GENDER DIFFERENTIALS IN ADOPTION OF SOIL NUTRIENT REPLENISHMENT TECHNOLOGIES IN MERU SOUTH DISTRICT, KENYA

BY

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DECLARATION

I, **Edith Gathoni Kirumba**, hereby declare that this thesis is my original work, and has not been presented for a degree in any other University or for any other award.

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Declaration by supervisors:

We confirm that the work reported in this thesis was carried out by the candidate under our supervision.

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Dedication

To my family and friends, for their undying love and support without which I would not have made it to this point in my life.

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LIST OF ABBREVIATIONS AND ACRONYMS

CGIAR:	Consultative Group on International Agricultural Research
CIAT:	International Centre for Tropical Agriculture
CIMMYT:	International Maize and Wheat Improvement Centre
FAO:	Food and Agriculture Organization of the United Nations
FPR:	Farmer Participatory Research
FHH:	Female Headed Household
GIS:	Geographical Information Systems
ICRAF:	World Agro forestry Centre
ICRISAT:	International Crops Research Institute for the Semi-Arid Tropics
IFAD:	International Fund for Agricultural Development
IFPRI:	International Food Policy Research Institute
ISFM:	Integrated Soil Fertility Management
KARI:	Kenya Agricultural Research Institute
KEFRI:	Kenya Forestry Research Institute
MHH:	Male Headed Households
PRA:	Participatory Rural Appraisals
RUFORUM:	Regional Forum for Capacity Building in Agriculture
SSA:	Sub-Saharan Africa
SNRT:	Soil Nutrient Replenishment Technology
UNDP:	United Nations Development Programme
WB:	World Bank

OPERATIONAL DEFINITIONS OF KEY CONCEPTS AND TERMS

Gender: refers to socially constructed roles and socially learned behaviors and expectations associated with males and females (World Bank, 2000).

Gender Roles: Gender roles are the socially constructed roles that women and men assume as a result of being born male or female.

Gender Differentials: differences or variations in gender relations at the household level that influence the adoption of soil fertility replenishment technologies.

Adoption: The subsequent decision to fully utilize an innovation as the best course of action is called adoption (Nabifo, 2003). A formal technology adoption survey may be conducted 2-4 years following technology release (CIMMYT, 1993).

Adopter: farmer who at the time of the research had used at least one of the introduced technologies in their farm either for fodder or soil amelioration for eight cropping seasons.

Non-adopter: farmer who at the time of the research had not used any of the introduced technologies in their farm for eight cropping seasons but may have tested them or was aware of them.

Soil Nutrient Replenishment Technologies: Farming practices that have been researched and passed on to farmers as appropriate practices for improved soil fertility in various project sites. They include *Leucaena trichandra, Calliandra calothyrsus, Tithonia diversifolia* and combinations of these technologies with manure or fertilizer.

Participation: active involvement of the potential adopters of a soil fertility improvement technology in project field days, workshops, training sessions, and farmers' groups' activities.

Project activities: Involve problem diagnosis meetings, field days, village training workshops, nursery group meetings where farmers and scientists exchange knowledge and ideas through an interactive mode.

Household: A household is composed of a head, relatives living with him/her, and other persons who share the community life for reasons of work or other consideration.

Head of household: the person who makes/influences major decisions regarding household and farm resources and directly influences decisions on adoption of soil fertility replenishment innovations.

Female-headed households: Households that are run and represented by a widow, divorced or single woman without the mediation of a father or male relative.

Male-headed households: Households where a husband is present and resident on the farm and is the final decision maker on the important issues pertaining to the household.

De facto female-headed households: households where the head is the wife of a male migrant. Headship is usually temporary in nature since the husband will automatically assume the headship whenever he is around (Gladwin et al., 2002).

De jure female-headed households: households where the female head belongs to one of these categories: single, widowed, divorced or separated.

Socio-economic factors: factors affecting adoption that relate to issues such as access to and control of resources, level of education, off farm employment, security of tenure among others.

Institutional factors: formal or informal institutions that facilitate a farmer's adoption of technologies, such as credit lending institutions, extension services and farmers' groups.

Demographic factors: Information relating to age, household headship and size in the study area.

Farm characteristics: factors that involve the farm; for instance area under cash crops, farm size, area under food crops that may/may not influence adoption.

ABSTRACT

Understanding gender differentials in adoption of soil nutrient replenishment technologies is critical to the successful uptake of these soil improving innovations by farmers. The importance of gender issues in adoption of soil innovations is increasingly gaining global recognition and there is a strong call for its integration in development projects and programs. This study was conducted firstly to investigate gender differences in the frequency of participation in soil related project activities, secondly, to determine how choices of technologies adopted differed between male and female headed households and finally to investigate socio-economic, institutional, farm characteristics and demographic factors influencing adoption. Primary data was collected using semi-structured interview schedules, focus group discussions and key-informant interviews. Secondary sources included the agro forestry systems journal, science direct, agricultural systems journal, nature journal, and related articles, books and periodicals.

Descriptive and bi-variate analyses were done to determine relationships between the variables under study. Descriptive analysis involved the use of means, percentages, range, standard deviation and cross tabulation. Bi-variate analysis was conducted by use of Chi-square and T-tests run at $P<0.05$ to test for significant relationships between variables. Multi-variate analysis was done by use of logistic regression analysis to determine factors that significantly influenced adoption. The results indicated that female headed households participated in significantly lesser numbers in project activities than male headed households. Further, adoption of cattle manure and mineral fertilizer was significantly higher for male headed households in comparison to female headed households. The results of logistic regression analysis indicated that in male-headed households, adoption was significantly influenced by number of cattle owned, access to credit, number of adults working on farm and farmer group membership.

For female headed households, adoption was significantly influenced by size of land under cash crops, number of goats owned, number of adults working on farm, participation in project activities, and farmer group membership. Based on these results, there is a clear need for strategies, policies and efforts geared towards promoting gender parity in adoption of soil fertility enhancing technologies. Efforts aimed at increasing adoption and agricultural productivity for both male and female headed households should consider increasing farmers' membership in groups and improve their ability to purchase inputs such as fertilizers and labor.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Africa South of the Sahara is the only remaining region of the world where per capita food production lags far behind that in other regions of the world (Bationo et al., 2006). Africa's food insecurity is directly related to insufficient total food production. Depletion of soil fertility, along with the concomitant problems of weeds, pests and diseases, is a major biophysical cause of low per capita food production in Africa (Sanchez, 2002). Although Africa's relatively unfavorable natural endowment with respect to soils has been recognized, research over the past 10-15 years has raised concerns that Africa's soil capital is deteriorating at an alarming rate (World Bank, 2006).

In particular, the major nutrients, nitrogen (N) and phosphorus (P) are commonly deficient in these soils. This scenario of nutrient depletion is reflected in food deficits across most parts of Sub-Saharan Africa every-year and leads to the continuous import of food aid from the surplus producing countries of the west (Okalebo et al., 2006). Over the next 20–25 years, global food demand is expected to increase by around 50%. About 80% of the increased demand is expected to come from developing countries, particularly countries in sub-Saharan Africa where nutritional deficits are still increasing (Dar and Twomlow, 2007).

The United Nations task force on hunger, which was convened as part of the United Nations millennium project to address hunger and poverty issues, recognized the plight of small scale farming communities in Africa and identified improvement of soil health as one of the key actions needed to raise agricultural productivity and reduce hunger in rural communities (World Bank. 2006). Over the decades. small scale farmers have removed large quantities of nutrients from their soils without using sufficient quantities of manure or fertilizer to replenish the soil (Sanchez. 2002). The Africa Fertilizer Summit held in Abuja. Nigeria in 2006. estimated that in 2002-2004. as much as 85% of African farmland had nutrient mining rates of more than 30kg ha^{-1} of nutrients per year. and 40% had rates greater than 60kg ha^{-1} yr^{-1}. Total nutrient mining could be as high as 8 million tons of nutrients per year across the region. Consequently. about 95 million hectares in Africa have reached such a state of degradation that very substantial investments will be needed to make them productive again (Bationo et al.. 2006).

In the Central Kenya Highlands. farmers themselves have persistently lamented that low soil fertility is a major constraint to food crop production (Sanchez and Jama. 2000). One of the major factors contributing to this decline is soil impoverishment caused by continuous cropping without adequate fertilizers and/or manure. mostly due to lack of readily available resources to replenish the soil. This has resulted in an imbalance between nutrient inputs. harvest removal and other losses. reaching critical proportions (Murage et al.. 2000). Uundoubtedly. substantial efforts have been made to replenish the fertility of degraded soils in attempts to raise crop yields. towards self-sufficiency and export. The ISFM paradigm acknowledges the need for both organic and mineral inputs to sustain soil health (Buresh et al.. 1997; Vanlauwe et al.. 2002). Among the most promising organically based soil nutrient replenishment practices are: animal manure.

compost, incorporation of crop residues, natural fallowing, improved fallows, relay or intercropping of legumes (and dual purpose legumes), and biomass transfer using nitrogen fixing tree fallows (Place et al., 2003).

