo, (2013) revealed that education level of a farmer increases his ability to obtain; process and use information relevant to adoption of a new technology. This is because higher education influences respondents' attitudes and thoughts making them more open, rational and able to analyze the benefits of the new technology critically (Waller *et al*., 1998). Further, well educated farmers are aware of sources of information and more efficient in evaluating and interpreting information about new technologies than those with less education (Shieferaw *et al*., 2009). According to a study by Okunlola *et al*., (2011) on adoption of new technologies by fish farmers and Ajewole, (2010) on adoption of organic fertilizers found that education level had a positive and significant influence on adoption of the technology. Carrer *et al*., (2017), in his study also found a positive relationship between education level and the adoption of technologies. Higher education levels potentially increases farmers' ability to process information and make informed decisions (Carrer *et al*., 2017). However, some authors have reported significant negative effect of education level on the rate of technology adoption (Banerjee, *et al*., 2008; Samiee *et al*., 2009). Higher educational attainment can present a constraint to adoption because it offers alternative livelihood strategies, which may compete with agricultural production (Uematsu and Mishra, 2010).

2.6.2.3 Gender

Studies have shown that gender is an important factor affecting adoption decision at the farm level. The effect of gender of the household head on adoption decisions is location-specific (Gbetibouo, 2009). In many parts of sub Saharan Africa, women are often deprived of property rights due to social barriers. Consequently, women have less access to production resources than men (Gbegeh and Akubuilo, 2013). This often undermines their capacity to embrace labor-intensive agricultural innovations. Male-headed households are often considered to have more access to information about new technologies and take risky businesses than female-headed households (Asfaw and Admassie, 2004). On the contrary, female - headed households may have negative effects on the adoption of soil fertility replenishment technologies because they have limited access to information, land and other resources due to traditional social barrier (Tenge *et al*., 2004). However, in some regions of Africa, Kenya included female farmers have been found to be more likely to adopt natural resource management and conservation practices (Dolisca *et al*., 2006).

2.7.2.4 Household Size

Household size as a proxy to labor availability may influence the adoption of new technologies positively if its availability, reduces the labour constraints (Marenya and Barrett, 2007). A Household with a larger pool of labour is more likely to adopt agricultural technology which requires a lot of labour and use it more intensively because they have less labour shortages at peak periods. Most farm operations in sub-Saharan Africa is provided by the family rather than hired, therefore, lack of adequate family labour accompanied by inability to hire labour can seriously constrain adoption practices (Nkonya *et al*., 2008). Nonetheless, households with many family members may divert part of the labour force to off-farm activities in an attempt to earn income to ease the consumption burden imposed by a large family size (Tizale, 2007; Gbetibouo, 2009).

2.7.2.5 Extension Services

Acquisition of information about a new technology enables farmers to learn the existence and the effective use of technology. This facilitates its adoption. Farmers will only adopt the technology they are aware about it. The extension service is the key driving force behind technology dissemination in the agricultural sector in developing countries. Availability and access to extension services is a key aspect of technology adoption (Mwangi *et al*., 2015). According to Akudugu *et al*., (2012), access to extension services can counteract the negative effect of lack of formal education of farmers which hinders them from technology adoption.

Access to extension services exposes farmers to new technologies and their potential benefits (Charles *et al.*, 2017). Further, contact with extension services gives farmers access to information on innovations, advice on inputs and their use, and management of technologies (Menale *et al.*, 2009). Access to information reduces the uncertainty about a technology's performance and hence change individual's assessment from purely subjective to objective over time (Bonabana- Wabbi 2002). Access to extension services has been a major aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agents act as link between the farmer researchers or promoters for example national/county government. This helps to reduce transaction cost incurred when passing the information on the new technology to a large heterogeneous population of farmers (Genius *et al*., 2010). It is believed that frequent contacts with extension agents can enhance the exposure of farmers to improved production technologies and practises (Owombo *et al*., 2011; Kidane, 2001). Therefore, access to extension services facilitates the up-take of technology. Studies by Adesina and Zinnah, (1993) and Nkonya, *et al.*, (2008), among others, have shown that access to extension services is an important factor in adoption decisions.

2.7.2.5.1 Agricultural Extension in Kenya

Agricultural extension in Kenya started in the early 1900s, but its only notable success was in the dissemination of hybrid maize technology in the late 1960s and early 1970s. The government through the Ministry of Agriculture provided the bulk of extension services to both smallholder and commercial farmers. After the implementation of structural adjustment programs (SAPs) in the 1980s, the Kenyan government came under considerable pressure to scale down its dominant role in national economy (FAO, 1997). Kenya's agricultural extension budget together with extension staff numbers has plummeted significantly. At that time, the performance of the public agricultural extension service in Kenya was questioned and it's effectiveness became a very controversial subject (Gautam and Anderson, 1999). The traditional public extension system was perceived as outdated, using top-down approach, paternalistic, uniform (one-sizefits-all), inflexible, subject to bureaucratic inefficiencies. The critics argued that it was unable to cope with the dynamic demands of modern agriculture. (Republic of Kenya, 2005b).

To respond to the challenges, the then Ministry of Agriculture and Rural Development formulated the National Agricultural Extension Policy (NEAP) to guide and harmonize the management and delivery of agricultural extension services (Rivera, 2000; Rivera 2001; Government of Kenya (GoK), 2001). The NEAP recognized the need to diversify, decentralize and strengthen the provision of extension services to increase their sustainability and relevance to farmers. The NEAP formed the basis for all extension service within the government and in its interaction with other stakeholders in research and development. To operationalize the NEAP, the ministry prepared a National Agricultural and Livestock Extension Program (NALEP) and NALEP Implementation Framework. However, the policy has been criticized for been ambiguous on the specific roles of various actors in extension provision for example it was unable to specify how the private sector would be encouraged to play a stronger role in extension. Therefore, there has been a desire to reform the public extension into a system that is cost effective, more responsive to farmers' needs, broad-based in service delivery, accountable and with in-built sustainability mechanisms. Further, there has also been a call for stronger involvement of stakeholders and beneficiaries at grass root level. Currently, agricultural sector, particularly public extension service has been devolved to county governments and much of what has been discussed above is not known to the policy makers at county level and the extension services have virsually collapsed.

2.8 Farmers' Perceptions

Perception is the process through which an individual gains understanding of what is happening and forms an opinion/attitude/judgment about it. The way farmers perceive attributes of a given technology influences their adoption behaviour. Farmers' perception of a technology is a critical determinant in the decision to adopt a technology (Nabifo, 2003). Many studies on adoption reveal that, farmer's perception of technology-specific attributes is an important factor in explaining farmer's adoption behavior. Farmer's perception of technology-specific attributes of agricultural technologies influence his/her preferences and thus adoption decisions (Odera, *et al*., 2000)

If farmers' perceptions are that a technology is not profitable, there will be minimal investment in the technology. Further, technology adoption is influenced by perceived costs of the technology and access to information regarding the technology. (Boahene *et al*., 1999). The perceptions pertaining compatibility of the new practices with their farming system is another contributing factor of adoption of new practices (Alonge and Martin, 1995). The farmer's choice of action/decision will depend on his evaluation of these factors and other outcomes, in terms of his/her own personal perspectives.

The characteristics of innovations as perceived by the farmer influence adoption behaviour (Rogers 1983). Rogers postulated that characteristics of an innovation as perceived by a farmer influence the rate at which it is adopted. He presented five aspects of an innovation that have major influence on the rate of adoption:

(i) Relative advantage: the degree to which an innovation/idea is considered superior to others.

(ii) Compatibility: It is the degree to which an innovation is perceived as consistent with the existing values, past experiences, and the need of potential adopter.

(iii) Complexity: It is the degree to which an innovation is perceived as relatively difficult to understand and use.

(iv) Trialability: It is the degree to which an innovation may be experimented with on a limited basis.

(v) Observability: It is the degree to which the results of an innovation are visible to others.

Further Rogers (1983), argued that, apart from the characteristics of an innovation, characteristics of an adopter and his or her environment or situation are equally important. These aspects of technology are important as they can be applied to any agricultural technology.

2.9 Dissemination Pathways

Farmers preferences for dissemination pathways do exist. The choice of dissemination pathway should be based on their effectiveness and capacity to reach larger number of farmer (Roderick *et al*., 2008). In Kenya, technology dissemination has been facilitated by a series of dissemination pathways including farmer field schools (FFS), field days (FD), farmer teachers (FT), fellow farmers (FF), print media, public gatherings commonly known as *barazas* , radio programs and on- farm demonstration (Khan *et al*., 2008a; Amudavi *et al*., 2009). These dissemination pathways can be classified depending on the nature of information delivery. Dissemination of technologies using different pathways is resource driven and therefore it would be expected that the varied technology adoption levels would have an implication on the cost effectiveness of the pathways being used. The effectiveness of a dissemination pathway depends on the number of farmers that receive information and on how successful that pathway influences farmers' decision to adopt a given technology (Ricker-Gilbert *et al*., 2008; Doss, 2006). If ineffective pathways are used, farmers will be encouraged to spend time searching for relevant information thus increasing the information search costs. This, therefore, implies the need to evaluate the effectiveness and efficiency of the pathways being used in order to isolate the ones which are not only effective but also efficient, contingent on resource availability (Mauceri *et al*., 2005).

2.10 Knowledge of Soil Fertility Replenishment Technology

Awareness is a mental process of knowing about an object. A first prerequisite for a farmer to apply a new technology is to be aware about the existence of the technology. At this stage an individual gathers knowledge about technology or an innovation, forms an attitude and finally makes decision about its acceptance or rejection. Knowledge about a technology is often influenced by farmers' access to information (Lambrecht, *et al*., 2014; Baumgart-Getz, *et al*., 2012; Greiner *et al*., 2009) and social networks within which the farmers interact (Greiner, *et al*., 2009; Knowler & Bradshaw, 2007). Access to information increases farmers' awareness (Lambrecht *et al*., 2014) and evaluation capacity of existing technologies (Prokopy *et* *al*., 2008). According to Ekong, (2003), awareness is "the first stage of adoption process" of agricultural technology. Once the farmers have knowledge about the existence of a new technology they may consider using it or not. The supply and diffusion of information about a technology requires well organized extension system. Certain farmers might be more eager to learn than others and therefore, actively engage in search for new information about farming. Literature shows that, lack of farmers knowledge on issues that affect agricultural production on their farms has led to the increased establishment of awareness program especially in sub Saharan countries. However, awareness level of farmers about agricultural technologies that can increase production still remains low.

2.11 Challenges Faced by Farmers' in Adoption of Agricultural Technologies

The sustainable growth of the agricultural sector critically depends on the adoption of improved technologies, such as disease-resistant seed varieties, use of modern management practices and soil and conservation techniques. The adoption of new technology in agriculture is, therefore, the core of agricultural growth and poverty alleviation. Unfortunately, the adoption of new agricultural technology, including soil enhancing technologies, is dismally low (Pierpaoli, *et al*., 2013) as a large number of factors can affect the adoption process. This is probably because, new agricultural technologies are often correlated with risks and uncertainties about proper application, scale appropriateness and suitability with the prevailing environment, and importantly with farmers' perceptions and expectations (World Bank, 2008).

Climate change is a serious threat to local food production and family well-being resulting in malnutrition, hunger and persistent poverty in many regions of sub

Saharan Africa Kenya included (Luhano, 2013). While some aspects of climate change, such as increased precipitation, may bring localized benefits, there is a wide range be a range of adverse impacts for example reduced water availability, frequent extreme weather events, and lower productivity of some crops, resulting in the reduction of farmers' income (Iglesias *et al*., 2015). Economic constraints and barriers to adaptation such as social acceptance, workload and biodiversity limit farmers' adaptation. These actions include strategies such as alterations in crop management such as planting dates or crop varieties and livelihood strategies (Jin *et al*., 2015). This scenario may impact negatively in the adoption of technologies because of the uncertainty of the benefits.

Farmers in developing countries, where infrastructure is poorly developed and access to markets is limited, must often find their own solutions to their economic problems (Tilt, 2008). In addition, productivity of most crops in these areas is low and families are often forced to supplement farm incomes from other livelihood activities. Decisions normally depend on perceptions of risk and the potential returns, as well as and their culture (Twomlow *et al.*, 2002). Ashrafi *et al.*, (2007) in their study enumerated several problems that farmers face in the developing countries. Some of the problems include lack of control over water use for irrigation, land fragmentation, difficulties in transferring inputs to farmlands as well as transporting their produce to markets. Other problems include low level of mechanization, lack of finance, lack of knowledge about modern technologies, high illiteracy levels and traditional methods for cultivation. Nonetheless, some studies find reasons beyond the above mentioned constraints. For instance, Marenya and Barret (2007) based on a study in Kenya, shows that without addressing complementary factors such as soil quality, merely availing infrastructure alone cannot ensure sustained adoption of agricultural technologies.

2.12 Analytical Methods used in Adoption Studies

Various models have been used to analyze socioeconomic factors affecting adoption decisions. Tobit model (1958) can be used to analyze the dependent variable where some data points can be zero or censored. However, the Tobit model imposes restrictions when the variables and coefficients determining whether and how much to adopt decisions are identical. Yet, earlier studies (Cragg, 1971; Coady, 1995) indicated that such decisions might not be intimately related. Logit and Probit models simply analyze the effects of regressors on the choice to use or not to use a technology. These models are statistically similar (Akinola *et al*., 2011), except that the Probit model assumes a normal cumulative distribution function (thus has fatter tails) while the Logit model assumes a logistic distribution of the dependent variable. Although parameter estimates may differ in the two models because the two distributions have different scales, Amemiya (1981) and Agresti (2002) noted that it would require enormous sample sizes to have significant differences in the two models. Use of either model is thus discretionary. Variants of the Logit model include the ordinary Logit (binary Logit), the ordinal logistic, nominal logistic and the multinomial Logit.

The ordinal logistic regression model is used when the dependent variable is ordered while nominal logistic handles nominal categorical responses. Multinomial logistic modeling is a special case of ordinary logistic approach, developed to address the case where the dependent variable can take on more than two values that are not ordered. Unlike Logit models, probit models lack flexibility - they do not easily incorporate more than one prediction variables (Montgomery *et al*., 2001). The alternative to analyze farmers' adoption decisions is to use Double hurdle models such as the Heckman model, Double – limit hurdle model; and the two-stage combination of the Probit and Truncated regression models. The model is preferred because of its flexibility and ability to analyze the adoption of different soil fertility replenishment technologies (Hassan and Nhemachena, 2008) among farmers in the study area.

2.13 Theoritical Framework

Different types of models that have been used to explain adoption decisions of new technologies. However, no single model can explain all aspects of adoption (Thangata & Alavalapati, 2003). There remains a lack of consensus on elements which form the primary drivers to adoption. However, adoption and diffusion of innovations theory developed by Rogers (1995) has been widely used. The theory attempts to predict the behaviour of individuals and a social group in the process of adoption of new innovation, considering their personal characteristics, social relations and characteristic of the innovation (Thangata & Alavalapati, 2003). Further, Van den Ban and Hawkins (1996) assert that the Diffusion of Innovation theory can be used in studies related to agricultural extension because it explains how new technologies spread across the community

According to Rogers (2003), adoption occurs when one has decided to make full use of the new technology as a best course of action for addressing a need. Adoption is determined by several factors including socioeconomic, environment, and mental processes that are governed by a set of intervening variables such as individual needs, knowledge about the technology and individual perceptions about methods used to achieve those needs (Thangata & Alavalapati, 2003).