Despite these impressive advances over the last three decades, soil improvement projects commonly suffer from inadequate rates of adoption and/or abandonment soon after promotion (Franzel, 1999). To explain this situation, Bationo et al. (2006), reports that one of the lessons learned during the Africa Fertilizer Summit held in Abuja Nigeria in 2006 was that farmers' decisions to adopt soil fertility improvement innovations were not merely driven by soil and climate but a whole set of factors cutting across the biophysical, socio-economic, institutional and political domain. A holistic approach in soil fertility research and assessment of adoption of resulting innovations must embrace the full range of driving factors such as social, economic, demographic, biophysical, institutional and political factors.

Further, the increasing importance of analysis of gender issues in adoption of soil innovations is gaining global recognition in the development agenda and there is a strong call for its integration in development projects and programs (Gladwin et al., 2002). In Africa, gender is an economic, social, institutional, household, agricultural and equity issue and must be accorded the serious attention it deserves (IFPRI, 2005). Issues relating to gender in agriculture have been the subject of discussion in the African context for many years but the linkage between the gender experts and the agriculturalists has remained weak. As a result much has been said and written about gender imbalances but little has been achieved to address the situation. The influence of gender on uptake of soil nutrient replenishment innovations has been noted in studies conducted in Eastern Africa (Muriu. 2005; Adiël. 2004; Mwangi et al., 1996). In other studies. gender of the household head has been found to be an important determinant of adoption of soil fertility management technologies (Place et al., 2004). As such, there is a need to further investigate the impact of gender on adoption patterns.

Additionally. literature reveals that soil fertility management technologies developed jointly in participation with farmers stand a better chance of uptake (Pound et al., 2003). This is especially so because experience shows that most capital-based technologies developed in isolation from resource-poor farmers have low rates of adoption (Fort. 2007). However. gender differences have been witnessed in participation in soil fertility related project activities. As reported by Njuki (2001), men participate in greater numbers than women in project activities in Central Kenya and thus women who provide much of the labor do not receive sufficient training required to implement the technologies on their farms. As such, there is a need to investigate how participation in soil fertility related project activities varies between male and female farmers (Chinangwa. 2006).

In the study area. the research sought to investigate choices of technologies adopted by male and female headed households. As well. there was a need to examine and analyze socio-economic. institutional. farm characteristics and demographic factors that influenced adoption of soil nutrient replenishment technologies at household level. Additionally. of importance was to determine how the frequency of participation in soil related project activities differed for male and female headed households. As such. this study sought to delve into these issues and further provide recommendations that would inform policy and gender mainstreaming initiatives geared towards increased adoption of soil nutrient replenishment technologies by targeting farmers, extension agents, researchers and project implementers.

1.2 Problem Statement

Soil nutrient depletion in small holder farms in Meru South district of Central Kenya was noted as a major cause of insufficient food production. Some of the factors that contributed to this situation were stated as: continuous cropping without adequate use of fertilizers and manure to replenish the soil, low adoption of soil and water conservation measures and cultivation on steep slopes. As a result, soil nutrient depletion was reflected in food deficits across most households in the area.

Major strides had been made by researchers (Mugendi et al., 1999, Mucheru et al., 2002 and Adiel, 2004) in attempts to increase crop yields and enhance food sufficiency in Meru South district and the integrated soil fertility management approach had been widely promoted as the best strategy towards resolving the problem. This approach encouraged the combination of mineral and organic inputs to replenish soil fertility. The most commonly used organic inputs were biomass transfer using leguminous shrubs, manure use and intercropping of legumes. Recommended rates for mineral inputs usage were also been largely emphasized. Despite these efforts, adoption by farmers had been relatively low. This necessitated research into factors influencing adoption; which ranged from bio-physical to socio-economic, institutional, and demographic factors. Previous studies by Adiel, 2004 and Muriu, 2005 in Central Kenya recommended investigations into the influence of gender on the choices of technologies adopted, factors influencing adoption and examination of differences in participation between male and female farmers as information needed to inform decision making and to increase uptake levels by small holder farmers.

However, past research in the study area done by Mucheru et al., 2002, Vanlauwe et al., 2002, Mugendi et al., 1999) focused mainly on biophysical factors of adoption with limited work on socio-economic aspects of adoption. As a consequence, there was very little mention of gender differences in adoption of soil fertility replenishment technologies by male and female headed households. Research on how the frequency of participation in soil fertility related project activities differed among male and female-headed households had not been done. Also lacking was information on the choices of technologies for adoption between male and female-headed households, and the socio economic, institutional, farm and demographic factors influencing their adoption. These were the concerns that necessitated this study.

1.3 Research Questions

The study sought to answer the following research questions:

1.3.1 Does the frequency of participation in soil fertility related project activities differ between male and female-headed households?

1.3.2 Do the choices of soil nutrient replenishment technologies for adoption by male and female-headed households differ?

1.3.3 Do socio-economic, demographic, farm and institutional factors influencing adoption of soil nutrient replenishment technologies differ between male and female-headed households?

1.4 Research Objectives

The specific objectives of this study were:

1.5.1 To examine and analyze whether the frequency of participation in soil fertility related project activities differs between male and female-headed households.

1.5.2 To determine whether choices of soil nutrient replenishment technologies between adoption differ between male and female headed households.

1.5.3 To investigate whether the socio-economic, demographic, farm and institutional factors influencing adoption of soil nutrient replenishment technologies differ between male and female-headed households.

1.5 Research Hypotheses

The following research hypotheses guided this study:

H1: In soil fertility related project activities, there are differences between male and female headed households in the frequency of participation.

H2: Choices of soil nutrient replenishment technologies adopted differ between male and female-headed households.

H3: Adoption of soil nutrient replenishment technologies by male and female-headed households maybe influenced by demographic, socio-economic, farm and institutional factors.

1.6 Justification and Significance of the Study

Soil fertility decline leading to household food insecurity is a problem facing farmers in Meru South District. Scientists such as Mugendi et al., 1999, Mucheru et al., 2002, Vanlauwe et al., 2002, have made deliberate efforts at resolving this problem by introducing soil fertility replenishment technologies such as biomass transfer using leguminous shrubs like: *Tithonia diversifolia, Leucaena trichandra and Calliandra calothyrsus* Proper manure management and application of recommended fertilizer quantities are messages that scientists have communicated to farmers over time (Murage et al., 2000, Buresh et al., 1997).

However, adoption of these technologies by farmers has been slow and often, targeted numbers have not been reached (Place et al., 2003). This has necessitated an investigation into factors that influence adoption. As it stands, information on factors influencing adoption at household level is very scanty. As well, little has been done to reveal whether or not there exist gender differences in choices of technologies adopted. Lacking also is information on how the frequency of participation in soil related project activities by male and female headed households differs. These existing gaps in knowledge made a study of this nature a necessity.

As such, the analysis would not only be helpful in predicating choices of technologies adopted by gender and factors influencing adoption at household level, but would also provide gender disaggregated data on the frequency of participation in project activities. In a nutshell, the findings of this study could help inform gender sensitive policymaking.

identify areas for further research and enhance gender targeted technology design and dissemination of extension messages aimed at increasing adoption levels.

1.7 Conceptual Framework

According to Thangata and Alavalapati (2003), different models have been suggested to explain the decision to adopt new technologies. Following Rogers (1983) diffusion of innovations model, adoption behavior is a mental process governed by a set of intervening variables: individual needs, knowledge about the technology, and individual perceptions about methods used in meeting those needs in a specific environment. Further, the Haggerstrand Innovation diffusion model (Hagerstrand, 1966) explains that adoption of technologies is best achieved through transfer of information about the innovation. Such information is either the result of inter-personal communication or exposure to the mass media. Diffusion of innovations thus begins at micro-scale and advances to macro scale as information goes round.

Rogers (1995) defines adoption as a decision to make full use of an innovation as the best course of action, and rejection or non-adoption as a decision not to adopt an innovation. Nonetheless, these intervening variables are shown to depend on a set of socio economic, institutional and demographic factors. Accordingly, when scientists first introduce a technology in a community, adoption is slow. Through the process of "demonstration effects" of the early adopters, information, knowledge, and experience of the new technology spread to other potential adopters and the rate of adoption increases. This process continues until all of the potential adopters are exposed to and adopt the new practice. However, this model does not adequately address gender differentials in adoption of soil nutrient replenishment technologies, which this study takes into account.

There are frameworks that have been developed to mainstream gender into development, such as the Harvard analytical framework designed by the Harvard School to demonstrate that there is an economic case for allocating resources to women as well as to men (Maina et al., 2006). Another is the Moser framework developed by Caroline Moser, which is based on her concepts on gender roles, citing the triple roles of women (reproduction, production and community management), and the double roles of men (productive and community politics) as well as the practical and strategic gender needs that these entail (Moser, 1993). In addition is the women's empowerment framework, which views the empowerment of women as central to the development process (Maina et al., 2006).

The above-mentioned frameworks however could not fully address this study's concerns as they do not address the issue of household gender relations and participation in development, which this study sought to address. In contrast, the gender analysis matrix and Naila Kabeer's Social relations framework aim at determining the different impacts of development interventions on women and men (IFPRI, 2005). For this reason, this study borrows from Rogers' and Hagerstrand innovation decision-making models, the Gender analysis matrix and the Naila Kabeer's social relations frameworks to explain gender differentials in adoption of technologies. The conceptual framework designed for this study is as shown in Fig 1.1.

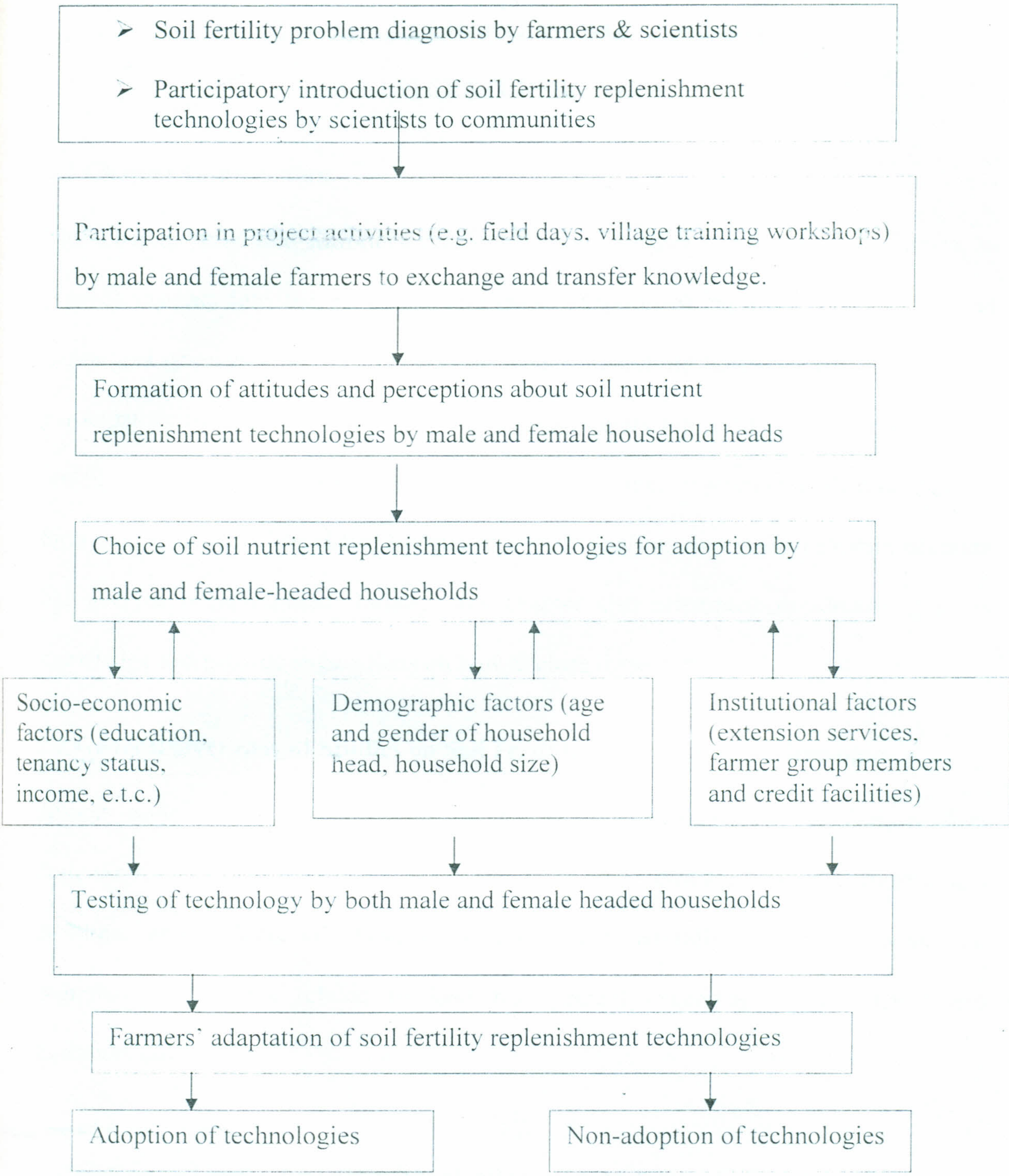

Figure 1.1 : Adopted and modified from the diffusion of innovations model (Rogers, 1983)

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter Introduction

This chapter sought to introduce and explain soil fertility enhancing technologies, to provide insights into the processes that entail adoption of these technologies, and to define and conceptualize the concepts of gender, household headship, participation and participatory rural appraisals. It also delves into factors that influence adoption of soil fertility enhancing innovations, be they socio-economic, institutional, demographic or farm characteristics. The use of logistic regression analysis as a tool to explain adoption has also been highlighted. Finally, this chapter also attempted to identify gaps in knowledge and provide suggestions on how to close these gaps.

2.2 General Overview of Studies on Soil Fertility Replenishing Technologies

African soils exhibit a variety of constraints, among them soil erosion, nutrient deficiency, low organic matter, aluminum and iron toxicity, acidity, crusting and moisture stress. Some of these constraints occur naturally in tropical soils, but degradation processes related to land management exacerbate them (Henao and Baanante, 2001).

With intensified agriculture and reduced fallowing periods, soil fertility has emerged as a key problem in many farming systems throughout the tropics. In recent years, with increasing costs of mineral fertilizers, scientific interest has turned towards the evaluation of organic fertilizers based on locally available resources including green manures and mulches. Research has focused on the quality, quantity and methods of application of biological materials. These studies now complement a wealth of research conducted over the last half century in East Africa demonstrating the positive responses of crops to organic fertilizers (Franzel and Scherr, 2002, Place et al., 2003, Franzel and Wambugu, 2004). For instance, manure is reportedly used by over 95% of all smallholder farmers in the Kenyan Highlands (Lekasi et al., 2001).

In several areas, researchers and farmers have developed improved tree fallows as one means to increase crop yields. In Malawi and Zambia, for example, planting the shrubs *Tephrosia vogelii, Sesbania sesban, Gliricidia sepium* or *Cajanus cajan* in fallows for two years, cutting them back, then following them with two to three years of maize cultivation increased maize yields compared with planting continuous unfertilized maize (Franzel et al., 2003).

Another practice for improving soil fertility is biomass transfer; the manual transfer of greenmanure to crops, which increases crop yields, extends the harvesting season and improves the quality of produce. Transfer of high-quality biomass sources of nitrogen and phosphorus, such as *Tithonia diversifolia,* a common shrub in Western Kenya, Central Kenya and Eastern Uganda, has shown promising effects in increasing maize yields. In Western Kenya, green leaves from tithonia are incorporated into the soil at planting of maize, bean, kales, French beans, and tomatoes (Place et al., 2004).

Further, in the highlands of central Kenya, farmers plant fodder shrubs, especially *Calliandra calothyrsus* and *Leucaena trichandra*, to use as feed for their stall-fed dairy cows (Franzel et al., 2003). Calliandra is a fast growing tree that fixes atmospheric nitrogen, thus enhancing soil fertility, and its use on contours reduces soil erosion. The farm-grown fodder increases milk production and can substitute for relatively expensive purchased dairy meal, thus increasing farmers' income. Fodder shrubs also conserve the soil, supply fuel wood and provide bee forage for honey production.

2.3 Diffusion, Acceptance and Adoption of Technologies

Diffusion is defined as a process by which an innovation is communicated through certain channels over time among members of a social system. After the diffusion of the technology, awareness and interest are created, thereafter, trial and evaluation occurs. The subsequent decision to fully utilize an innovation as the best course of action is called adoption. Adoption is essentially a process through which an individual passes from first hearing about an innovation to the final adoption (Nabifo, 2003).

Some of the factors that affect potential adoption are also key determinants of adoption. Rogers (1983) reports that potential adopters are socially integrated with a large degree of opinion leadership in their social systems. Swinkels and Franzel (1997) categorized key characteristic perceptions of potential adopters of a technology into their feasibility, profitability, and acceptability. The profitability evaluates whether the benefits outweigh the costs and the feasibility entails the ease with which the farmer can manage various aspects of the technology such as planting, weeding and other activities.