This study was informed by Diffusion of Innovation theory. Rogers (1995), stated that the adoption of technology is related to innovation decision process through which an individual passes from first knowledge of an innovation to forming an attitude towards the innovation, deciding to adopt or reject the innovation, implementing the new ideas, and confirming the innovation decision. Farmers have to get interest concerning innovation/technology because, when this happens, he/she tends to seek for more information on his/her own and when this happens adoption can take place. According to Rogers, (2003) the adoption and diffusion model identifies five aspects that influence adoption: perceived attributes of the innovation; type of innovation decision; communication channel; nature of the social system; and the extent of change agent promotion efforts (Rogers, 2003). Some of Rogers' generalizations as significant variables that affect adoption, which have also been used in other adoption studies, include educational level, farm size and income.

The adoption diffusion of innovations model is a useful model for understanding farmers' decision making processes when they consider taking up and eventually adopting new technologies. This model assumes that the heart of the diffusion process lies in the modeling and imitation by potential adopters of their neighbours with the new practice (Rogers, 2003), and that the tendency to adopt new practices relies on the relative innovativeness and the personal attributes of farmers, with some farmers adopting innovations more quickly than others. There is an assumption in this model that research generates information that is inherently valuable, desirable and suitable for increasing farm production and productivity. In this study, it is also assumed that SFRT technologies are feasible, efficient and suitable for increasing productivity in the North Rift region of Kenya.

Therefore this study adapted Rogers' model but also considered other studies conducted on adoption to gain insights on influencing factors (Ajayi *et al*., 2006; Ajayi, 2007; Ajayi *et al*., 2007; Kiptot *et al*., 2007).

2.14 Conceptual Framework

The conceptual framework presented in Figure 2.1 below explains the factors that determine the farmer's decision to adopt soil fertility replenishment technologies. The framework illustrates how social and economic factors directly influence adoption.

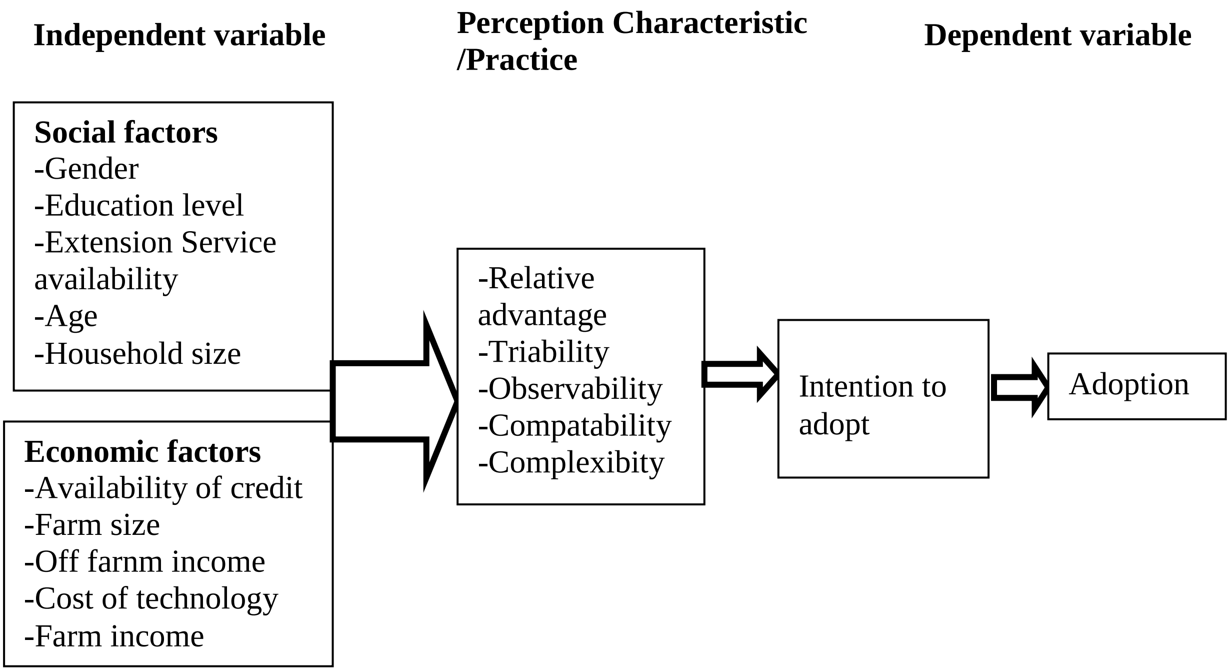

Figure 2. 1: Conceptual Framework

Source: Personal Unpublished, 2018

The conceptual framework for this study is based on the fact that adoption of agricultural technology depends on a wide range of variables which include social and economic factors. The framework presupposes that, successful soil fertility replenishment technology adoption by all farmers is a function of socio-economic factor. This in turn influences farmers' views about the practices (perceptions) based on their felt needs and prior experience.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

This chapter highlights the methodology of the study. It contains information on area of study, research design, demonstration treatments, selection of farmers, data types and sources, target population and sample size, sources and types of data, methods of data collection, data collection procedure and data analysis

3.1.1 Area of the Study

The study was undertaken in Uasin Gishu and Trans Nzoia counties in the North Rift region of Kenya.

3.1.2 Uasin Gishu County

Uasin Gishu county lies between longitudes 34^{o} 50’ and 35^{o} 37’ East and latitudes South and 0^{o} 55’ North. It is a highland plateau. The terrain varies greatly. The altitude ranges between 1,500 metres above sea level at Kipkaren in the West to 2,100 metres above sea level at Timboroa in the East. Eldoret Town, the main town of Uasin Gishu county, is at an attitude of 2,085 metres, marks the boundary between the highest and the lowest altitudes of the county. The general landscape of this county is that of undulating plateau with no significant mountains or valleys. The land is higher in the East and lower towards its western border. The average rainfall ranges between 900 mm -1,200 mm. Due to high altitude in the county, temperatures are relatively low. The highest is about 24^{0}C and the lowest is 8.8^{0}C. Humidity is moderate, averaging 56%. The average temperatures in the county are 18^{0}C during the wet season with a maximum of 26.1^{0}C during the dry season (Republic of Kenya, 2004).

The land use pattern in the county has been influenced by variation in altitude, rainfall, and temperature and underlying geology. The county has three noticeable soil types according to FAO UNESCO classification: Ferralsols, Acrisols and Nitisols. Due to favourable topographical and climatic conditions, the entire county has a high potential for agricultural and livestock production (MoA, 2006). However, a large area (> 50%) of the county has inherently low soil fertility and is underlain by murram (Jaezold and Schmidt, 2012). In the past, the county was almost exclusively farmed by large mixed farms. During 1973/74, about 290 000 ha were cultivated in large units, many of them commonly owned. The desire to own and farm the land individually has resulted in subdivision and this trend will continue due to population growth (Jaezold and Schmidt, 2012). The county is currently divided administratively into six sub counties and thirty wards (Appendix 6).

3.1.3 Trans Nzoia County

This county is part of the North Rift Valley of Kenya, providing the bulk of maize to the country commonly known as the 'grain basket' of Kenya. It comprises of five administrative sub counties namely Kiminini, Saboti, Cherangany, Endebess and Kwanza. These are further sub-divided into twenty five administrative wards (Appendix 7). The county is situated at the 1°01′N 35°00′E / 1.017°N 35°E / 1.017; at an altitude ranging from 1,700 to 2,100 m above sea level. It receives unimodal types rainfall with a mean of 1,145 mm per annum (Jaetzold and Schidmt, 2012; average of 30 years), with peak periods in May to August and dry spells in December to March. Mean maximum and minimum temperatures are 27.8 and 10^{o}C, respectively. The soils are predominantly the Ferralsols, with pockets of Acrisols, Nitisols and other orders in some areas. Land sizes vary from small (< 0.2 ha) to large (above 10 hectares) and ownership from individual to hired land. Management depends on the ownership; hired land receives lower nutrient inputs compared to individual land(Wanyama *et al.*. 2006). Soils of the study sites are inherently low in fertility. Further, in this county there is soil degradation and nutrient depletion due to continuous cultivation, removal or burning of crop residues, loss of nutrients through soil erosion and overgrazing between cropping seasons (Jaetzold and Schidmt, 2012). At pre independence, the Trans Nzoia county was almost exclusively farmed as large-scale mixed farms, and by 1973/74, 185,000 ha of land was still cultivated in large units. Because of the comparatively high population density, and the multiple ownership of the mixed farms, many of them have been subdivided into individually managed smallholdings. It is estimated that 200-220 large farms of approximately 500 ha each in size will remain, while the rest of the land is owned by smallholder farmers in units of > 2 to 6 ha in size (Jaezold and Schmidt 2012).

3.2 Research Design

A research design is a plan for selecting subjects, research sites and data collection procedures to answer the research questions or objectives (Okiro and Ndungu, 2013). It provides a context within which a study is conducted (Kothari, 2004). In this study descriptive survey design was adopted. The design was used because it is able to access the occurrence, happenings and matters the way they are (Mugenda and Mugenda, 2003). Further, by using descriptive studies, the high levels of accuracy is achievable. This can be realized by the use of systematic research methods for collecting data from a representative sample of individuals, using structured instruments composed of closed-ended and/or open-ended questions, observations, and interviews (Gakure and Ngumi, 2013). Descriptive research generates both qualitative and quantitative data, that define the state of nature at a point in time.

Survey research involves asking questions of a sample of individuals, who are representative of the group or groups being studied. Such studies may have a variety of purposes such as describing, comparing and correlating. A quantitative data allows for the use of econometric models to determine the influence of different factors like adoption of SFRT.

On farm demonstration - On-farm demonstrations of selected soil fertility replenishment technologies at each of the three sub counties was carried out. Demonstration studies are used by agricultural extension personnel to demonstrate the benefits of using a new technology/practice or product (Kothari, 2004).

Demonstrations are normally carried out when the research behind the new technology has already been conducted. Demonstration studies are normally used to show the farmers/producers what could be expected by adopting the new technology or product. In this study, the demonstration provided a rare opportunity to compare side-by-side, the performance of six soil fertility management options. The study used participatory approach whereby farmers managed the trials and participated on technology evaluation, the prerequisite for technology adoption. The materials used and their rates of application, varied with each technology. In this study six soil fertility replenishment technologies were tested using the following inorganic and organic fertilizers: DAP, 23.23.0 (NPK), Rutuba (bio organic fertilizer), Mavuno (a type of fertilizer that has been blended), CAN, manure and lime formulations as described below:

3.2.1 Demonstration Treatments

(i) FURP recommendation: 75 kg N + 26 kg P /ha - 129 kg DAP/ha fertilizer was used at planting to give 26 P kg/ha + 191.9 kg/ha CAN at topdressing to bring N to 75 kg N/ha.

(ii) FURP plus lime recommendation: 75 kg N + 26 kg P /ha + 2 ton of lime (CaO) - 129 kg DAP/ha fertilizer was used at planting to give 26 P kg/ha + 191.9 kg/ha CAN at topdressing to bring N to 75 kg N/ha + 2 tones lime.

(iii) ½ (FURP + Rutuba recommendation**:** 13 kg P /ha DAP + 37.5 kg N /ha (64.5 kg DAP/ha fertilizer was used at planting to give 13 P kg/ha + 96 kg/ha CAN at topdressing to bring N to 37.5 kg N/ha) + I/2 rate Organic manure (trading under the name Rutuba bio organic) 125 kg/ha at planting + ½ rate CAN- topdressing 125 kg/ha.

(iv) Rutuba recommendation**:** 0.819 P kg + 77.6 kg N equivalent to 250 kg/ha at planting + 187.5 kg/ha CAN topdressing.

(v) Mavuno recommendation**:** 28.4 kg P + 100 kg N equivalent to 250 kg/ha at planting + 187.5 kg/ha CAN topdressing.

(vi) National Agricultural Accelerated Input Access Programme (NAAIAP) recommendation**:** 25.1. P + 100 kg N + 6 manure ton/ha equivalent to 250 kg/ha 23:23:0 at planting and 150 kg/ha CAN plus 225kg/ha Manure 6 tons/ha.

3.2.2 Description of Materials Used

This section contains brief description of the organic and inorganic fertilizers used in the demonstration plot. These imputs include DAP, Mavuno planting, Rutuba, NPK (23:23:0), agricultural lime and manure.

3.2.2.1 Koru (Homa) lime

Koru lime, also known as Super calcium fertilizer, is a mixture of calcium hydroxide, calcium oxide and calcium carbonate, a by - product of the hydration plant at Homa Mining Company in Koru, Kenya (Table 2.1).

Table 3. 1: Chemical Composition of Koru lime

Compound	% in Koru lime
$CaCO_3$	78.58
CaO (burnt lime)	20.8
Fe_2O_3	0.29
Al_2O_3	1.2
MgO	1.06
SiO_2	0.42

3.2.2.2 Diammonium Phosphate (DAP)

DAP fertilizer is an excellent source of P and nitrogen (N) for plant nutrition. It's highly soluble and thus dissolves quickly in soil to release plant-available phosphate and ammonium.

- Nitrogen - 18% N
- Phosphorus - 46 % P_2O_5

3.2.2.3 Rutuba Fertilizer

This is an organic fertilizer which is fortified with macro and micro nutrients. It is packed in 50 kg bag and it contains the following nutrients

- Nitrogen (N) – 1.05%
- Phosphorous (P_2O_5) – 0.75%
- Potassium (K_2O) – 1.63%
- Calcium (CaO) – 0.8%
- Magnesium (MgO) – 0.2%
- Iron mg/kg – 7600
- Copper mg/kg – 450
- Manganese mg/kg – 1207
- Zinc mg/kg - 438

3.2.2.4 Mavuno Fertilizer

Mavuno fertilizer is manufactured by Athi River Mining Company Limited. The factory based at Athi River, Kenya, in the outskirts of Nairobi. Mavuno fertilizer is a blended fertilizer containing 10 essential plant nutrients. The fertilizer comes in two forms of "planting" and "top dressing". The Essential Nutrients contained in MAVUNO planting are:

- Nitrogen (N) - 10%
- Phosphorous (P_2O_5) - 26%
- Potassium (K_2O) - 10%
- Sulphur (SO_4) - 4%
- Calcium (CaO) - 10%
- Magnesium (MgO) - 4%

Plus appropriate additions of other Trace Elements like:

- Zinc
- Copper
- Molybdenum
- Boron

3.2.2.5 NPK (23:23:0)

This fertilizer contains different amounts of nutrients. The nutrients are often written on the bag or packing slip as percentages, or as N: P: K (Nitrogen: phosphorus: potassium). The essential nutrients contained in 23:23:0 include

- Nitrogen - 23% N
- Phosphorus - 23% P_2O_5

3.2.2.6 Calcium Ammonium Nitrate

Calcium ammonium nitrate (CAN) 27 % N, is a highly efficient nitrogen fertilizer with calcium. It contains nitrogen in both the N- NH_4 at 13, 5% and N- NO_3 at 13.5%. N- NO_3 forms to provide plant nutrition during the plant growing period.