The acceptability encompasses the number of advantages that outweigh the disadvantages. In addition to relative advantage of a technology, Rogers (1983), includes the extent to which the technology is perceived as difficult (degree of complexity). This refers to the experimentability of the technology given limited resources, and the degree to which the technology matches with existing needs, socio-cultural beliefs and previously introduced ideas (compatibility), as key factors that are evaluated by potential adopters.

CIMMYT (1993), stated that monitoring of technology acceptability with farmers may be conducted 2 years after the experimental trials, with 10-15 farmers. This monitoring process identifies problems associated with the technology and informs subsequent adoption decisions. A formal technology adoption survey may be conducted 2-4 years following technology release (CIMMYT, 1993).

2.4 Defining and Conceptualizing Gender

Maina et al. (2006) reported the definition of gender as the basis of controversy between different schools of thought. The sociological, particularly the feminist development perspective describes gender as the socially constructed attitudes, roles and activities that relate to being male or female in a society.

All societies create and define gender roles. They also reinforce behavior and actions that are deemed consistent with the definitions allocated to each gender. However, gender prescriptions are mainly learnt through the process of socialization and through the cultural milieu of the society concerned. The general approach in development strategy over the last 20 years has moved from women in development (WID) to gender and development (GAD). Thus, the focus has shifted from women in isolation to women in relation to men. Specifically, the gender approach considers the roles of men and women, how they differ, their interrelationships and the different impacts that policies and programs have on them. According to IFPRI (2005), GAD also does acknowledge the differential roles and potentials of both gender but also affirms the equal importance of these roles.

It has become increasingly clear that sustainable implementation of rural development projects is a function of socio-economic and gender context in which they operate. Gender analysis is important because productivity and efficiency are enhanced when interventions are targeted towards the actual users. However, hitherto the situation has been disappointing because there is a general failure to address women's real priorities, include input from women in the planning or design of new technology, provide women with a choice of alternatives and establish any viable communication networks at the local level to assess community level impact (IFPRI, 2005). Further, there is need to pay attention to inter-household dynamics because different household structures have different resources and face different incentives (FAO, 2004).

2.5 Concept of Household Headship

The term "household" has been perceived in diverse ways in scholarly literature on development. The household has been defined as an aggregate of persons, generally but not necessarily bound by ties of kinship, who live together under the same roof and eat together or share in common the household food. A household is composed of a head, relatives living with him/her, and other persons who share the community life for reasons of work or other consideration (Njuki, 2001). Additionally, inter-household dynamics focus on difference and similarities on how decisions are made and resources used across male and female headed households. Similarly, intra-household dynamics focus on how decisions are made and resources allocated within a male or female headed household (IFPRI, 2005).

Gladwin et al (2002) found that household headship cannot be defined simply either by who earns more, or who makes the decisions. One of these attempts is suggested by Mencher and Okongwu (1993) in which there are four aspects of household headship, namely, authority or power, decision making, economic power, and the right to children in case of divorce. She also suggested a distinction between "female-supported" households, which are defined only in terms of economic contribution, and "female-headed" households. Earning power certainly is an important factor in determining who is in charge, but from this it does not follow that earning more and being a head of the household are in fact the same thing.

According to Mudhara et al. (2006), two different types of female-headed households have been identified in existing literature. These are: the *de jure household*, where the female head belongs to one of these categories: single, widowed, divorced or separated; and, the *de facto household*, where the head is the wife of a male migrant. Of the two, the *de facto* headship is usually more temporary in nature since the husband will automatically assume the headship whenever he is around. Even while away, some vital decisions have to be referred to him for his final decision. A variant of the *de jure* type is the case where the widowed mother is living with her son and family. In such instances, the married son will often designate his mother as head of the household out of respect. This does not mean that she has major decision making power.

The number of female-headed households has become a common phenomenon in many countries in sub-Saharan Africa. In many parts of Kenya, female managed households with migrant husbands account for 47 percent on average (FAO, 2004). Female-headed households, whether *de facto* or *de jure,* are commonly characterized by smaller land holdings, smaller family sizes and fewer number of farming adults, and are relatively undercapitalized. With fewer resources, female-headed households are more likely to adopt technologies that require less of their limiting resources (Mudhara et al., 2006).

2.6 Participation in Project Activities

To begin with, participation has been defined as the process through which people are sensitized to make them more responsive to development programs and to encourage local initiatives and self-help (Misiko, 2001). In refocusing the research and development process, there has been a growing interest in the use of participatory approaches in natural resource management, agriculture and rural livelihoods sectors. These have included: participatory rural appraisals, farmer participatory research, participatory technology development, participatory action research, participatory learning and action, gender and stakeholder analysis, community-based natural resource management, and sustainable livelihoods approach (Gonsalves et al., 2005)

The underlying goal of participatory research is to seek wider and meaningful participation of user groups in the process of investigating and seeking improvements in local situations, needs and opportunities. Participatory approaches are envisioned to help agricultural research and development respond to problems, needs and opportunities identified by users. They also seek to identify and evaluate technology options that build on local knowledge and resources, ensure that technical innovations are appropriate for local socio-economic, cultural and political contexts, and promote wider sharing and use of agricultural innovations. In adoption studies, Farmer Participatory Research and Participatory Rural Appraisals are the most commonly used methodologies in dissemination of technologies to small scale farmers (Pound et al., 2003).

2.6.1 Farmer Participatory Research

Farmer participatory research is the practice of farmers and researchers working together to develop new agricultural technologies. The focus of farmer participatory research is the development of agricultural technology to increase food productivity. This focuses on the identification, development or adaptation, and use of technologies specifically tailored to meet the needs of small, resource-poor farmers. Participatory rural appraisal (PRA) is the main approach used to implement farmer participatory research (FPR). The various methods/approaches in participatory rural appraisals (PRA) are discussed as follows.

2.6.1.1 Participatory Rural Appraisals

Farmers and researchers work together in this approach on problem definition, design, management and implementation of trials, and evaluation by combining informal research by farmers with formal on-farm testing procedures, indigenous knowledge and science-based knowledge all mixed to meet farmers' needs. Ideally, a collaborative relationship means balanced participation in and control over the research process in order to achieve the objectives of both farmers and scientists (Rocheleau, 2003).

Various tools are used in participatory rural appraisal. A classification into visualized analysis, interviewing and sampling, and group and team dynamic methods has been suggested (Gonsalves et al., 2005). Examples include: *participatory mapping and modeling*; where people are asked for example to make maps or three dimensional representations of their wealth and social status. *Time lines, trend and change analysis*; that seek to describe changes in land uses, changes in cropping patterns, and chronologies of events relevant to local life. *Seasonal calendars* are also used to indicate seasonal variations in activities, labor, expenditure, debts, etc. *Wealth and well-being grouping and rankings* can be done to categorize households or individuals (Braun, 2000).

Other methods include: *Regular monitoring*, which is done to learn which technology options farmers prefer by talking to them about their experiences, using open-ended and probing questions. *Focus-group discussions* are organized and a summary of the main results (e.g., yield) and the experiences of all the farmers are presented during the discussions. *Formal evaluation* is usually done towards the end of the trial period (e.g., the cropping season) mainly with each farmer in the focus-group recording which technology options they prefer and why (Gonsalves et al., 2005).

Further, *Key informant interviews* are conducted when farmers in the focus-group have learned a lot about the technologies and have gained confidence on how to experiment with new technologies. *Farmers' groups* are formed to encourage focus-groups to grow into a broader 'interest group', with many more farmers, so that new farmers can learn from the more experienced farmers. Similarly, *Conducting field days, and village training workshops* can give many farmers in the village an opportunity to see the technology options and discuss the advantages and disadvantages of each. *Support expansion* is also done to support new farmers with the basic resources they need (e.g., with seed) to start their own production systems (Pound et al., 2003).

In addition, *the mother-baby approach* is one of the on-farm participatory mechanisms used to introduce and test a range of technology options suited to a heterogeneous community (Snapp, 2002). It involves three "levels" – mother trials, baby trials, and farmer experimentation. The mother trial is the one that scientists and farmers design on a demonstration plot while the baby trials are the ones that farmers try on their farms upon learning from the mother trials. The approach is used to help characterize farmers' risk management strategies, target technology to specific groups (e.g., women farmers), and to provide lessons on how to broaden adoption (Rusike et al., 2003).

However, despite the mentioned benefits of participation, In West Africa, Adesina and Baidu-Forson (1995) reported that the participation rate of women farmers in project activities was much lower compared to that of men. Time use data in Southern Africa suggests that women spend considerably less time than men in meetings, which limits their active participation in issues that affect their lives (Rusike et al., 2006). There is thus a need to investigate gender differences in participation in project activities.

2.7 Factors Influencing Adoption of Soil Fertility Replenishment Technologies

Factors influencing adoption of soil fertility enhancing technologies can be classified into demographic, farm, livestock, socio-economic and institutional factors (Chinangwa, 2006). This section also attempts to hypothesize how each of these factors influences adoption, by providing supporting literature.