3.2.2.7 Manure

It is a valuable fertilizer that contains a broad range of nutrients such as nitrogen (N),phosphorus (P) and potassium (K) as well as micronutrients such as copper (Cu), manganese (Mn) and zinc (Zn). Manures with added bedding are also an excellent source of organic matter which improves soil quality when applied to soil. The water, nutrient and organic matter contents of manures, however, vary greatly making them more difficult to manage than synthetic fertilizers.

3.2.3 Experimental Design/Plot Layout

Table 3. 2: Outline of the Demonstration Plots Showing the Treatments Layout.

Mavuno Technology		**NAAIAP technology**		**RUTUBA Technology**
28.4 kg P + 100 kg N/ha		25.1 P kg + 100 kg N + Manure 6 tons/ha		0.819 P kg + 36.8 kg N/ha
		(Path)		
FURP and Rutuba Technology		**FURP Technology**		**FURP + LIME Technology**
13.4 kg P + 38.6 kg N/ha		75 kg N + 26 kg P /ha		75 kg N + 26 kg P + 2 tons of lime (CaO)/ha

22 m

The treatments were applied simultaneously in plots measuring 6 m x 6 m in all the sites. The paths between the plots was 1m. Seed rate was 125 kg /ha and the spacing was 75 cm x 30 cm. Hybrid 513 from Kenya Seed Company, which is recommended for medium altitude areas of Kenya (Guantai *et al.*, 2007), was planted in all the sites. Agricultural lime, DAP, NPK (23:23:0), Rutuba and Mavuno fertilizers were broadcast evenly and incorporated using a hoe within 15 cm soil depth (plough layer).

Two seeds of maize were planted per hole and later thinned to one at two weeks after emergence. The crops were sprayed to control pests during growth. They were also weeded two times. Treatment allocation was as shown in Table 3.2.

3.2.4 Selection of Farmers to Host Demonstration

Site selection involved the farmers themselves, researcher, area chiefs and the local agricultural extension officers. One farmer was selected per sub county. The selection of the respective farmers was done during the *barazas* (local gathering) organized by the area chief and agricultural extension officer. The objectives of the demonstration were explained during the *barazas*. The farmers interested in hosting in demonstrations in their farms were selected by acclamation. The selected farmer for each site was then visited by the researcher and the extension officers to confirm the suitability of the site. The researcher provided the input such as maize seed, inorganic fertilizers and Rutuba (organic fertilizer) while the farmers provided the manure. The farmers also provided labour. The farmer groups participated in the major activities for example planting, weeding, topdressing and harvesting. Supervision was undertaken to ensure farmers understood the treatments. Participatory on-farm trials were carried out to assess farmer's perception towards the selected technologies and the challenges they face in adopting the technologies. The interview on perception was done when the crop was at maturity stage. In Turbo, Soy and Cheranganyi, 39, 37 and 32 farmers were part of the assessment, respectively. The on-farm trial was conducted in 2017 and in 2018 assessment was done to establish the challenges facing the farmers who participated in the demonstration and had decided to adopt the technologies.

3.2.5 Technologies Adoption Assessment

In order to assess whether farmers who participated in the demonstration started trying any of the proposed practices semi-structured open interviews was used. The interviews were performed after one year to assess if farmers started trying each of the proposed technologies as a result of the participatory demonstration. Further, they were asked to elaborate on constraints associated with the implementation of the SFRT.

To assess the performance of each technology farmers agreed to use observation technique. Farmers who participated in the demonstration agreed to use the cob size as the criteria for ranking the treatments. This visual observation was also indicative of the grain weight.

3.3 Data Types and Sources

Data that was used in this study was collected from two sources. These were:

3.3.1 Primary Data

Primary data was sourced through administration of questionnaire. Primary data was obtained directly the household head. The information that was collected included off farm income, farm income, farm size, cost of technology, access to credit, age of the household head, education level of the household head, gender of household head, access to extension services, and household size. Information was obtained through interviews and administration of semi-structured questionnaires. Each questionnaire was sub-divided into sections in order to capture the required information as attached in (Appendix i).

Enumerators who were mainly extension officers from the Ministry of Agriculture, Livestock and Fisheries (MoALF) were trained for two days on the techniques of data collection, administration of questionnaires and ethical issues. Corrections of any anomalies/ambiguities were made on the questionnaire during a brainstorming session with all the stakeholders (farmers, researcher, extension agents).

3.3.2 Secondary Data

Secondary data was obtained by reviewing a number of relevant documents with a view to gathering information about adoption of agricultural technologies. These documents were obtained from institutional libraries, scholarly journals, books, economic surveys, World-Wide Web, statistical reports, thesis and dissertations, bulletins, monthly and annual reports and government publications.

3.4 Population and Sample Size

Sample size refers to the number of items to be selected from the universe to constitute a sample (Kothari, 2004). According to Mugenda and Mugenda, (2003), for descriptive studies, 10% and above of the accessible population is enough for the entire study. In this study, there were 166,635 maize farmers in the Uasin Gishu county while Trans Nzoia county had 173,520 farmers out of which 24,139; 30,694 and 28,494 were found in Turbo and Soy and Cherangany sub county, respectively (MoALF, 2014). The size of the sample was determined by using a formula as specified by Pindyck *et al* (1991) as follows;

$$n = \frac{Z^2 pq}{e^2} \quad \ldots\ldots\ldots(3.1)$$

Where

n = sample size

Z = normal quartile e.g. for 95% interval (1.96)

p= is the estimated proportion of an attribute that is present in the population (0.5)

q = 1- p.

e= margin of error (precision) - (0.05)

$$n = \frac{Z^2pq}{e^2} = \frac{(1.96)^2\,(0.5)\,(0.5)}{(0.05)^2} = 384 \text{ sample}$$

Based on the formula, a sample size of 384 was required. This was suitable and large enough to allow reasonable and accurate interpretation of the results for the study. This sample size ensured that the main characteristics of the household were captured.

Proportionate sampling technique method was used to distribute the sample size of 384 farm households amongst the selected sub counties.

Table 3. 3 Distribution of Sampled Households Selected in Trans Nzoia and Uasin Gishu Counties

County	Sub county	Maize farmers Per sub county	Wards	Maize farmers per ward	Sampled households
Uasin Gishu	Turbo	13,610	Kamagut	2,950	24
			Tapsagoi	6,210	51
			Ngenyilel	4,450	36
	Soy	16, 408	Kipsomba	5,450	43
			Moi’s Bridge	8,200	79
			Soy	2,758	26
Trans Nzoia	Cherangany	19,434	Sirenyere	5,115	46
			Sitatunga	7,223	33
			Kaplamai	7,096	46
Total		**49,452**		**49,452**	**384**

Source: CIDP, 2018

3.5 Sampling Procedures

This study used multi-stage purposive, proportionate, simple random and systematic sampling techniques. In the first stage, the Trans Nzoia and Uasin Gishu counties were purposively selected from the North Rift region as they are the major maize producing counties popularly referred to as the “grain basket” counties of Kenya. In the second stage, Turbo and Soy and Cherangany sub counties from Uasin Gishu and Trans Nzoia were selected, respectively. These sub counties were purposively selected. The sub counties were selected because they are the major maize growing zones where some of the soil fertility replenishment technologies have been disseminated through on-farm demonstrations. In the third stage, wards namely Kamagut, Tapsagoi and Ngenyilel were purposively selected in Turbo sub county. In Soy sub county, Moy’s Bridge, Kipsomba and Soy wards were selected. Further, in Trans Nzoia Sinyerere, Kaplamai and Sitatunga wards were selected. These are the major maize producing wards in the respective sub counties. The sampled wards formed the strata for the study. The first farmer was randomly selected. Systematic sampling technique was used to select the subsequent farmers for the interview. Systematic sampling technique was used because it reduces the potential for human bias in the selection of farmers to be included in the sample. As a result, the systematic sample provides a sample that is highly representative of the population being studied (Kothari, 2004). A semi structured questionnaire was used. Single visits personal interviews were conducted. Where the household head was absent a second visit was made. Face-to-face personal interview was used.

3.5.1 Observations

The information was collected by way of investigator’s own observation, without interviewing the respondents. The information collected was mainly related to inputs used by farmers during planting and top dressing. This was possible because the data was collected between April and August; a time when most activities related to maize production is carried out. The information that was obtained in relation to the study relates to what was happening then and not complicated by either the past behaviour or future attitudes as well as intentions. In this study, field observation was done when visiting the homes of the respondents in the study area. The tool used in this method was checklists in order to provide information about actual aspects to be observed, and observations were thereby noted down. Observation was also used to gather information pertaining the performance of the technologies.

3.5.2 Focused Group Discussions

Focus group discussion (FGD) is a dymamic group discussion used to collect information in a specific topic (Wilkinson, 2004). A focus group discussion allows a group of 8 – 12 informants to freely discuss a certain subject with the guidance of a facilitator or reporter or researcher. FGD was selected with a number of reasons: it is quick and relatively easy to set up, group dynamics can provide useful information that individual data collection does not provide. Further, it is useful in gaining insight into a topic that may be more difficult to gather information through other data collection methods (Wilkinson, 2004). Morgan (1997) recommends that 3 to 6 FGDs are sufficient to get the required information. Morgan (1997) has further, suggested over recruiting by at least 20% of the total number of participants required.

Three FGDs were conducted, each with 7 participants (3-4 females and 4 male maize farmers). The first FGD was conducted in Turbo sub county. Participants were farmers from Ngenyilel, Tapsagoi and Kamagut wards. The second FGD was conducted in Soy sub county. Participants were farmers from Kipsomba, Moi's Bridge and Soy wards. The third FGD was conducted in Cherangany sub county; Participants were farmers from Sinyerere, Sitatunga and Kaplamai. The participants were recruited with the help of ward agricultural extension officers and chiefs. The discussion was guided by enumerators who had a focus group discussion guide. However, the discussion was influenced by what participants said. Some of the issues raised in the discussion were incorporated in the questionnaire for further investigation. With the participants' consent, all focus group discussions were audio recorded for future reference. Focused Group Discussions FGDs were used to assess the community's knowledge of soil fertility replenishment technologies, trends of adoption and causes of adoption or non adoption. A checklist was used in this approach.

3.6 Pre-testing the Research Instruments

A pilot study was conducted to test the suitability of the farmers' interview schedule and the questionnaires. Ten farmers from each sub county were randomly selected and interviewed. Three agricultural extension officers, each representing a sub county, participated in the pre-testing exercise which was done in Moiben and Saboti sub counties in Uasin Gishu and Trans Nzoia, respectively. The goal of pre-testing the research instruments was to ensure the instrument is tested in various conditions to test its reliability. Interviewers for the pre-test were particularly able to help in identifying problematic areas of the questionnaire and address them.

3.7 Data Analysis Techniques

This section provides a description of different approaches that was used to analyze data in line with specific study objective. The data was statistically analyzed using computer software program Statistical Package for Social Sciences (SPSS). The data was checked for completeness, consistence and reliability before analysis. The different analytical approaches used in this study are further discussed below.

3.7.1 Descriptive Statistics

Descriptive statistics was used to analyse the characteristics of selected households. In this case, cross tabulation, frequency tables and general statistics such as means, standard deviations of certain variables were worked out. Descriptive measures were derived for farmer characteristics such as age, gender, level of education, household size, access to extension, size of land, farm income, off-farm income, cost of technology and access to credit that enabled the researcher to understand their social-economic status as indicator to their willingness and ability to take up the SFRT. The challenges farmers face in the adoption of SFRT was also analyzed using descriptive statistics

3.7.2 Description of Analytical Method Used

This section provides a description of the methods which were used in analysis of the data set to test the statistical significance of the various factors hypothesized to influence the use of technology and perception of farmers towards SFRT.

3.7.2.1 Multinomial Logit (MNL) Model

This study adopted a Multinomial Logistic (MNL) regression model (McFadden, 1973) to analyze the social and economic determinants of farmers' decisions to adopt a technology. The MNL model was employed instead of Tobit and probit model because they also assume that non-adopter of a given practice does not adopt any other technology as they only allow zero or one dependent variables. When there is more than one practice to choose from when a farmer does not pick one does not mean he/she is a non adopter. Hence, non-adoption of one technology or practice does not necessarily put the farmer in non-adopter category. Further, it is widely used in adoption decision studies involving multiple choices. This model provides convenient closed form for underlying choice probabilities, with no need of multivariate integration, making it simple to compute choice situations characterized by many alternatives (Akinola *et al*., 2011). The model was used to determine factors influencing adoption of soil fertility replenishment technologies. The MNL model is preferred because of its flexibility and ability to analyze the adoption of different soil fertility replenishment technologies (Hassan and Nhemachena, 2008) among farmers in the study area. This supports the model appropriateness for the various soil fertility replenishment technologies options. The model involves a dependent variable, the technology adoption decision variable (Y) and a set of explanatory/independent variables that might influence the final probability, P_i, of adoption of the technologies. These explanatory variables can be thought of as being in a k vector X_i and the model then takes the form

$$P_i = E\ [(Y_i n_i) \setminus X_i] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.2)$$

The logits of the unknown binomial probabilities (that is, the logarithms of the odds) are modeled as a linear function of the X_i.

$$\text{Logit (Pi)} = \text{In}\ [(P_i/I\text{-}P_i\ )] = \beta o + \beta 1X\ 1i + \ldots..\ \beta\ k\ X\ ki\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3.3)$$

The unknown parameters βj (j = 1, 2, 3...k) are usually estimated by Maximum Likelihood method.

Studies by (Doss, 2006) indicate that the key determinants or factors of adoption of agricultural technologies include social and economic factors. The social factors include: farmer’s level of educational, age, gender, household size, availability of extension services. The economic factors are farm size, cost technology, off-farm income, farm income, availability of credit. The empirical model was determine both the social and economic factors. The empirical model is specified as:

$$A = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + e$$

A = the categorical dependent variable of adoption decision of farmers;

Xi = the ith independent variable (i = 1, 2, 3, ...10);

βi = the parameters to be estimated; and

e = error term.

Table 3. 4 Description of Explanatory Variables

Description	Units of Measurement
Size of land in ha	Hactares
Cost of technology in Ksh	Ksh
Income in Ksh earned from off-farm activities	Ksh
Income in Ksh earned from on- farm activities	Ksh
Access to credit measured by the farmer's access 1 if there was access, 0 otherwise	
Age of respondents in	Years
Number of household members	
Number of years of formal education a respondent had	Years
Gender of the household head Gender of the chief decision maker (Dummy 1 = Male, 0 = Female)	
Access to extension measured by the farmer's access 1 if there was access, 0 otherwise	

3.7.2.2 Assumptions of the Multinomial Logit Model

1. The multinomial logit model assumes that data are case specific; that is, each independent variable has a single value for each case.
2. The multinomial logit model also assumes that the dependent variable cannot be perfectly predicted from the independent variables for any case.
3. Collinearity is assumed to be relatively low, as it becomes difficult to differentiate between the impacts of several variables if this is not the case.
4. The odds of preferring one class over another do not depend on the presence or absence of other "irrelevant" alternatives.
5. There should be no outliers**,** high leverage values **or** highly influential points

3.7.3 Assessment of Farmers' Perception on Performance of SFRT in the Demonstration Plots.

To determine farmers' perception about SFRT, on-farm demonstrations were set in Turbo, Soy sub counties in Uasin Gishu and Cherangany Trans Nzoia county. The farmers were asked to give their perceptions about the technologies in the demonstration by responding to some positive statements using a Likert scale. Likert scales was used to measure perception because it gives greater degree of accurancy than a simple "yes/no" questions. The perceptions of farmers towards the selected technologies indicators were measured by use of a 5 point likert scale. Following Okon, (2005) a 5-point Liker-scale was used to determine the perception of farmers on soil fertility replenishment technologies (captured with a scale thus: Strongly agree = 5; agree = 4; undecided = 3; disagree = 2 and strongly disagree = 1). The Likert scaling is a method of ascribing quantitative values to qualitative perception to make it amenable to statistical analysis. A mean score was obtained for each respondent and adopted as a measure of the level of perception (Likert, 1932; Diker *et al*., 2011). This is summarized with the equation below:

$X = \Sigma fn/N$……………………………………………………………………3.5

Where

X = mean score;

Σ = summation sign;

f = frequency or number of respondents who responded Positively;

n = Likert nominal value of each scale;

N = Number of respondents.

3.7.3.1 Effect of Socio-Economic Factors on Perception

The multiple regression analysis was employed to investigate the effect of selected socio-economic characteristics of the respondents on their perception of SFRT. The choice of this model was based on its adequacy in situations where there is the need to predict the value of a variable based on the value of two or more other variables (Berger, 2003). According to Berger (2003), the regression model in its explicit form is given as:

$Yi = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots + \beta_p X_{pi} + e_i$ ………………………………………… (3.6)

Where

Y_i is the dependent variable

β_0 is the constant term

β_1 to βp are coefficients relating to p explanatory variables of interest

e_i is the error term.

CHAPTER FOUR

RESULTS

4.1 Overview

This chapter addresses descriptive statistics, and inferential statistics of factors influencing adoption of SFRT in Uasin Gishu and Trans Nzoia counties.

4.2 Characteristics of the Respondents

The sample population for this study comprised of 384 respondents who included 125 and 259 farmers from Trans Nzoia and Uasin Gishu counties, respectively. The farmers were drawn from the three wards name Tapsagoi, Ngenyilel and Kamagut in Turbo Sub County in Uasin Gishu. Further, in Soy sub county farmers who interviewed were from Mois Bridge, Kipsomba and Soy wards. In Trans Nzoia county the respondents were from Cheragany sub county where the core wards for the study were Sinyerere, Sitatunga and Kaplamai.

4.3 Social Characteristics of the Households

The study sought to establish the gender distribution among the key respondents in Uasin Gishu and Trans Nzoia counties. The findings are given in Table 4.1. According to the data 87(69.6%) and 181(69.9%) of the households were headed by men for Trans Nzoia and Uasin Gishu, respectively. In Trans Nzoia county 38(30.4 %) of the house heads were women whereas 78(30.1%) of households were headed by women in Uasin Gishu county. This implies that the proportion of female who engage in maize production is low compared to male headed households. Further, the results show that the majority of respondents were in the age brackets of 36 to 45 years

(32.8%) and >55 years (40.9%) for Trans Nzoia and Uasin Gishu counties, respectively. The age category 45 to 55 years was 31.2% in Trans Nzoia county while in Uasin Gishu county the respondents in the same category were 39.8%. The study also revealed that 8.0 % for Trans Nzoia and 1.9% for the Uasin Gishu were youth (18 to 35 years). This implied that the participants were either in their middle age or elderly, perhaps because they had experience on maize farming. The youths within the age group (18 to 35 years) in the study area were not actively participating in maize production. The result implies that the majority of youth were not actively involved in maize production. This was collaborated by the focused group discussions where it was revealed that most of the youths preferred white colour jobs as opposed to maize production and therefore their parents were not keen on empowering them with required inputs/land.

Majority (44.0% and 46.0%) of the household heads in Trans Nzoia and Uasin Gishu, respectively, had attained secondary school level of education followed by primary level of education at (30.4%) for Trans Nzoia and (27.4%) for Uasin Gishu county. Those who attained tertiary level of education (college and university education) constituted 20.8% and 22.0% for Trans Nzoia and Uasin Gishu, respectively. In both counties less than 5.0% of household heads had no formal education. These results indicated that the majority of farmers had attained basic education that could help them assess the technologies. During the Focus Group Discussions (FGD), it was revealed that farmers in the study area agreed that formal education affects adoption of SFRT. There was consensus among all the farmers in the respective sub counties that formal education enhanced farmers’ capability to obtain process and understand information that was considered relevant for adoption of SFRT. It was concluded that formal education greatly affected the farmers’ decisions to adopt SFRT.

In Trans Nzoia county, 95.2% of the sampled households had access to extension services and only 4.8% households did not have access to extension services. In Uasin Gishu county, 83.8% of maize farmers could access extension services while 16.2% of the farmers could not access the same. These results indicate that the majority of farmers in both Trans Nzoia and Uasin Gishu counties had access to agricultural information. Therefore, farmers in both counties were able to access information on any innovation or technology from the extension officers. The findings revealed that the respondents who depended on agro-stockiest as the source of agricultural information was higher (20.8%) in Trans Nzoia county compared to (10.0%) in Uasin Gishu county. The study established that only 8.8% of the respondents received agricultural information from the media in Trans Nzoia while in Uasin Gishu 24% of interviewed farmers received information from the media. This implies that the majority of the respondents were able to access agricultural information. During the focus group discussion participants claimed that government extension officers in many instances are limited in number and cannot afford to provide regular services to farmers. Lack of incentives to extension workers was also a challenge to provide services on a regular basis. However, to verify this argument, the county profile indicates that the current ratio of extension worker to farmers is 1:1500 and 1: 1620 for Uasin Gishu and Trans Nzoia county, respectively. This implies that the ratio of extension worker: farmer is in both counties is high and therefore the extension officers may not be able to serve farmers well. The findings in this study indicate that the household size for both counties was large (>5 members) at 69.6% and 60.0% for Trans Nzoia and Uasin Gishu, respectively. This implies that the households have labour source required in farming activities. However, this may not be necessary in this region because maize production is highly mechanized.

Table 4.1 Summary of the Social Charateristic of the Respondents

Variable	Trans Nzoia Frequency	Trans Nzoia Percent	Uasin Gishu Frequency	Uasin Gishu Percent
Gender of the Respondents				
Male	87	69.6	181	69.9
Female	36	30.4	78	30. 0
Age of the Respondents				
18 to 35 years	10	8.0	3	1.9
36 to 45 years	41	32.8	45	17.4
45 to 55 years	39	31.2	103	39.8
>55 years	35	28..0	106	40.9
Education Level				
Non formal education	6	4.8	12	4.6
Primary	38	30.4	71	27.4
Secondary	55	44.0	119	46.0
Tertiary	26	20.8	57	20.0
Access to Extension				
Access	119	95.2	217	83.8
Do no access	6	4.8	42	16.2
Sources of Extension Service				
GoK (extension service)	75	60.0	152	56.7
Agro stockiest	26	20.8	26	10.0
Media	11	8.8	62	24.0
Private extension	8	6.4	2	0.8
Research Institutions	1	0.8	4	1.5
Internet/mobile phones	3	2.0	9	3.5
No access to information	1	0.8	4	1.5
Household Size				
1 to 4 members	38	30.4	101	40.0
> 5 members	87	69.6	158	60.0

Source: Survey Data, 2018

4.4 Economic Characteristic of the Household Head

Results in Table 4.2 shows that 65.6% of the interviewed households in Trans Nzoia county depend on farming as their major source of income while in Uasin Gishu county 67.2% depend on the same. Further, 20.8% and 15.8% of the household heads interviewed had business as their main source of income in Trans Nzoia and Uasin Gishu county, respectively. The findings revealed that the respondents who depended on formal employment as the source of income was higher (11.2%) in Trans Nzoia county compared to 9.7% in Uasin Gishu county. About 2.4% of the respondents in Trans Nzoia and 7.3% Uasin Gishu reported to have casual work as their main source of income. The results show that more households are dependent on farming as a source of income in both counties. This indicates that farming is a significant source of livelihood for farmers in this region.

The majority (>65%) of the household heads in both counties are smallholder farmers owning farms of less than five hectares. However, Uasin Gishu county, 36% of household heads had land sizes ranging from six to ten hectares compared to Trans Nzoia county which had 18.4%. The study also revealed that farmers who had farm sizes above eleven hectares were higher (16.6%) in Uasin Gishu county compared to 9.6% in Trans Nzoia county. This implies that the majority of the maize producing farmers in both counties are smallholder farmers as opposed to the belief that the main maize producers are larger scale farmers. The results also suggest that there are larger land parcel in Uasin Gishu county under maize production compared to Trans Nzoia county. It was also revealed during the FGD that the prevailing land tenure systems in the study area encouraged land fragmentation thus hindering the effective adoption of some technologies.

Table 4.2 shows that 53.6% of respondents in Trans Nzoia county had access to credit compared to 39.0% farmers in Uasin Gishu county. Majority (61%) of the farmers in Uasin Gishu county could not access credit while in Trans Nzoia county 46.4% of the farmers could not access credit. These results imply that there is a limited accessibility of credits/loan in Trans Nzoia county which may impact on the usage of agricultural technology. In one of the Focused Group Discussions, a prominent maize producer in the study area claimed that it was due to his ability to access credit that enabled him to implement agricultural technologies. According to another participant, access to labour and farm implements required cash which was difficult to access. Farmer's participating in FGD believed that access to credit would facilitate the maize producing farmers to effectively and efficiently adopt SFRT with ease.

The results further revealed that 89.6% and 83.0% of the respondents reported that they could afford the technologies in Trans Nzoia and Uasin Gishu, respectively. Further, the results revealed that farmers who could not afford the technologies in Trans Nzoia county was low (10.4%) compared to (17.0%) in Uasin Gishu county. This implies that most of the respondents use the inputs recommended SFRT, however not in the right quantities. The results showed that that 61.6% and 45.2% of the household interviewed in Trans Nzoia and Uasin Gishu county, respectively, had off-farm income. The findings also revealed that the number of respondents who did not have off-farm income was higher (54.8%) in Uasin Gishu compared to Trans Nzoia county (38.4%). This implies that the majority of the respondents depended on agriculture as their main source of income.

Table 4.2 Summary of the Economic Characteristic of the Respondents

	Trans Nzoia		Uasin Gishu	
Variable	**Frequency**	**Percent**	**Frequency**	**Percent**
Sources of Income				
Farming	82	65.6	174	67.2
Business	26	20.8	41	15.8
Formal Employment	14	11.2	25	9.7
Casual work	5	2.4	19	7.3
Farm Size (ha)				
<5				
6 to 10	90	72.0	180	69.5
>11	23	18.4	36	13.9
	12	9.6	43	16.6
Access to Credit				
Access	67	53.6	101	39.0
Do not access	58	46.6	158	61.0
Cost of Cechnology				
Afford	112	89.6	215	83.0
Cannot afford	13	10.4	44	17.0
Off- farm Income				
Available	77	61.6	117	45.2
Not available	48	38.4	142	54.8

Source: Survey Data, 2018

4.5 Inferential Results and Test of Hypotheses

This section of the thesis deals with analysis of social and economic factors affecting adoption of SFRT, perception of farmers. The MultInomial logistic (MNL) regression model was used to answer the hypotheses one and two of the study whereas Likert Scale was used to evaluate the perception of farmers on SFRT. Further, the effect of socio-economic factors on perception was analysed using multiple regression model.

4.5.1 Social Factors Affecting Adoption of SFRT

The results from the MNL model used to determine social factors influencing the adoption of SFRT are presented in Table 4.3. These results showed that the coefficient on gender was negative and had significant effect on the adoption of

FURP at -1.844 ($p < 0.1$), FURP plus lime -2.015 at ($p < 0.05$) and Mavuno technologies at -1.688 ($p < 0.001$). Further, the results revealed that the age of the household had mixed findings. It had positive and significant influence on the adoption of FURP 1.960 ($p < 0.1$), 1.948 FURP plus lime ($p < 0.05$) and a significant negative influence on the adoption of Mavuno -1.617 ($p < 0.001$). Therefore, it can be inferred that as one gets older the likelihood of adopting these technologies also increases. The longer the farming experience a farmer has the more practical experience he acquires and the more he/she is able to make rational choices and decision for improved profitability of enterprise. However, Mavuno technology had negative and significant -1.469 ($p < 0.001$) effect on adoption of SFRT. This is probably because the older farmers are not familiar with blended fertilizers and therefore they are reluctant to try what they do not understand.

4.5.2 Economic Factors affecting Adoption of SFRT

The results of the economic determinants of adoption of SFRT among the respondents are presented in Table 4.3. The size of land had a negative influence on choice of Rutuba ($p < 0.05$) significance levels. This implies that an increase in the size of land by one hectare would decrease the probability of adopting Rutuba by 3.9%. For the choice of SFRT among maize farmers in Uasin Gishu and Trans Nzoia counties, the empirical result revealed that the variable off-farm income was negative and statistically significant at -18.234 ($p < 0.001$), -2.364 ($p < 0.05$), and -2.515 ($p < 0.1$) probability levels for FURP, ½ rate Rutuba plus ½ FURP and NAAIAP technologies, respectively. This implies that the increase in the off-farm income was diverted to activities other than farming. The results further revealed that the coefficient for access to credit had mixed effects on the adoption of the technologies. It was a positive determinant of the choice of using NAAIAP technologies at 1.749 ($p < 0.1$) among maize farmers in the study area but a negative determinant in the adoption of FURPL at-0.088 ($p < 0.1$). Farm income also had a negative and significant effect on adoption of FURPL at-0.669 ($p < 0.05$). This is probably because lime is not easily available in the agro stockiest stores as opposed to the fertilizers used in the NAAIAP technology. Further, cost of technology had a negative influence on choice of FURP and Rutuba at -4.032 ($p < 0.05$ and -15.688 ($p < 0.001$) significance levels. Therefore, it can be inferred that as the off-farm, size of land, and cost of technology decrease the likelihood of adoption process reduces.