2.7.1 Demographic Factors Influencing Adoption

Rogers (1983) observed that age had no definite direction on adoption whereas Lekasi et al. (2001) reported a positive relationship between age and potential adoption of soil fertility management innovations. Older farmers were said to use the technology due to their wealth and social status relative to their younger counterparts (Wekesa et al., 2003). Other studies reported that household size was one of the most important factors that determined adoption of soil fertility improvement technologies and that the larger the household size, the more likely the household was to adopt soil fertility improvement innovations (Snapp, 2002). It was also noted that family size was positively related to adoption and labor constraints often limited farmers' use of soil improvement innovations (Ovorak, 1996).

2.7.2 Farm Characteristics

The main farm characteristics that have been found to influence adoption include farm size, area under cash crops and food crops and livestock ownership. To begin with, farm size has been found to be positively associated with technology use (CIMMYT, 1993; Rogers, 1983). Small farms have been said to have a greater likelihood of adopting improved varieties as they are more intensively managed. The adoption of reduced tillage in Nigeria was found to be positively related to farm size. In West Africa, however, farm size was not found to be a significant factor influencing adoption of soil fertility improvement technologies (Adesina and Baidu-Forson, 1995).

Similarly, the area of land under food and cash crops in hectares has been found to positively influence adoption decisions as cash crops and food crops can be sold to generate income that may be used to hire labor or purchase fertilizers (Adiel, 2004). The larger the area of land under food crops, the higher the likelihood that a farmer would adopt soil fertility improvement technologies, with the expectation that he would increase his food stocks and probably generate income from the sale of surplus produce (Adesina and Chianu, 2002).

2.7.3 Livestock Ownership

Further, livestock ownership has been found to increase the probability of adoption. Neupane et al. (2002) indicated that livestock ownership positively influenced adoption decisions. Fodder tree technologies were more likely to be adopted by households with cattle, goats and sheep. Mwangi et al. (1996) in a study conducted in Tanzania found that the number of cattle owned had a positive influence on adoption of soil improvement technologies. Tiruneh et al. (2001) in Ethiopia; reported that the number of livestock had a positive and significant impact on the gross value of output for both households. However, in all cases, female-headed households owned fewer livestock compared to male-headed households.

2.7.4 Socio-economic Factors Influencing Adoption

Thangata and Alavalapati (2003) in a study conduted in Malawi identifies socio-economic factors influencing adoption of soil fertility improvement technologies as farmers' perception of soil fertility as a problem, off-farm income, level of education, ability to hire labor, security of tenure and participation in agricultural training activities.

Franzel et al. (2003) found that perception of soil fertility as a problem was a key determinant of the acceptance of improved fallows in Western Kenya. If farmers' perceptions were that soil fertility was not a problem, labor and capital resources would not be channeled towards this cause. Rusike et al. (2003) confirmed this in early-stage-analysis of adoption of potential soil fertility innovations like hedgerow intercropping. They reported that limitations to adoption potential included inappropriate targeting, where the farmers' priority problem was not low soil fertility.

Further, in Southern Africa, Mapiye et al. (2006) found that availability of off-farm employment decreased adoption potential. As off-farm income increased, the probability of adoption decreased by 26%. This may have been because as farmers became more engaged in off-farm activities, their reliance on the farm was likely to reduce thus limiting adoption of soil improvement technologies. With regard to the level of education, the ability to understand a technology was found to be highly dependent on education levels and therefore, early adopters according to Rogers (1983) had a favorable attitude towards education. Most technologies were noted as requiring an education component in their understanding (Franzel, 1999).

Moreover, availability of labor was cited as a major limiting factor to adoption of soil fertility enhancing technologies. In West Africa, it was reported that most of the labor in farms was provided by family members and the exodus of the youth from rural to urban areas was noted as affecting the extent to which these adoption occurred. Farmers indicated that they had to reduce the number or size of their fields in order to adjust to the labor constraint. Others said that due to labor shortage, they had not been able to adopt technologies that required extensive labor investments (Ayuk, 1997). However, use of hired labor was said to increase opportunities to undertake other farm activities.

Place and Adholla (1998) indicated that security of tenure influenced adoption positively in studies done in Western and Central Kenya. Since soil conservation measures for improving soil fertility require long-term commitments and investments, women are at distinctly disadvantageous position in improving productivity of their land due to their lack of access and the absence of land tenure security (FAO, 2005). More over, it was also found that farmers who participated in farmer training courses and listened regularly to agricultural programs on the radio were more likely to adopt. Further, Adesina, (1996) established that limited participation in technology development resulted in poor adoption of sorghum varieties.

2.7.5 Institutional Factors Influencing Adoption

Ouma et al. (2002) in a study undertaken in Central Kenya noted institutional factors influencing adoption as contact with extension agents, access to credit and membership in a farmer's group. To begin with, extension services are a major source of technical information for farmers. Enyong, (1999) reported that contact with extension agents was one of the most important factors that determined adoption. This was because farmers' contact with extension agents allowed them greater access to information on the technology, through greater opportunities to participate in demonstration tests (Obonyo, 2000).

Further, farmers who had access to credit were said to have more options to acquire costly new technologies such as improved seeds or fertilizer (Ouma et al., 2002). The lack of cash and access to credit was important in farmer's decision making at household level and central to a farmer's use of a technology. In Africa, rural women had less access to credit than men, which limited their ability to purchase inputs and adopt soil fertility replenishing technologies that required hired labor (Mapiye et al., 2006).

Furthermore, Tenge et al. (2004) reported that membership in farmer groups was found to be positively influencing the adoption of soil fertility enhancing technologies. In West Africa, it was noted that soil fertility improvement innovations had higher success rates in adoption when soil fertility management projects worked through farmers' groups (Adesina and Chianu, 2002).

2.7.6 Use of Logistic Regression Analysis in Adoption Studies

The logistic regression model is a very useful tool especially in situations in which one wants to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. This is because the model accounts for both categorical and dichotomous dependent variables within a study (Agresti, 1996).

According to Borooah (2002), logistic regression is similar to linear regression but is suited to situations in which the dependent variable is dichotomous. Logistic regression coefficients can be used to estimate odds ratios for each of the independent variables in the model. As such, logistic regression was most appropriate for this study due to its unique ability to account for both categorical and dichotomous dependent variables.

The logistic regression model has been applied in various adoption studies in Africa to predict adoption patterns by analysis of various variables posited to influence adoption positively or negatively. The wide usage of this model in agricultural research and analysis indicates its reliability and applicability. In Southern Africa, the model has been extensively applied in studies concerned with adoption of fertilizers and manure, the findings of which have been used to recommend integrated soil fertility management as the best strategy to replenish soils in Southern Africa (Chinangwa, 2006 and Mudhara et al., 2003).

Similarly, the logistic regression model has been applied in Ethiopia and Tanzania to evaluate and predict adoption of farm management practices by male and female headed households (Tiruneh, 2001 and Mwangi et al., 1996). In Kenya, logistic regression analysis has been done to predict adoption of organic and inorganic fertilizers in the Rift valley region, and in adoption of organic and mineral soil fertility improving technologies in Central and Western Kenya (Wekesa, 2003 and Obonyo, 2000. The findings of these studies have largely influenced decision making among research institutions on design and dissemination of soil fertility enhancing innovations. Based on these examples and many others across Africa, it is apparent that the Logistic regression model is a dependable tool in analysis of variables influencing adoption. For this study, the model analyzed gender differentials in adoption of soil fertility improving technologies with a view to providing predictability of adoption patterns by male and female headed households in Central Kenya.

2.8 Identifying and Closing Gaps in Knowledge

Based on the evidence presented in this literature review on the soil fertility problem in Africa, and in particular in the Central highlands of Kenya, it is apparent that concerted efforts are required to reverse this situation. A lot of work has been done in Central Kenya with a view to introducing and educating farmers on soil fertility replenishment technologies such as biomass transfer using *Tithonia diversifolia*, *Leucaena trichandra*, and *Calliandra calothyrsus* coupled with proper management and application of manure and inorganic fertilizers (Mucheru et al., 2002, Mugendi et al., 1999). The introduction of these technologies was done to improve soil fertility with the ultimate goal of enhancing food security among farming communities in the area.

However, socio-economic studies conducted to evaluate adoption of these technologies have showed low adoption rates (Adiel, 2004, Muriu, 2005). The reasons given for this trend have been varied but have mainly revolved around socio economic factors such as gender, benefits of a technology, farmers' resource endowments and biophysical aspects of farming such as slope of land and farm/plot size. There have been studies that have tried to link gender to adoption, albeit by way of mention. Studies conducted in Ethiopia, Tanzania and Zimbabwe (Chinangwa, 2006 and Tiruneh et al., 2001) revealed that gender plays a critical role in adoption of soil fertility replenishment technologies and as such cannot be ignored. The importance of equal participation of both men and women in soil fertility related projects has also been emphasized though regrettably, women have been found to participate in lesser numbers than men, a factor that has greatly contributed to the unsuccessful implementation of projects.