Table 4.3: Effects of Socio-Economic Factors on Adoption of SFRT

	Technologies											
	DAP + CAN (FURP)		**(DAP + CAN + lime) (FURPL)**		**Mavuno**		**Rutuba**		**½ rate Rutuba plus ½ FURP**		**23:23:0 +CAN (NAAIAP)**	
Variable	**β**	**P value**	**B**	**P value**	**B**	**P value**	**β**	**P valve**	**β**	**P value**	**B**	**P value**
Intercept	10.379	0.000	4.093	0.998	-11.107	0.998	19.333	0.000	-15.688	0.000	2.718	0.999
Size of Land	0.005	0.723	0.045	0.998	0.011	0.716	-0.39	0.026**	-0.020	0.105	0.147	0.147
Farm Income	-1.423	0.359	-0.669	0.029**	-1.529	0.362	-0.317	0.687	-0.421	0.571	0.156	0.156
Off- farm Income	-18.234	0.000***	-2.040	0.403	-2.824	0.127	-1.881	0.101	-2.364	0.034**	-2.515	0.054*
Access to Credit	1.029	0.466	-0.088	0.078*	14.268	0.985	0.370	0.605	-0.607	0.369	1.749	0.098*
Cost of Technology	-4.032	0.021**	-0.068	1.000	0.822	1.000	-15.688	0.000***	-14.636	4.402	0.393	1.000
Gender	-1.844	0.054*	-2.015	0.030**	-1.688	0.006***	0.467	0.658	10.456	3.490	- 0.492	0.481
Age	1.960	0.017**	1.948	0.011**	-1.617	0.006***	1.349	0.592	3.514	2.856	-1.469	0.037**
Education	0.317	0.693	0.516	0.508	0.637	0.175	0.341	0.659	0.750	0.956	1.148	0.116
HH Size	0.234	0.752	0.508	0.480	0.828	0.993	0.109	0.721	1.357	0.871	0.195	0.756
Ext. Access	14.926	0.981	15.102	0.274	5.361	0.993	4.671	0.810	1.689	0.490	14.957	0.890

Number of observations 384: LR chi-square =568; Probability sig. = 0.001; -2Log likelihood = 78.132, Pseudo-R^2 = 0.135
sterisks denote the level of significance *= 10%, ** = 5% while *** = 1%

Source: Survey Data, 2018

4.6 Perception of Farmers on the recommended SFRT

On-farm evaluation of SFRT on demonstration sites to ascertain the perception of farmers towards the technologies is presented in Table 4.4. The findings show that the farmers in Uasin Gishu and Trans Nzoia counties had clear and favourable perception of declining soil fertility and its effects. This is evidenced by their agreement with the positive statement that decline in soil fertility is a problem (mean score 5.0). The results revealed that the respondents in both counties had a positive perception regarding the fact that SFRT could address the decline in soil fertility. This is evidenced by their agreement with the positive statement that SFRT can be used to address decline in soil fertility (mean score 3.5). The data shows that the respondents were fairly aware that the inputs used in these technologies were available (mean of 3.4). Further, they agreed that these technologies were affordable (mean score of 4.1). The farmers in this region also perceived that the technologies could work well in any farm (mean score 4.6). The respondents perceived that the Ministry of Agriculture Livestock and Fisheries (MoALF) was effective in dissemination of these technologies (mean score 4.0). The perception of farmers regarding knowledge of these technologies had a means score of 1.8 while the availability of information pertaining these technologies had a mean score of 2.6. The perception statements recorded mean scores above the cutoff of 3.6.

Table 4.4: Respondents Perception of SFRT

S/no	Perception Statement	Strongly Agree (5)	Agree (4)	Undecided (3)	Disagree (2)	Strongly Disagree (1)	Total	Mean rating Max = 5
1.	There is decline in soil fertility in this area	130 (93.5)	8 (5.8)	0 (0)	0 (0)	1 (0.7)	139 100	5.5
2.	There are SFRT that can be used to address decline in soil fertility	45 (45.5%)	40 (40.4)	1 (1%)	10 (10.1%)	3 (3%)	99 (100%)	3.5
3.	The SFRT used by farmers	15 (29.4%)	0 (0%)	3 (5.9%)	18 (35.3%)	15 (29.4%)	51 (100%)	1.8
4.	The information about these SFRT are readily available	25 (34.2%)	24 (32.9%)	0 (0%)	14 19.2%)	10 (13.7%)	73 (100%)	2.6
5.	The inputs used in these technologies are readily available	65 (59.6%)	28 (25.7%)	0 (0%)	16 (14.8)	0 (0%)	109 (100%	3.4
6.	These technologies are affordable	75 (65.2%)	28 (24.3%)	0 (0%)	12 (10.4%)	0 (0%)	115 (100%)	4.1
7.	These technologies can work well in any farm	100 (78.1%)	24 (18.8%)	3 (2.3%)	0 (0%)	1 (8.0%)	128 (100%)	4.6
8.	These technologies have negative effects on soil fertility.	65 (64.4%)	28 (27.7%)	0 (0%)	0 (0%)	8 (7.9%)	101 (100%)	3.6
9.	There are no challenges involved in using these technologies.	45 (52.9%)	12 (14.1%)	0 (0%)	24 (28.3%)	4 (4.7%)	85 (100%)	3.0
10.	The MOALF is effective in disseminating the technologies	65 (58.6%)	28 (25.2%)	6 (5.4%)	12 (10.8%)	0 (0%)	111 (100%)	4.0
	Total mean							**35.6**
	Grand mean							**3.6**

Source; Demonstration Data, 2018

4.7 Farmers assessment of the performance of SFRT

Farmers' assessment scores on the performance of the SFRT are presented in Table 4.5. Using the visual observation of the size of maize cob, farmers from Trans Nzoia county ranked the FURPL (33.3%) as their best technology, followed by the Mavuno technology (25.6%), NAAIAP (15.4%), FURP (12.8%), ½(FURP + Rutuba) (7.7%) and Rutuba (5.1%) in descending order. According to farmers in Uasin Gishu county, FURPL and Mavuno technologies were ranked as the best technologies both at (27.5%). Further, the farmers in Uasin Gishu county could not see any differences from using FURP and NAAIAP technologies hence both the technologies were ranked third (14.5%). In both counties Rutuba and ½(FURP + Rutuba) technologies performed poorly. The results imply that Rutuba and ½(FURP + Rutuba) technologies are not suitable for the region.

Table 4.5: Farmers' Assessment of performance of the SFRT

	Trans Nzoia county			Uasin Gishu county		
Challenge	**Freq.**	**%**	**Rank**	**Freq.**	**%**	**Rank**
1.FURP	5	(12.8)	4	10	(14.5)	3
2. FURPL	13	(33.3)	1	19	(27.5)	1
3. Mavuno	10	(25.6)	2	19	(27.5)	1
4. Rutuba	2	(5.1)	6	5	(7.2)	6
5. ½(FURP + Rutuba)	3	(7.7)	5	6	(8.7)	5
6. NAAIAP	6	(15.4)	3	10	(14.5)	3

Source: Survey Data, 2018

4.8 Determinants of Farmers' Perception on SFRT

Linear multiple regression analysis was computed to determine the factors that affect farmers' perception. The finding of the regression analysis is presented in Table 4.6. Age and education negatively influenced perception at $p<0.01$. This indicates that as the age of the respondents increases their corresponding perception to use and invest on SFRT decreases. Further, variable size of land, cost of technology and access to credit positively influenced perception at $p < 0.01$ while farm income has a positive significant perception on SFRT at $p < 0.05$.This means that there is probability of increasing perception if the technology is affordable and there is access to credit.

Table 4.6: Regression Analysis to Identify the Determinants of Farmers' Perception on SFRT

Variable		Unstandardized Coefficent	T	Sig.
Variable	**B**	**Std error**		
Constant	3.470	0.608	6.154	0.000
Age	-0.360***	0.125	-2.873	0.005
Education	-0.197***	0.677	-2.912	0.004
Household Size	-0.001	0.022	-0.067	0.947
Access to Extension	0.086	0.163	0.527	0.598
Size of Land	0.031***	0.012	2.631	0.009
Farm Income	0.460**	0.205	2.252	0.026
Off-farm Income	-0.019	0.171	-0.112	0.911
Cost of Technology	0.083***	0.031	2.249	0.006
Access to Credit	0.171***	0.040	4.258	0.001

R^2; 0.682 : significance. = 0.568;
sterisks denote the level of significance *= 10%, ** = 5% while *** = 1%

Source: Survey Data, 2018

4.9 Respodents' Knowledge of SFRT

Table 4.7 shows the awareness of agricultural technologies by the respondents. All the technologies recorded low awareness level among the respondents except Mavuno technology. The results indicated that 29.8% and 32.6% of farmers were aware of FURP technology in Trans Nzoia and Uasin Gishu respectively. In Trans Nzoia county 18.2% of` farmers were aware of FURP plus lime while in Uasin Gishu county 17.1% were aware of the same. The results further revealed that 21% of the respondents in Trans Nzoia county were aware of Rutuba technology compared to only 10.9% in Uasin Gishu county. On average, 8.3% of farmers in Trans Nzoia were aware of ½ rates (FURP + Rutuba) and in Uasin Gishu only 3.4% were aware of this technology. In this study, 22.3% of farmers in Trans Nzoia were aware of NAAIAP technology while Uasin Gishu 24.6% was also aware of the technology.

Table 4. 7 Awareness of Farmers Towards SFRT

	Trans Nzoia		**Uasin Gishu**	
Technology	**Aware**	**Not Aware**	**Aware**	**Not aware**
1. DAP + CAN (FURP)	36 (29.8)	85 (70.2)	57 (32.6)	118 (67.4)
2.DAP + CAN + lime (FURPL)	22 (18.2)	99 (81.8)	30 (17.1)	145 (82.9)
3.Mavuno (Mavuno Planting + CAN)	55 (45.5)	66 (54.5)	98 (56.0)	77 (44.0)
4.Rutuba (Rutuba + CAN)	26 (21.5)	95 (78.5)	19 (10.9)	156 (89.1)
5.½ rate (FURP + Rutuba)	10 (8.3)	111 (97.70	6 (3.4)	169 (96.6)
6.NAAIAP (23:23:0 + Manure + CAN)	27 (22.3)	94 (77.7)	43 (24.6)	132 (75.4)

Source: Survey Data, 2018

4.10 Challenges Affecting Farmers in Adoption of SFRT

According to the results of this study (Table 4.8) lack of capital was ranked the highest among the limitations preventing farmers from fully adopting SFRT in both counties at 69.2% and 39.1% for Trans Nzoia and Uasin Gishu, respectively. Further, in both counties lack of manure ranked third at 15.0% for Trans Nzoia county and 13.0% for Uasin Gishu. In Uasin Gishu county 37.8% the farmers did not experience any challenges in the adoption of SFRT compared to Trans Nzoia county at 12.8%. Lack of soil amendment ranked the least constraint in adopting SFRT at 0.0% in

Trans Nzoia county and 1.4% in Uasin Gishu county. This result in this study imply that the majority of the farmers in the two counties were not able to get credit or they were reluctant to access the credit probably due to high interest rate the financial institutions in Kenya charge. During the FGD in Trans Nzoia county, participants explained that it required financial resources in order for the SFRT to be adopted and that they lacked access to credit facilities. Further, some farmers did not have the necessary assets to act as collateral that is required by lending institutions to acquire credits/loan. The other challenges were absence of lending institution, high interest rate and low producer price.

Table 4.8 Constraints to Adoption of STRT

	Trans Nzoia county			Uasin Gishu county		
Challenge	**Freq**	**%**	**Rank**	**Freq**	**%**	**Rank**
1. Cost of Inorganic Fertilizer	0	(0.0)	6	2	(2.9)	5
2. Lack of manure	6	(15.0)	3	9	(13.0)	3
3. Lack of Soil Amendments	0	(0.0)	6	1	(1.4)	6
4. Labour	1	(3.0)	5	4	(5.8)	4
5. Lack of Capital	27	(69.2)	1	27	(39.1)	1
6. Non	5	(12.8)	4	26	(37.8)	2

Source: Survey Data, 2018

4.11 Hypotheses Testing

i.The first hypothesis tested the effect of social factors such as level of education, age, gender, household size, farm size and access to extension services on the adoption of SFRT among the maize farmers in the North Rift region of Kenya. The results indicated that coefficient gender was negative and had significant effect on the adoption of FURP, FURP plus lime and Mavuno technologies. Similarly, age had negative significant effect on the adoption of Mavuno technology. The negative and significant effect of the two variables led to the rejection of the first hypothesis

ii. The second hypothesis tested the effect of economic factors such as farm size, availability of credit, farmer income, off farm income and cost of technology on the adoption of SFRT among the maize farmers in the North Rift region of Kenya. The results indicated that all the variables had negative significant effect on the adoption of the technologies. These results led to the rejection of the second hypothesis

CHAPTER FIVE

DISCUSSION

5.1 Overview

The main socio-economic characteristics and activities of respondents in Trans Nzoia and Uasin Gishu counties are discussed in the sub-sections below.

5.2 Socio- economic Characteristic of the Respondents

The findings of the study indicate that gender of household heads was dominated by males. This could be attributed to culture of the society in Trans Nzoia and Uasin Gishu counties whereby the male are favoured in terms of land ownership thus access to loans/credit and agricultural inputs such as agro-chemicals, fertilizers and extension services. This is similar with earlier findings (Mwangi *et al.,* 2015; Atuhaire *et al.,* 2014; Wambua, 2014; Njarui *et al.,* 2012). Similarly, Jera and Ajayi, (2008) and Kassie *et al.,* (2012) in their study found that female headed households may respond less favourably to adoption of new technologies than male headed households due to wealth differences as well as cultural factors. The observed result in this study is in line with the finding of Adesope *et al*., (2012) who found that, the active productive age of farmers is between 44 and 55 years. According to Ayoade (2013; Babasanya *et al*., 2013) farmers in this age range can withstand stress which may have an implication on farmers productivity as well as the spread of innovation. The study also revealed that the percentage of the youth engaged in maize production is low. These results suggest that the youth do not engage themselves fully in the farming activities. Majority (above 40%) of the respondents in this study had attained secondary level education. The level of educational enhances peoples' ability to acquire knowledge regarding technologies faster hence introducing new agricultural techniques in the educated society should not encounter many difficulties Kassie *et al*., (2013).

The study further revealed that farmers had access to extension services mostly from sources such as government extension agents, agro stockiest and media. According to Caswell *et al.*, (2001), exposure to information about a new technology significantly affects farmers' choices about it. The high numbers of household members revealed in this study may determine adoption process. Several authors Njuguna *et al*., (2015); Mignouna *et al.*, (2011); Bonabana-Wabbi, (2002) assert that a larger household have the capacity to relax the labor constraints required during introduction of new technology or during the peak of farming, for example, during weeding and harvesting when farming labour is required

The majority (>65%) of respondents in both counties were engaged in farming as their main occupation. This is expected because most farmers in this region depended entirely or mostly on agriculture as their major source of livelihood. That implies that farmers have limited scope to earn income from other sources; the situation is further aggravated by marketing system and fluctuating prices for their produce and high input prices. According to Afolami *et al*., (2015); Urassa, (2015), being engaged fully in farming is an indication that farmers have limited resources of income. Most of the respondents in the study area were small scale farmers (>65 %). This shows that there was land pressure in both counties. The observed results are in line with those of Uaiene *et al*., (2009), who argued that population increase in developing countries, Kenya included significantly impact on the ability adopt to new technologies.