It was against this background that this study was undertaken to investigate how the frequency of participation differed among male and female headed households, to determine whether male and female headed households differed in their choices of technologies for adoption, and finally to examine and analyze factors, be they socio-economic, institutional, farm characteristics and demographic factors that influenced adoption decisions. As such, the findings of this study are intended to fill in gaps in the body of knowledge and provide useful recommendations to future researchers, policy makers, extension agents and project implementers that could inform future actions geared towards increasing adoption of soil nutrient replenishment technologies.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Chapter Introduction

This chapter provides a description of the study area, the research design that the study employed, a map of the study area, sampling procedure and sample selection, and strategies used for data collection and analysis.

3.2 Study Area

The study was carried out between November 2006 and April 2007, in fourteen villages in Mukuuni location, Chuka division, Meru South District of Kenya. The area is located in upper midland 2 and 3 (UM2 and UM 3), a predominantly maize growing area, which is also referred to as a coffee agro-ecological zone. The altitude is 1200-1600m above sea level with an annual mean temperature of 20^0 C. Annual rainfall varies between 1200 and 1400mm. The rainfall pattern is bimodal, falling in two seasons, with the long rains between March and June and short rains between October and December (Mucheru et al., 2002).

The soils are Humic Nitisols, according to FAO-UNESCO classification of 1974, described as deep, well weathered with moderate inherent fertility (Jaetzold and Schmidt, 1983). The average land size is 3 acres per household. The farming system in the area is characterized by integration of both crops and animals. A wide variety of species and breeds of livestock, which include cattle, goats, sheep and poultry are found in the area.

Maize is the main staple food, which is cultivated form season to season (Muriu, 2005). The major cash crops grown in the area are coffee (*coffee arabica*) and tea (*Camelia sinensis*) and food crops like maize (*Zea mays*) and beans (*Phaseolus vulgaris*), potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomea batatas*), cassava (*Manihot esculanta*), bananas (*Musa spp.*), various fruits and vegetables (Muriu, 2005). All land is demarcated and owned individually under the freehold system of land tenure. The area is densely populated with a population of about 700 persons per km^2 (Republic of Kenya, 2001).

3.2.1 Study Design

As a result of soil fertility decline leading to low yields and food insecurity, a project under the auspices of VLIR (Flemish government) was initiated in Meru South District in the Central Kenya highlands in 2002. The main objective of this project was to promote the wide scale adoption of newly introduced soil fertility improvement technologies by farmers. This was to be done through participatory approaches with the intention to reduce the soil infertility problem in the area and enhance food security in small-holder farmer households.

The Farmer Participatory Research (FPR) methodology was adopted. The main features of FPR include problem diagnosis and participatory rural appraisals aimed at increasing the efficiency of the technologies and engaging farmers in dialogue about options (Rusike et al., 2006). During the participatory diagnostic stage of the project, leguminous shrubs (*Calliandra calothyrsus, Leucaena trichandra*) and biomass transfer species (*Tithonia diversifolia*) were identified as potential soil fertility improvement technologies. This was due to their cost effectiveness, appropriateness, simplicity and multi-purpose nature in meeting the needs of resource poor farmers (Nyende and Delve, 2004).

Three sites; Mukuuni location, Murugi location and Kirege location in Chuka division in the district were selected. The Mother-Baby approach was used to set up demonstration trials in farmer-selected farms. Mother trials are randomized complete block design with factorial levels determined based on where responses are expected and with two to four replications per site in order to give statistically valid results in farmers' fields (Snapp, 2002). They are researcher-designed and managed trials. Baby trials are located around mother trials, and consist of a few treatments chosen from the mother trial by the farmers. They are unreplicated, and may be managed by researchers or farmers. Baby trials allow farmers to see for themselves the performance of treatments at different trial sites, and allow for faster, larger-scale testing at different locations under different management conditions. Informal trials are designed and managed by farmers using their choice of technologies and experimental methods (Rusike et al., 2006).

The 'best bet' technologies were tested on maize and comprised biomass transfer using *Tithonia diversifolia* and leguminous shrubs such as *Leucaena trichandra* and *Calliandra calothyrsus*. New innovations such as appropriate application of mineral fertilizers and cattle manure management were also taught. During field days, village training workshops and farmer nursery groups, farmers were taught how to plant, tender, use and manage the technologies in their farms by project scientists and extension agents. Interactive exchange of knowledge and ideas between farmers, extension agents and researchers was encouraged. They were also encouraged to visit the demonstration trials to learn more about the technologies. The farmers also exchanged information and technologies among themselves and were able to make choices on which technologies to adopt, or adapt, given their different household composition and resource allocations.

By the time the study was conducted in one of the study sites, Mukuuni Location, during the 2006/2007 seasons, the farmers had visited the demonstration plots eight times during the short and long rains seasons of 2002/2003, 2003/2004, 2004/2005, 2005/2006. This survey was conducted to evaluate the differential adoption of these 'best bet' technologies with gender as the primary concern. The Figure 3.1 shows the location of Meru South District in Kenya.

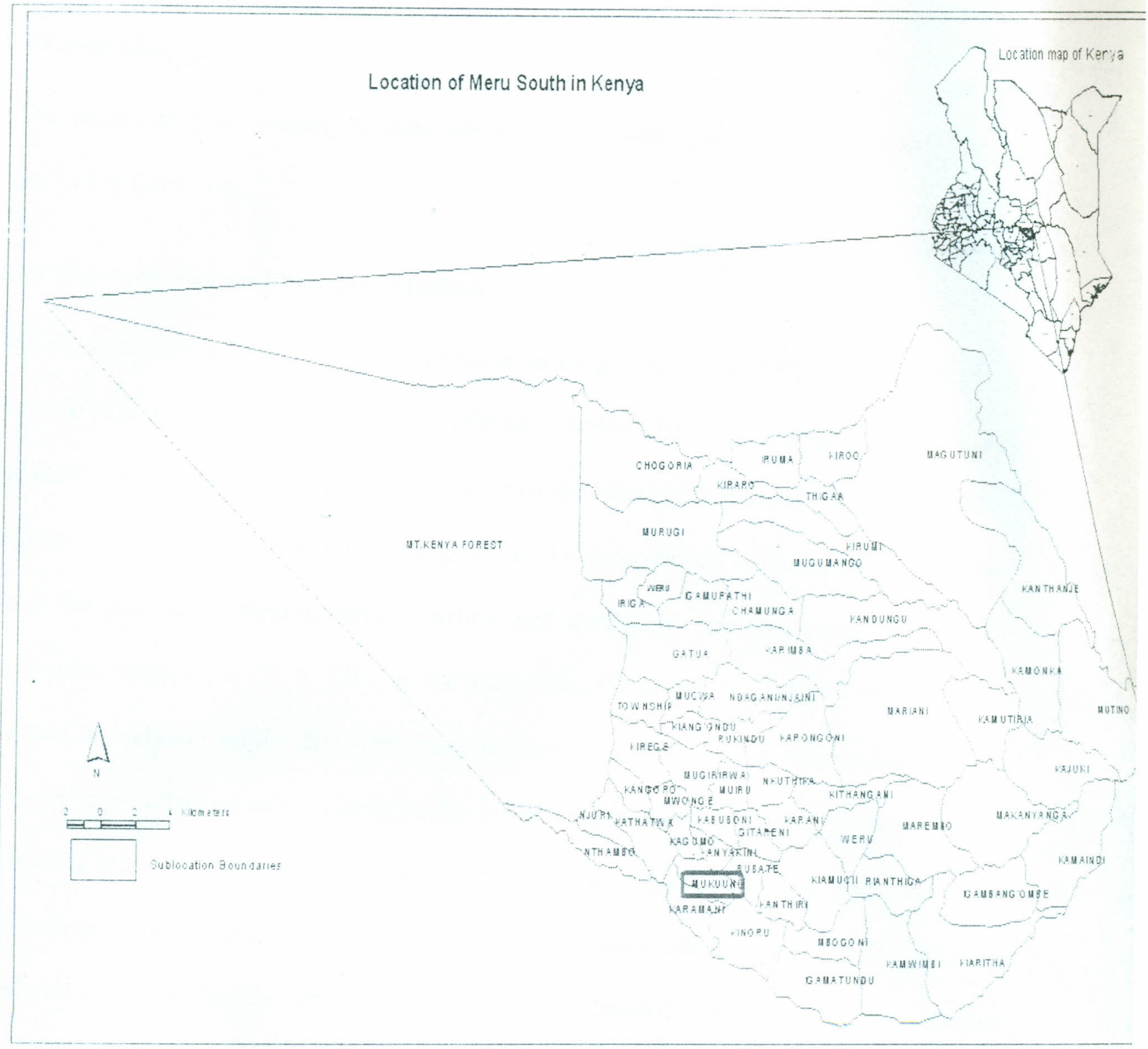

Figure 3.1: Map of Kenya showing the location of Meru South District. Area circled in red indicates the study site (Mukuuni Location). Source: ICRAF GIS laboratory.

3.3 Sampling

The main sampling strategies used for this study were simple random sampling and purposive sampling.

3.3.1 Sample Size and Sample Selection

All the households in the study area practice farming as the major economic activity. The sample size used for this study was 140 households (70 male headed and 70 female headed). This sample size was representative of the total population of 350 households by a proportion of 40%. A sampling frame of all 350 households in the area was obtained from the provincial administration's office, and availed by the area chief. Of the total household population (N = 350) in the study site, 90 of the households were female-headed households while 260 were male-headed households. A sampling frame of the adopter population already existed in the VLIR (Flemish Government) project records. From the study's household population, 160 households had adopted at least one of the technologies by the time the study was conducted. Of these adopter households, 108 were male-headed households while 52 were female headed. Of the 190 non-adopter households, 142 were male headed while 38 were female headed.

Male-headed households were sampled by use of simple random sampling while female-headed households were purposively sampled because they were fewer in number. Of the 70-adopter households selected, 35 were male-headed while another 35 were female-headed households. The same sampling procedure was applied to select non-adopter households.

3.4 Data Collection

This study was a survey that relied on both primary and secondary sources of data. Primary sources of data were obtained by the use of semi-structured interview schedules, key informant interviews and focus group discussions. To begin with, appendix 1 was first pre-tested on a sample of 10 farmers from a site different from the study site (i.e. Murugi Location of Chuka district in Meru South), and necessary changes to the research instruments were made, after which they were administered to the study site's sample. Key informant interviews, and focus group discussions were also conducted to augment information generated through semi structured interview schedules.

Secondary data was synthesized from books, periodicals, journals, newsletters, electronic media (internet) and reports from the Ministry of Agriculture. District Development Plans and soil fertility management related articles were also reviewed with a view to gathering information on gender differentials in the adoption of soil nutrient replenishment technologies.

3.4.1 Primary Data Sources

Primary data sources used were semi structured interview schedules, key informant interviews and focus group discussions.

3.4.1.1 Semi-Structured Interview Schedules

Semi-structured interview schedules were administered to 140 respondents. Seventy were designed for adopters and another 70 for non-adopters. The semi-structured interview schedules generated both qualitative and quantitative data that was collected through self-administration between November 2006 and April 2007 by the researcher.

3.4.1.2 Key Informant Interviews

The key informants interviewed were 14. This sample formed 10% of the study's sample size (N=140). The key informants were purposively selected with an intention to elicit an incisive and enlightening opinion of gender issues in adoption of soil nutrient replenishment technologies. They included; project nursery group leaders (1 male, 1 female), the area extension officer, 4 non-adopter households (two male household heads and two female household heads), 4 adopter households . (two male households heads and another two female household heads), the chairman of the area farmers' cooperative society, one local administration official and a ministry of agriculture official. The key informants were engaged in personal interviews using an open-ended interview guide to obtain information on gender differentials in adoption of soil nutrient replenishment technologies. This was done in April 2007.

3.4.1.3 Focus Group Discussions

Three focus group discussions were organized, one comprising of men only, another women from female-headed households, and a third women from male-headed households. For proper facilitation of the discourse, each focus group comprised 10 members. Gender analysis tools such as the gender access to and control of resources profile were applied. An open-ended question guide was also used to generate information within the groups. This was done in April 2007.

3.5 Data Analysis

Data analysis began by ensuring that the interview schedules were correctly filled in and a coding sheet was developed by use of a software named the statistical package for social scientists to ease entry and coding of the interview schedules. Summary tables were then prepared on all the responses. The second stage of the analysis involved descriptive analysis, where cross tabulation, means, percentages, range, and standard deviation were generated. The third phase of analysis was statistical analysis. Independent sample t-tests at $p<0.05$ were done to test for the equality of means. The first objective was analyzed by use of t-test in order to examine how the frequency of participation in soil related project activities differed between male and female-headed households.

Chi-square tests at ($p<0.05$) were run to determine significant relationships between categorical variables. They were run to analyze the second objective so as to investigate how the choices of soil fertility replenishment technologies (tithonia, leguminous shrubs such as calliandra and leucaena; cattle manure and inorganic fertilizers) differed between male and female-headed households. The binary logistic regression model was run to predict socio-economic, farm characteristics, demographic and institutional factors that significantly influenced adoption by male and female-headed households. Qualitative data obtained through open ended questions in interview schedules, focus group discussions and key informant interviews were analyzed using the non-numerical, unstructured, data indexing and theorizing (NUD*IST 5) software program in order to generate written scripts and thematic groupings of the data collected and also to support the study's statistical findings.

3.5.1 Logistic Regression Model Specification

In this study, the logistic regression model was used to analyze gender differences in adoption of soil nutrient replenishment technologies at household level. The logistic regression model is a non-linear regression model that has a binary response variable and thus has a binomial distribution with parameters (probability of success). According to Pampel (2000), the model equation is as follows:

$$\text{Logit}(E[Y]) = \text{Logit}(P) = X^T \beta$$

The Logit (E [Y]) is the binary response variable. It represents the probability of the number of events being successful. It is an index reflecting the combined effects factors that predict adoption. The Logit (P) is the natural log of the odds of success. It is defined in the open unit interval (0, 1). $X^T \beta$ is the product of the transpose of the column matrix X of explanatory variables and the unknown column matrix β of regression co-efficients.

The dependent variable was a dichotomous variable depicting adoption of a technology and took the value of 1 if the farmer had adopted at least one technology and 0 if none. The independent variables included demographic, socio-economic, farm characteristics and institutional factors. The hypothesized effects were based on available literature and the researcher's considerations.

3.5.1.1 Demographic Factors

HHSIZE was a continuous variable that depicted the number of members in a household. Labor constraints are said to often limit farmers' use of soil improvement innovations, for instance due to the high labor demands of biomass transfer technologies such as *Tithonia diversifolia* (Gladwin et al., 2002). It was anticipated that the larger the family size, the bigger the pool of labor available. The variable was therefore expected to increase the probability of adopting the technology, especially the labor intensive components. AGE was a continuous variable that indexed the age of the household head. Age has been noted to influence adoption positively or negatively (Rogers, 1983). Age was a proxy for experience in farming. This way, it influenced adoption of technologies positively. Conversely, age could be a proxy to readiness to change. Most elderly people resisted change, as they were conservative. In this case, age could negatively influence adoption (Mose et al., 2000). Consequently, the net effect on age could not be determined a priori.

3.5.1.2 Farm Characteristics

FARMSIZE was a continuous variable referring to the variable farm size in hectares. Farm size has been found to influence adoption decisions positively (Sullivan, 2000). The size of the farm is a proxy for wealth. It was thus predicted that it could influence adoption positively. However, in some cases, the bigger the farm sizes, the higher the flexibility for crop rotations. In such cases, this variable was expected to negatively influence the adoption (Lapar and Ehui, 2003).

FOODCROP indexed the area of land under food crops in hectares. Wekesa et al. (2003) reported that a larger area under food was considered to increase a farmer's interest in new technologies and therefore area under food crops was posited to influence adoption positively. CASHCROP was a continuous variable that indexed the area of land under cash crops in hectares. Cash crops provide income to farmers. As a result, it was predicted that the area of land under cash crops would have a positive influence on adoption. CATTLE indexed the continuous variable on cattle ownership while GOATS was a continuous variable that depicted the variable on ownership of goats. SHEEP referred to the continuous variable on the number of sheep owned. Fodder tree technologies were more likely to be adopted by households with cattle, goats and sheep (Neupane et al., 2002). It was thus postulated that ownership of cattle, goats and sheep was likely to influence adoption positively.

3.5.1.3 Socio-economic Factors

EDUCATION was a dichotomous variable that measured the farmer's access to formal education. The variable took the value of 1 if the farmer had education (primary to university education), 0 if the farmer had no education. Education was considered a proxy for ease of understanding new skills and access to information. It was therefore expected to influence adoption of the technology positively (Adesina and Chianu, 2002).

PARTICIPATION was a dichotomous variable that indexed the variable on participation in soil related project activities. The variable took on a value of 1 if the farmer participated and 0 if otherwise. It was hypothesized that participation would be positively related to adoption as it exposed farmers to information about the soil fertility improvement technologies (Kariuki and Place, 2005). TENURE was a dichotomous variable that indexed whether the farmer had security of tenure. Security of tenure took a value of 1 if the farmer purchased or inherited land and 0 if the land was leased/borrowed/rented. It was expected that borrowed, rented/leased would be negatively related to adoption, as renting or leasing land was a sign of land scarcity (Diane and Zeller, 2007).