Despite the importance of access to credit, the results in this study revealed that the majority of farm households, especially in Trans Nzoia county lack access to formal credit. These findings concur with Abdulai and Huffman, (2005) who observed that many farmers have difficulty accessing credit/loans due to high interest rates, which prevents investment in profitable technologies like SFRT. Regarding the cost of technology, the observed result was expected because the majority of farmers, both large and smallholder in this region engage in maize production as a business. Generally, 95% of farmers in the two counties use fertilizer and certified seeds with some applying high amounts of fertilizer beyond the recommended rates (*personal communication*). Despite, the use fertilizer by the majority of farmers in the region, they do not use the recommended quantities. However, in most adoption studies the cost of technology has been found to be a constraint to technology adoption. In a study carried out in western Kenya by Mose (1997), found that farmer's adoption behaviour is influenced by the cost of inputs especially maize seed and fertilizers.

Off-farm income generating activities may help farmers to finance production costs like buying farm inputs, seeking market information, accessing extension services and hiring of labour (Obisesan, 2015). Further, off-farm employment enables households to increase their incomes, to overcome credit and insurance constraints and to increase their use of industrial inputs (Taylor *et al*., 2003). However, the effect of off-farm employment on agricultural production is ambiguous. According to Goodwin and Mishra (2002) the pursuit of off-farm income by farmers may undermine their adoption of modern technology by reducing the amount of household labour and time allocated to farming enterprises.

5.3 Effect of Social Factors on Adoption of SFRT

The study of gender in relation to agricultural technology adoption has reported mixed evidence regarding the different roles men and women play in technology adoption (Bonabana- Wabbi, 2002). However, in this study, the results revealed that coefficient gender was negative and had significant effect on the adoption of FURP, FURPL technology and Mavuno technologies. This implies that, the adoption of SFRT among respondents is adversely affected by farmers' gender composition. Females are normally occupied with domestic errands and are not resource endowed and therefore, if not fully involved, may impact negatively on both adoption decision and the extent of use of certain SFRT practices (Martey *et al*, 2014; Ogada *et al.*, 2014; Kassie *et al.*, 2009). The finding is in line with what World Bank (1998) reported on overall status of women, in sub Saharan Africa that women's participation in most activities is biased due to the socio cultural and economic environments. Women, on the other hand, have user rights to the land and bear the bulk of the agricultural and domestic work. These results are similar to the findings of (Adebisi-Adelani and Oyesola, 2013; Enete *et al.*, 2011) in Nigeria.

On the contrary, culturally, male have the mobility and participate in different extension programs and consequently have a greater access to information about new technologies (Asfaw and Admassie, 2004; Okuthe *et al*., 2013). Further, male farmers' are more resource endowed by virtue of their cultural setting and more apt to adopt new technologies (Baffoe-Asare *et al.*, 2013; Ajayi, 2007). Lavison, (2013), in his findings, also indicated that male farmers were more likely to adopt organic fertilizer unlike their female counterparts. However, some female heads are also enthusiastic enough and are willing to try new technologies (Jera and Ajayi, 2008).

The effect of age on adoption of technologies can be both positive and negative as revealed in this study. This is similar with the findings of (Uaiene *et al*., 2009) who asserted that with age, farmers accumulate more knowledge and personal capital and, thus, show a greater likelihood of investing in technologies, although it may also be that younger household heads are more flexible and hence likely to adopt new technologies, while older ones are less efficient to carry out demanding farm operations due to lack of experience resulting in low technology adoption. In this study, age of the household head significantly and positively influenced the adoption of FURP and FURPL. This was in agreement with earlier finding of Chiputwa *et al.,* (2011) who found age to have a positive effect on adoption and indicated that older farmers had experience in beneficial technologies and were shown to adopt them. The findings in this study could also mean that older farmers have gained knowledge and experience over time and are better able to evaluate technology information critically than younger farmers (Mignouna *et al.*, 2011; Kariyasa and Dewi, 2011). Moreover, a study conducted in Tanzania revealed that age had significant positive effect on soil and water conservation practices (Ashoori *et al.*, 2016).

The same results revealed age of the household had significant negative influence on the adoption of Mavuno technology. This is probably because of the fact that as the age of a farmer increases, the acceptance level about the introduced new practices decreases. Old farmers become exhausted and unable to take of their farmlands. On the other hand, younger farmers have more willingness to adopt the new practices. Similarly to Budry *et al*., 2006; Tiwari *et al*., 2008; Bekele *et al*., 2010); reported that age of household heads was negatively correlated. In the same manner, (Mugonola *et al*., 2013; Bekele and Holden, 1998) confirmed that younger farmers may invest more in soil conservation practices because they are often educated and are more aware of new technologies. This could be true to Mavuno technologies as it is new compared to the other technologies.

5.4 Effect of Economic Factors on Adoption of SFRT

Size of land gave a negative significant effect on the choice of Rutuba. The probable reason for the negative relationship between adoption and farm size could be due to the fact that adoption is farm specific. This means that it is not the size of the farm, but the specific characteristics of the farm that dictates the need for adopting a specific technology. This finding is in line with Deressa *et al*., (2009) who found that farm size was negatively related to adaptation to climate change. Similarly, Lunduka *et al*., (2012) reported significant negative effects of farmland holdings and opened-pollinated variety of maize in Malawi. Further, a study by Garcia, (2001) reported a negative relationship between the size of farmland holding and the probability of adopting soil and water conservation practices. The findings in this study are in line with those of Habtamu, (2006) and Budry *et al*., (2006) also found a negative and significant relationship between farm land size and the decision to retain soil and water conservation practices.

On the other hand, some studies have shown that small land holding hinder the usage of technologies compared to large land holding. The large farm size allows a farmer to experiment new technologies on a small portion of land without worrying about compromising the family food security (Uaiene *et al*., 2009). In addition, the benefits from large-scale adoption of new technologies are higher for larger farms (Zepeda, 1994). Further, technologies which are highly mechanized require economies of size to ensure profitability (Feder *et al*., 1985). Similarly, Eleni, (2008) affirmed that farm size has significant positive association with the adoption of introduced soil and water conservation practices.

The study revealed that farm income negatively influenced the adoption of Rutuba technology although this was not expected as it is believed that adoption of any new technology requires sufficient financial capital, particularly if new equipment is needed (Knowler, 2015; Knowler & Bradshaw, 2007). Further, the economic constraints of a household to access resources influence the ability and willingness to adopt technologies/innovations (Vedeld, 1990).

The results in this study revealed that coefficient off-farm income had a negative significant influence on the adoption of FURP, ½ rate Rutuba plus ½ FURP and NAAIAP technologies, respectively. This implies that the increase in the off-farm income was diverted to activities other than farming. This does not conform to the expectation of the study but in agreement with Bekele and Mekonnen's, (2010) observation that an increase in the income of farmers may be diverted to activities other than farming. Similarly, Goodwin and Mishra (2002) found that the pursuit of off-farm income by farmers may undermine their adoption of modern technology by reducing the amount of household labour and time allocated to agricultural production. This results concur with the findings by (Alene *et al*., 2009, Omiti *et al*., 2009a and Martey *et al*., 2014). Moreover, if this off- farm income contributes substantially to the total family income, the farmers' attention gets skewed from adopting SFTR towards other ventures. According to a study by Ashoori, (2016), non-farm income had significant negative effects on soil and water conservation measures. Contrary to these results, Mulugeta *et al.,* (2001) reported that off- farm income correlated positively with the adoption of soil and water conservation (SWC) practices. This is probably because income from off-farm activity increases the financial potential of farm which in turn encourages investment in soil and water conservation practices. Krishna *et al*., (2008) reported similar results. They said that off-farm income served as a source of income to invest in SWC practices and finally this led to better and continued use of conservation practices. Further, according to Diiro (2013), off-farm income provides farmers with some capital for purchasing inputs such as seeds and fertilizers.

The results further revealed that access to credit had a positive significant influence on the likelihood to adopt NAAIAP technology among the respondents in the study area. This finding concurs with Fisher and Carr (2015) who in their analysis of factors influencing adoption of drought-tolerant maize seed in Eastern Uganda found a positive relationship between access to credit and adoption of drought-tolerant maize variety. Generally, most farmers fear trying improved technologies because they do not have the necessary financial resources to purchase input/ equipment required in adopting the technologies (Omolehin *et al.*, 2007). This is partly explained by the fact that most agricultural innovations require complementary inputs such as fertilizers, seed and pesticides. These complementary inputs are difficult to come by due to the cash-trapped nature of farmers (Olwande *et al.*, 2009). Access to credit helps farmers out of their predicaments thereby influencing them to adopt new agricultural innovations (Nyamai, 2010). The results in this study are also consistent with the findings of (Feder *et al*., 1985 and Olwande *et al*., 2009).

This study has shown mixed evidence regarding the cost of technology. The cost of technology had a negative significant impact on the adoption of FURPL technology. The cost of technology has been found to be a constraint to technology adoption. The results concur with findings in other studies for instance, a study by Makokha *et al*., (2010) on determinants of fertilizer and manure use in maize production in Kiambu county, Kenya, reported high cost of labor and inputs, unavailability of demanded packages as major constraints to fertilizer adoption. Further, according to Muzari *et al*., (2013) the elimination of subsidies on prices of seed and fertilizers since the 1990s due to the World Bank-sponsored structural adjustment programs in sub-Saharan Africa has widened this constraint of adoption of technologies. According to Wekesa *et al*., (2003), when analyzing determinants of adoption of improved maize variety in coastal lowlands of Kenya found high cost of seeds as one of the major factors responsible for low rate of adoption.

The study further showed that the cost of technology had a positive and significant effect in the adoption NAAIAP technology. The finding is in agreement with Nambiro and Okoth, (2012) who reported a significant positive influence of cost of technology on the use of improved maize seed and inorganic fertilizer in western Kenya. Further, Shiferaw *et al,. (*2009) reported that major determinant of adoption of conservation practices as the price that farmers have to pay for technology in place. In Zimbabwe, Gumbo, (2010) reported that farmers reduced their use of inorganic fertilizer as a consequence increase of their prices.

5.5 Perception of Farmers on Soil Fertility Replenishment Technologies

Farmers in Trans Nzoia and Uasin Gishu counties had a clear and favourable perception of the declining soil fertility. The results concur with the findings of Ngoma, (2015) in Uganda where most of the respondents cited a decline in fertility of their fields. Pulido and Bocco (2014), argue that farmers’ awareness of soil degradation as a problem is an important factor in influencing their decisions to adopt improved soil fertility enhancing practices. As such, farmers become motivated to seek alternative ways to avert current problems based on various perceived constraints, including the characteristics of technologies available to them. Further, a study by Mugwe *et al*., (2009), among smallholder farmers in Kenya revealed that farmers were willing to adopt new soil fertility management practices only if they perceived soil fertility to be a problem. This implies that increased farmers awareness about soil degradation/decline through trainings, strips, tours and other sensitization approaches can facilitate adoption. Despite the fact that, respondents had favourable perception of the effectiveness of the Ministry of Agriculture Livestock and Fisheries (MoALF) in dissemination of these technologies probably they lacked knowledge about of the technologies. This could be an indication that even the extension officers were not aware of these technologies.

The perception of the respondents on the availability of inputs was fair. This is probably because the majority of the farmers in this region depend on government subsidized fertilizer which at times is difficult to access due to the bureaucracy involved and the distance to National Cereal and Produce Board (NCPB) depots. A study by Shiferaw *et al*, (2009) reveal that in most countries in SSA, farmers' adoption decisions for soil fertility technologies are influenced in part by level of access to external inputs such as mineral fertilizers, improved seed and herbicides. Farmers' proximity to input sources positively increases their use (Kassie, *et al*., 2013; Kamau, *et al*., 2014; Kansiime & Wambugu, 2014). Generally, the closer the resource-poor farmers are to the input markets, the lower are their transaction costs in terms of travel time and transportation costs, thereby lowering production costs (Shiferaw, *et al*., 2009) and increasing opportunities to adopt improved soil fertility management technologies (Teklewold *et al*., 2013).

The respondents perceived the technologies as affordable and the inputs used could work in all their farms. This was expected as farmers in both counties have similar soil management practices. These include the use of inorganic fertilizers and to a lesser extend organic fertilizers. According to a study by Nyoro, (2002) the highest adoption of mineral fertilizer in maize production zones (including Trans Nzoia and Uasin Gishu counties) was in the high-potential maize zone on average, where 95% of the households used fertilizer. However, high adoption rates of fertilizers are necessary but not sufficient for high maize productivity. The high adoption rates needs to be accompanied by use of recommended quantities of the fertilizers.

5.5.1 Performance of SFRT

The study revealed that Mavuno and FURPL technologies performed better than other technologies. The good performance of Mavuno and FURPL technologies could be due to the ameliorated soil pH around the maize rhizosphere that encouraged healthy root development with improved uptake of nutrients (Cifu *et al*., 2004). The results are concur with the findings of Chimdi *et al*., (2012); Adeleye *et al*., (2010); Bambara & Ndakidemi, (2010) who found that addition lime supplied extra Ca, Mg and other nutrients that improved maize growth. The calcium and magnesium ions in lime, apart from displacing hydrogen, aluminum and iron ions from the soil colloids thereby raising pH, it helps in making other fixed nutrients like phosphorus available for growth and productivity (Onwonga *et al*., 2010; Kisinyo *et al*., 2012).

NAAIAP technology which constitutes application of manure and inorganic fertilizer NPK (23.23.0) performed better compared to the sole application of organic material (FURP technology). These results concur with Mugendi *et al*., (1999) and Mutuo *et al*., (2000) on the integration of organic and inorganic soil fertility enhancing inputs.

Integrated soil fertility management practices involving the judicious use of combinations of organic and inorganic resources is a sustainable approach to overcome soil fertility constraints and contribute high crop productivity in agriculture (Abedi *et al*., 2010).

Application of inorganic fertilizers offer immediate corrective measure to nutrient deficiencies by supplying critically required nutrients in their correct forms for plant use, however, the continuous applications of inorganic fertilizers alone result in deterioration of soil health in terms of physical, chemical, and biological properties of the soil (Getachew *et al*., 2014). The application of inorganic fertilizers alone in rehabilitating degraded soils have yielded limited success in crop production even when they are available and affordable to farmers (Schröder *et al*., 2018; Goulding *et al*., 2016).

In this study the performance of Rutuba was poor in both counties according to the ranking done by the farmers. Organic fertilizer application can improve crop growth by supplying plant nutrients including the macro and micro nutrients. Moreover, organic fertilizer has been reported to improve physical, chemical, and biological properties of the soil, thereby providing a better environment for root development (Dejene *et al*., 2012). However, organic materials cannot by themselves reverse soil fertility decline because they have low nutrient content (Palm *et aI*., 1997).

5.5.2 Determinants of Farmers' Perception on SFRT

Farmer's age had a significant negative relationship with perception of SFRT. Coefficient age negatively influenced the farmers' perception of SFRT. This is probably because older people tend to become more passive about what happens in their farms (Truong and Yamada, 2002).Further, as age increases the corresponding perception of technologies also decreases. The results in this study suggest that older farmers are reluctant to invest on SFRT compared with young farmers (Amsalu *et al*., 2007). This implies that young farmers are able to access information on SFRT. Other findings indicate that Nwaru, (2004) the ability of a farmer to bear risk, adopt new innovations and be able to do normal work decreases with age. Older people are likely to be more resistant to change and innovations. The result is also in agreement with Omotesho *et al*., (2012) who obtained a similar results.

The level of education attained had a negative significant effect on perception of farmers on SFRT. This is contrary to the expectation of this study. The leve of education has been linked to increased exposure, awareness and knowledge (Ojo *et al*., 2005; Abdoulaye *et al*., 2014). Awareness of a problem has been cited as a motivation to the adoption of problem-solving technologies (D'Emden *at al.*, 2005). However, similar results were found in the studies conducted by the Rashid and Islam, (2016).

Coefficient farm income had a positive significant effect on farmers' perception of SFRT. Various studies indicate that higher incomes are associated with higher levels of adoption rates (Sheikh *et al*., 2003; Kahimba *et al*., 2014). Higher income means that the farmer can purchase inputs for crop production and hence can adopt SFRT.The perception of farmers towards STRT was positively influenced by access to credit. This is probably because credit access facilitates the ability to purchase inputs especially improved seed varieties and inorganic fertilizers (Geta *et al*., 2013; Teklewold *et al*., 2013).

According to this study coefficient cost of technology had a negative significant effect on perception of SFRT. The results are similar to the findings of Kudi, *et al.,* (2008) and Ugwumba and Chukwuji (2010) who found that high cost of feeds and other inputs contributed up to 97% of the production problems faced by fish farmers in Nigeria.

5.6 Knowledge of SFRT by Farmers

The results in Table 4.8 show that the biggest challenge to adoption of SFRT was lack of technical knowledge regarding these technologies. In this study, the majority of respondents expressed unawareness of the SFRT. Less than 50% of the respondents were aware of SFRT. Similar findings were found by Ajayi and Banmeke, (2007). Other findings include a study by (Chakravarty, 2012) in India which showed, about 60 percent of farmers knew little or nothing about climate change phenomenon and its impacts. Similarly, Laary *et al*., (2012), found that most farmers in Ghana are unaware of hazardous and inappropriate agrochemical products banned by government authorities and continue to use and handle them without protective measures. Further, the findings also agree with the view of (Chadwick, 2003) that agricultural development in African countries has been hampered by low level of knowledge exchange arising from poor linkages between various stakeholders.

Adesina, (1996) and IFDC, (1990) indicated in their studies that there was a gap between research, extension and farmers. The studies on the adoption of soil fertility enhancing technologies (SFETs) in the West African Semi Arid Tropic (WASAT) region have also cited infrastructural constraints and lack of information as the major reasons for the non-adoption of SFETs. Similarly, Kassie *et al.,* (2009) stated that access to information on new technologies is crucial to creating awareness and attitudes towards technology adoption. Generally, these results show there is a gap in knowledge of agricultural production enhancing technologies. However, it should be also noted that acquisition of knowledge does not guarantee its application.

This is probably because public agricultural extension service is characterized by poorly motivated staff, inadequate finances, lack of legislative policy for the coordinating the link between agricultural extension and other organizations, the bureaucratic procedures and poor linkages with other organizations (Kizilaslan *et al.,* 2007). On the other hand, there is a very weak linkage between research and extension (Allahyari, 2009)).

5.7 Challenges Farmers Face in the Use of SFRT

The major challenge identified hampering adoption of SFRT in the current study was lack of capital for purchasing input. Similar challenges have been identified elsewhere in literature (Ajayi *et at*., 2007; Ajayi *et al*., 2003). Smallholder farmers in developing countries have limited access to financial loans/credits therefore; they depend on savings from their low incomes, which limits opportunities to adopt certain practices such as SFRT (Nobeji *et al.,* 2011). This scenario may apply to Trans Nzoia county where the majority of the farmers (85%) are smallholder farmers owning less than < 5 hectares. The results were in line with Demeke, (2003) who reported a systematic association between farmers' participation in credit access and adoption of conservation structures. Further, Chiputwa *et al,* (2011) found that lack of access to cash or credit/cost of capital (interest rate) may hamper smallholder farmers from adopting new technologies that require initial investments. Access to credit by farmers enhances their purchasing power and this in turn may increase their ability to purchase improved seeds and inorganic fertilizers with consequent adoption (Oluyede *et al.,* 2007; Humphreys *et al.,* 2008; Nyamai, 2010). In Uasin Gishu county lack of income was not as a major challenge probably because farmers get income from the sale of milk as most of them keep better breeds of dairy animals compared to those in Trans Nzoia county (not indicated in the study). The income can act as a substitute for borrowed capital as it provides farmers with liquid capital for purchasing productivity enhancing inputs such as improved seed and fertilizers (Diiro, 2013).

Labour is an important variable in agricultural production process and is likely to influence adoption of other labour intensive technologies. In this study, lack of labour was not cited as a major challenge by the respondents. This revelation means that adoption of SFRT in the region is not associated with labour availability. This is probably because maize production in this region is highly mechanized and herbicides are used to control weeds. These results could also mean that most of the respondents use family labour due the large household size. The results concur with the findings of Bekele & Mekonnen, (2010) who in their study found that a large household size working on the farm reduces the farms' external labour requirements and is hence assumed to positively affect adoption of labour intensive agricultural technologies. Labour availability at the household level may also influence the decision to adopt improved soil and water conservation technologies (Yila and Thapa, 2008; Mazvimavi and Twomlow, 2009; Mugonola *et al*., 2013).

In another study by Odendo *et al.,* (2010) labour constraint had a significant impact on the adoption of tree fallows which are relatively labor-intensive. Similarly, labour is still considered a major constraint especially to "low external input" technologies (Drechsel *et al.,* 2012). Further, Gichangi *et al., (*2007) stated that in ASALs of Kenya farmers were worried of labor requirement for applying the organic fertilizer in the furrows. Likewise, Farouque and Hiroyuki, (2007) reported that preparation of organic manure was labor intensive and was ranked first in their study as a major constraint. In this study the cost of inorganic fertilizer was also not cited as major challenge in both counties. This is probably because of government subsidized fertilizer sold to farmers through National Cereal and Produce board (NCPB) in Kenya. The results of the study concur with the findings of (Ajayi *et al.* 2007; Humphreys *et al.,* 2008) who reported to that the cost and level of subsidy on fertilizer were determinants of financial attractiveness and the potential adoptability of the different soil fertility options. Further, in Zimbabwe, Gumbo, 2010 reported that farmers' reduced their use of inorganic fertilizer as a consequence of their higher prices.

Availability of manure in this study was a constrain to most household in the study area. This is in line with the other findings for instance a study by Nkonya *et al.*, (2008) indicated that in most sub-Saharan African smallholder farming systems the use organic manure for crop production is constrained by low biomass production. Farm yard manure is also becoming scarce because most farmers have few animals to produce adequate quantities of manure. Transport problems for the huge quantities of manure required, and poor management of manure resulting in low quality may limit its utilization (Kuntashula *et al.*, 2004).

CHAPTER SIX

CONCLUSIONS AND RECOMMENDATIONS

6.1 Overview

This study was conducted to assess factors influencing the adoption of SFRT. Specifically, the study set out to address four objectives namely: (i) To determine the effect of social factors such as level of education, age, gender, household size, farm size and access to extension services on the adoption of SFRT among the maize farmers in the North Rift region of Kenya. (ii)To determine the effect of economic factors such as farm size, availability of credit, farmer income, off farm income and cost of technology on the adoption of SFRT among the maize farmers in the North Rift region of Kenya. (iii) To establish the perception of maize farmers on soil fertility replenishment technologies in the North Region of Kenya. (iv)Assess the knowledge of maize farmers on SFRT in the North Rift region of Kenya. (v)To establish the challenges maize farmers face in the use of SFRT in the North Rift region of Kenya.

6.2 Conclusions

i) The social factors that significantly influenced farmers' decision to adopt FURP, FURPL and Mavuno or not, were gender of household head (negatively). Age had positive and significant influence on the adoption of FURP, FURPL and NAAIAP. However, it negatively influenced the adoption of Mavuno. The implication of these results is that the adoption of SFRT technologies could be enhanced through targeting of younger families

ii) The economic factors that significantly influenced the decision to adopt SFRT or not were off-farm income, access credit and cost of technology. Off-farm income household head (negatively) influenced the adoption of FURP, ½ rate

Rutuba plus ½ FURP and NAAIAP technologies. Coefficient access to credit negatively influenced adotipn of FURPL and (positively) for NAAIAP technology. Further, cost of technology negatively and positively for FURP and Rutuba, respectively. These results imply that limited accessibility of credits/loan and high cost of credit can impact negatively on the usage of some SFRT.

iii) The perception of farmer's regarding SFRT, availability of inputs, affordability of the inputs used in the technologies was positive. Despite the positive perception about this technologies farmers, were not using the technologies. This implies that probably farmers did not have knowledge regarding SFRT.

iv) The study revealed farmers had minimal knowledge about the SFRT.This could be an indication that even the extension officers were not aware of these technologies. Access to information on new technologies is crucial to creating awareness and attitudes towards technology adoption

v) The main challenge hindering the adoption of SFRT in both counties was lack of capital. However, the majority of the respondents in Uasin Gishu county did not anticipate any challenges in the adoption of SFRT. This result in this study imply that the majority of the farmers in the two counties were not able to access credit or they were reluctant to access the credit probably due to high interest rate the financial institutions in Kenya charge. Further, some farmers did not have the necessary assets to act as collateral that is required by lending institutions to acquire credits/loan.

6.3 Recommendations

The study recommends that the policy makers to focus:

(i) Research, extension and farmer linkage should be strengthened. This would enhance dissemination of the research findings by extension workers. However, the messages and the targeting is critical if extension is to contribute to technology adoption.

(ii) Credit schemes that are farmer friendly should be established to enable farmers have access to credit to facilitate their agricultural activities, since the adoption of technologies is largely depended on availability of inputs. Inputs such as fertilizer, seed, and labour can easily be sourced when farmer have access to credit .An alternative approach could be to mobilize the smallholders to form organizations through which to pool resources and obtain additional funding from either the government or financial institutions. Whichever approach is chosen, the funds should be low interest and easily accessible.

(iii) Researchers, development agents and the government ought to implement measures and strategies that will increase access to productive resources by female farmers. Facilitating access to productive resources by rural female farmers is not a one-time event, but an institutional process requiring permanent adaptation to changing circumstances of power, economics, and culture. An effective implementation of Kenya’s gender empowerment policy will significantly help to improve the conditions of rural female farmers in the years to come.

(iv) Based on these findings, introduction of new technologies to farmers should go hand in hand with on-farm demonstrations since it by doing that they would develop confidence and allay their fears associated with the technology.

(v) The government should device a policy that should encourage the youth involvement in the agricultural activities. This would enhance sustainable agricultural productivity as the old are aging out.

6. 4 Suggestions for Further Research

(i) Key area where focus is required is an assessment of the best way of linking farmers to research.

(ii) It will be useful to have more synthesis studies which cut across different fields of agricultural research like soil science and bring together findings of adoption processes for a wider range of sustainable agricultural technologies.

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APPENDICES

APPENDIX I: QUESTIONAIRE

ADOPTION OF SOIL FERTILITY REPLENISHMENT TECHNOLOGY SURVEY HOUSEHOLD INTERVIEW SCHEDULE

Dear Respondent,
I am a post graduate student of the University of Eldoret, in the Department of Agricultural Extension and Rural Development. I am carrying out a study on the Analysis of factors Influencing the Adoption of Soil Fertility Replenishment Technologies by maize farmers in the North Rift region of Kenya. I hereby request your patience and co-operation in responding to the questions in the questionnaire to enable me achieve my study objectives. The information provided will be treated with utmost confidentiality and shall on be used for academic and research purposes.

Name of enumerator(optional)………..……… Mobile No………………………..
Survey Date ___/___/ _______) (day/month/year)

County ---

Sub county: --

Ward: --

SECTION 1:

Q1.BACKGROUND INFORMATION
a)Farmers name……………………Phone Number---------------------(optional)

b)Sex.Tick where applicable.
1) Male
2) Female

c) Age of the household head
i) 18 to 35 years
ii) 36 to 45 years
iii) 46 to 50 years
iv) > 50 years

d) Main occupation of the household head.Tick where applicable.
1) Farmer
2) Business
3) Formal employment
3) Casual employment

e) Education level of the household head.Tick where applicable.
1) No formal education
2) Primary
3) Secondary
4).Tertiary

f) Household size-----------------------------members

Q.2. Agricultural production and other livelihood sources

a)What is the total size of your farm?

i) < 5 ha
ii) 6 to 10 ha
iii) >11 ha

b) How much land do you currently cultivate?--------------acres

i) < 5 ha
ii) 6 to 10 ha
iii) >11 ha

c) How much land is under maize…………………………. acres

d) Which is your preferred fertilizer for planting of maize? Tick where applicable.

1. DAP
2. NPK (23:23:0)
3. Mavuno planting
4. Rutuba bio-organic

e) Which is your preferred fertilizer for top-dressing of maize? Tick where applicable.

5. CAN
6. Urea
7. Mavuno topdressing

f) What rate of fertilizer do you use for planting? *Tick where applicable*.

Type of fertilizer	**Quantity**
DAP	a)125K g/ha b)187.5 kg/ha c)250 kg/ha
NPK (23:23:0)	a)125K g/ha b)187.5 kg/ha c) 250 kg/ha
Mavuno planting	a)125K g/ha b)187.5 kg/ha c)250 kg/ha
Rutuba bio-organic	a)125 kg/ha b)187.5 kg/ha c) 250 kg/ha

g) What rate of fertilizer do you use for topdressing? *Tick where applicable*.

Type of fertilizer	**Quantity**
CAN	a)125K g/ha b)187.5 kg/ha c)250 kg/ha
UREA	a)125K g/ha b)187.5 kg/ha c) 250 kg/ha
Mavuno Topdressing	a)125K g/ha b)187.5 kg/ha c)250 kg/ha

h) How many bags do get per acre?................................... in 50 kg bag
i) What is the total farm income per year-------------------------- Kshs

j. What are the off farm incomes for the household?

1. Business (kiosk, shop, hawking
2. Permanent/Salaried employment
3. Casual/Temporary employment

b) What is your main source of information and advice on agriculture? *(Tick where applicable)*

1) Government extension agents
2) Agro Input/chemical Suppliers
3) Media - Radio /Television/print
4) Private Sector extension agents
5) Researchers and Agricultural Colleges
6)Internet/phones(sms)
7)None

c. Are you aware of these technologies

(i) 75 kg N + 26 kg P /ha - 129 kg DAP/ha fertilizer was used at planting to give 26 P kg/ha + 191.9 kg/ha CAN at topdressing to bring N to 75 kg N/ha (FURP recommendation)
(ii) 75 kg N + 26 kg P /ha + 2 ton of lime (CaO) - 129 kg DAP/ha fertilizer was used at planting to give 26 P kg/ha + 191.9 kg/ha CAN at topdressing to bring N to 75 kg N/ha + 2 tones lime (FURP plus lime recomendation)
(iii)13 kg P /ha DAP + 37.5 kg N /ha (64.5 kg DAP/ha fertilizer was used at planting to give 13 P kg/ha + 96 kg/ha CAN at topdressing to bring N to 37.5 kg N/ha) + I/2 rate Organic manure (trading under the name Rutuba) 125 kg/ha at planting + ½ rate CAN- topdressing 125 kg/ha (½ (FURP + Rutuba recommendation)
(iv)250 kg/ha at planting + 187.5 kg/ha CAN topdressing (Rutuba recommendation)
(v) 250 kg/ha at planting + 187.5 kg/ha CAN topdressing (Mavuno recommendation)
(vi)250 kg/ha 23:23:0 at planting and 150 kg/ha CAN plus 225kg/ha Manure 6 tons/ha (National Agricultural Accelerated Input Access Programme (NAAIAP recommendation)

e.) If yes. Can you afford these technologies?
1.Yes
2.No

d. Have you ever implemented any soil fertility replenishment technologies? Tick where applicable
1. Yes
2. No
e. If yes which one ---

f. How often do you implement new technologies?Tick where applicable.
I. Very often,
2. Often
3. Rarely
4. Never

D4: AGRICULTURAL FINANCIAL SERVICES AND MARKETING
a. Do you have access to financial services? Tick where applicable.
1. Yes
2. No

b**.** If yes, have you received any Agricultural credit in the last 12 months? Tick where applicable.
1. Yes
2. No

c.If yes, in what form was it? Tick applicable
1. Cash
2. Inputs
3. Non

THANK YOU FOR YOUR COOPERATION

APPENDIX II: FOCUS GROUP DISCUSSION QUESTIONAIRE

Dear respondent,

I am a post graduate student of the University of Eldoret, in the Department of Agricultural Extension and Rural Development. I am carrying out a study on the Analysis of factors Influencing the Adoption of Soil Fertility Replenishment Technologies by maize farmers in the North Rift region of Kenya. I hereby request your patience and co-operation in responding to the questions in the questionnaire to enable me achieve my study objectives. The information provided will be treated with utmost confidentiality and shall on be used for academic and research purposes.

1a. General Information

Survey Date ___/___/___ (day/month/year)

b. Details

a) Name of the group---

b) Ward--

c) Sub County--

d) County---

The Interview Questions:

1. Comment on the farmers' social and economic characteristics and particularly whether they influence the level of adoption of SFRT technologies?

2. Describe the status of maize production in the area

3.Which fertilizers do you use for maize production (basal and topdressing)

4. Are you aware of these technologies?

5. Have you adopted any of the technologies? If no give reasons

6. What are the challenges and constraints affecting the adoption of these technologies.

7. What challenges how can these challenges be addressed and overcome ?

THANK YOU FOR YOUR COOPERATION

APPENDIX III: FIELD OBSERVATION GUIDE

Dear respondent,

I am a post graduate student of the University of Eldoret, in the Department of Agricultural Extension and Rural Development. I am carrying out a study on the Analysis of factors Influencing the Adoption of Soil Fertility Replenishment Technologies by maize farmers in the North Rift region of Kenya. I hereby request your patience and co-operation in responding to the questions in the questionnaire to enable me achieve my study objectives. The information provided will be treated with utmost confidentiality and shall on be used for academic and research purposes.

1. The level of use of SFRT

2. Agronomic practices used in maize production

3. Gender in relation to maize production

4. Land use and other farming practices that are a threat to maize production.

5. Type of fertilizers used.

APPENDIX IV: MEASURE OF PERCEPTION FROM THE ON FARM DEMONSTRATIONS

Dear respondent,

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1.**LIKERT SCALE RATING**

1. Strongly agree (SA)
2. Agree (A)
3. Undecided (U)
4. Disagree (D)
5. Strongly disagree (SD)

Questions	**SA**	**A**	**U**	**D**	**SD**
There is a decline in soil fertility					
There are STRT that can be used to address decline in soil fetility					
The SFRT are common					
The information about these technologies are readily available					
The inputs used in these technologies are readily available					
These technologies are affordable					
The technologies can work well in any farm					
These technologies have negative effects on soil fertility					
There are no challenges involved in using these challenges					
The MOALF is effective in disseminating the technologies					

2.Evaluation of performance of the SFRT

i. Rank the technologies according to the performance

Technology	Rank 1	Rank 2	Rank 3	Rank 5	Rank 5	Rank 6
1.FURP						
2.FURPL						
3.Mavuno						
4.Rutuba						
5.½(FURUP+ Rutuba)						
6. NAAIAP						

APPENDIX V: SOCIAL AND ECONOMIC CHARACTERISTICS OF FARMERS PARTICIPATION ON DEMONSTRATION

Name of enumerator(optional)…………….…… Mobile No…………….……..
Survey Date ___/___/ _______) (day/month/year)

County --

Sub county: ---

Ward: --

SECTION 1:

Q1.BACKGROUND INFORMATION
a)Farmers name……………………Phone Number---------------------(optional)

b)Sex.Tick where applicable.
1) Male
2) Female

c) Age of the household head
i) 18 to 35 years
ii) 36 to 45 years
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d) Main occupation of the household head.Tick where applicable.
1) Farmer
2) Business
3) Formal employment
3) Casual employment

e) Education level of the household head.Tick where applicable.
1) No formal education
2) Primary
3) Secondary
4).Tertiary

f) Household size-----------------------------members

g)What is the total size of your farm?
i) < 5 ha
ii) 6 to 10 ha
iii) >11 ha

h. What are the off farm incomes for the household?

1. Business (kiosk, shop, hawking
2. Permanent/Salaried employment
3. Casual/Temporary employment

g) What is your main source of information and advice on agriculture? *(Tick where applicable)*

1) Government extension agents
2) Agro Input/chemical Suppliers
3) Media - Radio /Television/print
4) Private Sector extension agents
5) Researchers and Agricultural Colleges
6)Internet/phones(sms)
7)None

h.) If yes. Can you afford these technologies?
1.Yes
2.No

i) If yes, have you received any Agricultural credit in the last 12 months? Tick where applicable.
1. Yes
2. No

Q.2) Adoption of the technologies

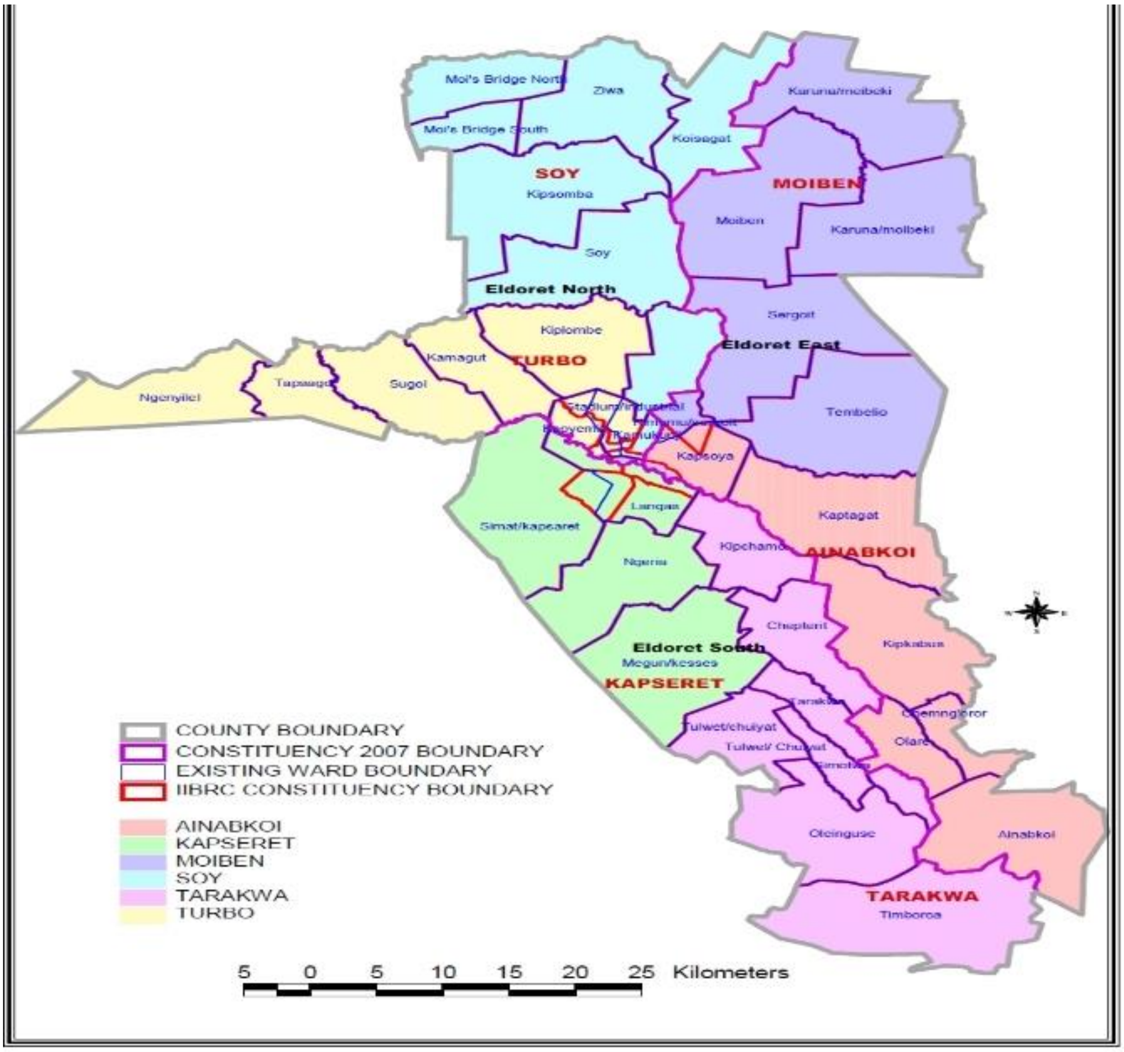
a)Have you adopted any of the technologies from the demonstration
b) What are the challenges encountered in adopting these technologies.

Major challenges against Adopting STRT Technologies

Challenge	**Tick as appropriate**
1. Cost of inorganic fertilizer	
2. Lack of manure	
3. Lack of soil amendments	
4. Labour	
5. Lack of capital	
6. None	

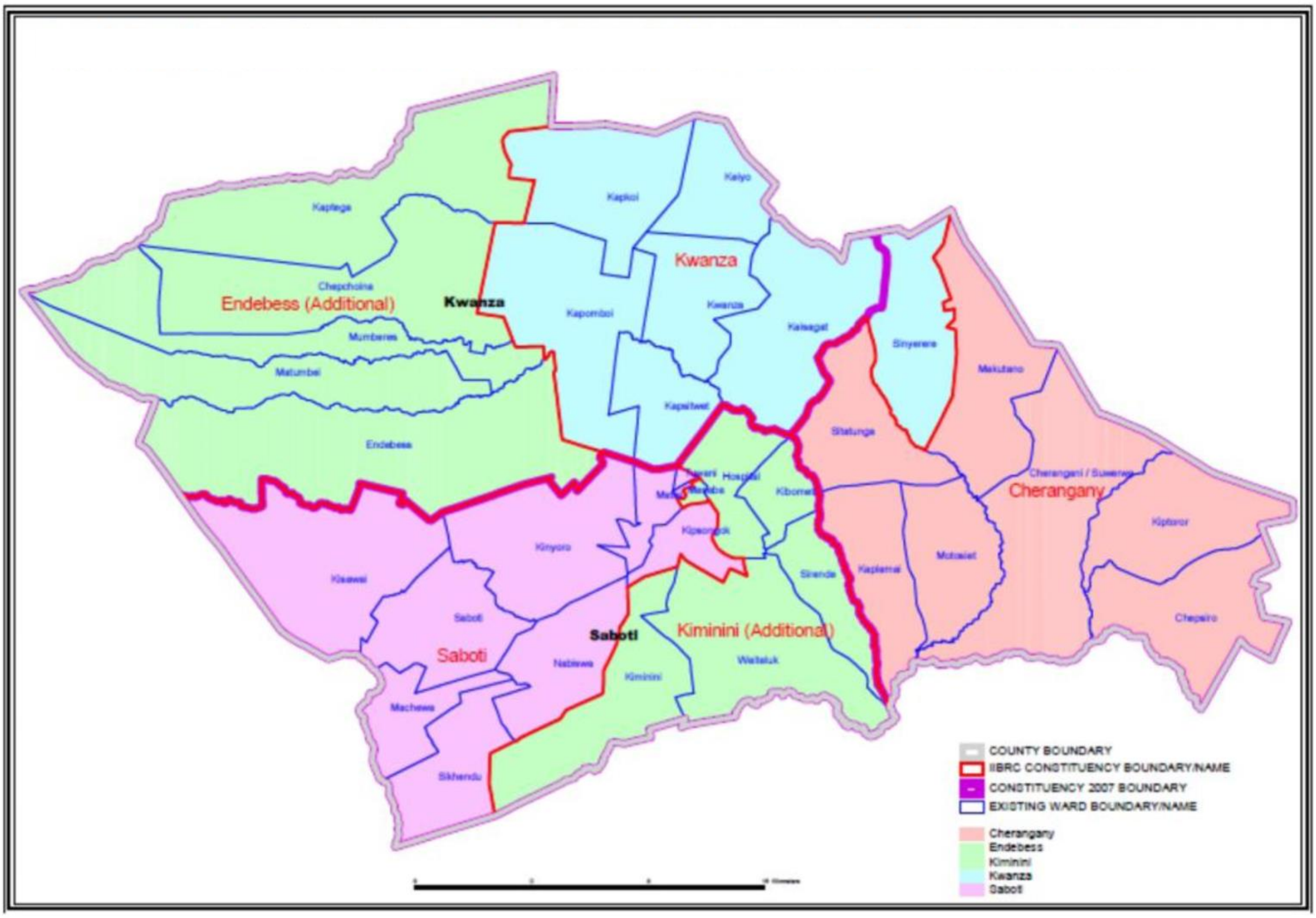
THANK YOU FOR YOUR COOPERATION

APPENDIX VI UASIN GISHU MAP SHOWING DISTRIBUTION OF THE WARDS



Source: Uasin Gishu County Integrated Development Plan 2013-2018

APPENDIX VII: TRANS NZOIA MAP SHOWING DISTRIBUTION OF THE WARDS



Source: Trans Nzoia County Integrated Development Plan 2013-2018

APPENDIX III : Similarity Index/Anti-Plagiarism Report