HIRELABOR indexed the ability of the household to hire labor. The dichotomous variable took on the value of 1 if labor was hired and 0 if otherwise. Studies conducted in West Africa cited labor availability as a major limiting factor to adoption of soil fertility replenishment technologies (Enyong, 1999). Consequently, availability of labor was expected to have a positive influence on adoption. PERCEPTION indexed whether farmers perceived a soil fertility problem in their farms. It took the value of 1 if yes, and 0 if otherwise. If farmers' perceptions were that soil fertility was not a problem, labor and capital resources would not be channeled towards soil fertility replenishment (Nabifo, 2003). As a result, farmers' perception of soil fertility as a problem was hypothesized to have a positive relationship with adoption.

OFFARM EMPLOYMENT was a dichotomous variable that indexed the variable on the household's access to off farm employment. It took the value of 1 if yes, and 0 if otherwise. Employment provided income to the household that could be used to purchase inorganic fertilizers and therefore led to the low usage of labor intensive soil fertility replenishment technologies. As such it was posited to influence adoption negatively.

3.5.1.4 Institutional factors

CREDIT depicted access to credit. The dichotomous variable took the value of 1 if there was access and 0 if otherwise. The statistically significant positive coefficient for access to credit was established in West Africa in a study identifying credit as a major constraint to adoption of planted forages (Elbasha et al., 1999). Access to credit was thus postulated to affect adoption positively. EXTENSION was a dichotomous variable that measured if the farmer had contact with extension agents, taking on the value of 1 if there was such contact and 0 if none. Extension was noted as a proxy to access to the technology (new skills) and was expected to increase the farmer's probability of adopting the technology (Pound et al., 2003).

GROUP was a dichotomous variable that indexed whether the farmer was a member of any farmers' group, taking on the value of 1 if the farmer belonged to a farmer's group and 0 if he did not belong to any group. Membership to an organization was assumed to increase farmers' access to information on technologies and markets through interactions with other farmers within the community and in some cases, with the outside world, and therefore increased farmers' adoption potential (Salasya et al., 1998).

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Chapter Introduction

In view of the global paradigm shift in agricultural research, there are calls towards research into factors influencing adoption of soil fertility enhancing technologies with special focus on gender aspects of adoption. The results presented in this chapter relay information on gender differentiated choices of technologies for adoption, gender differentials in the frequency of participation in soil fertility related project activities and factors influencing adoption.

The analysis presented in this chapter followed three stages, namely: descriptive, bi-variate and multi-variate analysis. Descriptive analysis of sample characteristics was done in section 4.2. In sections 4.3 (objective 1), 4.4 (objective 2) and 4.5 (objective 3), bi-variate analysis was conducted to determine the existence or lack of relationships between variables under study with adoption. This was achieved by use of t-tests and chi-square tests. Gender differentials in participation in project activities, gender differentials in choice of technologies adopted and the initial analysis of factors influencing adoption were all analyzed at bi-variate stage. Finally, factors that were significant in section 4.5 were later subjected to multi-variate analysis in section 4.6 by use of binary logistic regression.

4.2 Sample Characteristics

4.2.1 Households types and headship

For purposes of this study, male-headed households were those in which the husband was present and was the final decision-maker on important issues pertaining to the household while female-headed households were either *de jure or de facto* in nature. *De jure* female headed households were those that were run and represented by a widow, divorced or single woman, while *de facto* female headed households were those whose head was the wife of a male migrant. However, for this study, *de facto* female-headed households were not considered due to the temporary nature of household headship, as the husband automatically assumed headship whenever he was around. The majority of households in the area were male-headed (75%), while female-headed households comprised 25% of the population of households. *De jure* female-headed households formed 22.2% of the household population while 2.8% female-headed households were *de facto* in nature (Figure 4.1).

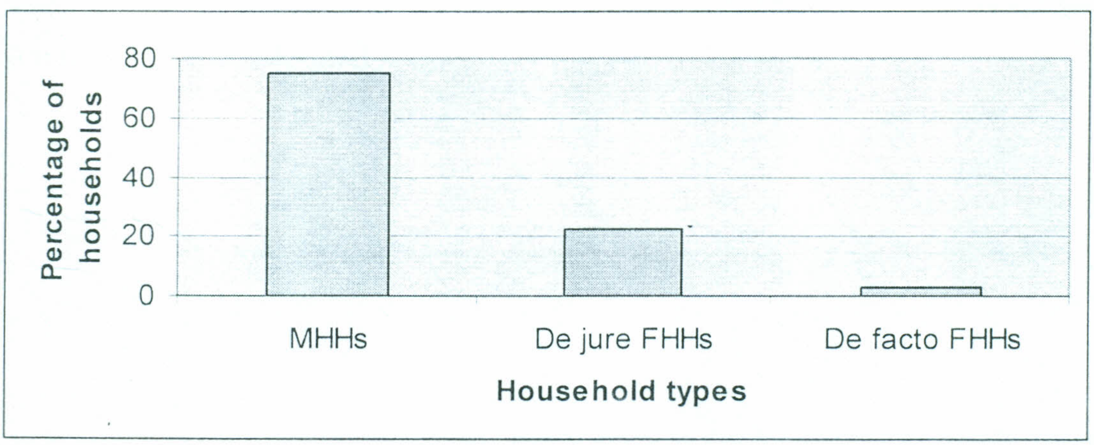

Figure 4.1: Household types in Meru South district as of April 2007
(Key: MHHs: male headed households: FHHs: female headed households)
Source: field data results

These findings underscore the fact that when households headed by women are taken into account, total female participation in agriculture is fully integrated into the research arena unlike when only male headed households are considered. It is important to consider the role of household headship because available data shows that female headship is relatively high and increasing in many places (Gladwin et al., 2002). In sub-Saharan Africa, for example, it is estimated that women head one-fourth of rural households. In some areas, they head almost half of households (Gladwin et al., 1997). Studies in Central America reveal that nearly 20% of rural households are headed by women, and in Bangladesh, the proportion of female headed households has risen from 5% to 16% over 20 years (Saito and Spurling, 1994).

4.2.2 Demographic Characteristics

The mean age of the household head for the sample was 47 years. Female household heads were found to be slightly older than male household heads for both adopters and non-adopters. There were marked differences in mean household sizes among adopter male and female-headed households, where male-headed household sizes were larger compared to female-headed households (Table 4.1).

Table 4.1: Gender Disaggregated Demographic Characteristics of Farmers in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Demographic variables	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age of household head	45.2	9.9	47.5	9.5	46.9	11.5	47.1	11.3
Household size	3.5	1.2	3.2	1.0	4.0	1.6	3.5	1.3
Number of adults	1.9	0.6	1.2	0.4	2.7	0.8	1.7	0.6

Key: MHHs: male headed households: FHHs: female headed households. Source: field data results

According to Mwangi et al. (1996), the youth are increasingly abandoning farming and leaving for 'greener pastures' in the cities, where they are employed in white or blue collar jobs. This study indicates the urgent need to sensitize and financially empower the youth to take up farming as an occupation, as this would contribute significantly to the country's food security.

Further, in studies conducted in Ethiopia, Tiruneh et al. (2001) found that household size and the number of adults working on farm were larger for male headed households in comparison to female headed households. This implies that at any given point, on average, a male headed household is likely to have more disposable labor than a female headed household. These findings reveal the serious need to increase access to labor by female headed households.

4.2.3 Farm Characteristics

The average farm size in the study area was 1 hectare. Male-headed households were found to have larger farm sizes than female-headed households among both adopters and non-adopters. Among adopters and non-adopters, male-headed households were found to have larger areas of land under food crops in comparison with female headed households. Further, adopter and non- adopter male-headed households had larger areas of land under cash crops in comparison to adopter *de jure* female-headed households (Table 4.2).

Table 4.2: Farm characteristics of farmers in Meru South District disaggregated by gender as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Farm characteristics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Farm size (hectares)	1.1	0.8	0.8	1.2	1.3	1.1	0.8	1.0
Land under food crops	0.5	0.5	0.4	0.7	0.6	0.7	0.5	0.9
Land under cash crops	0.2	0.4	0.2	0.2	0.3	0.5	0.3	0.3

Key: MHHs: male headed households: FHHs: female headed households. Source: field data results

Takane (2007) in a study carried out in Malawi corroborates these results. He found that on average, male headed households possessed larger portions of land than female headed households and also had larger areas of land under cash and food crops in comparison to their female counterparts. This may be due to the fact that male headed households are better endowed in land and labor. As such, the results suggest that women produce less and earn less from their farms, which could lead to adoption of fewer soil fertility enhancing technologies.

4.2.4 Livestock Ownership

In terms of ownership of livestock, male headed households on average owned more livestock than female-headed households. Additionally, adopters owned more livestock in comparison to non-adopters (Table 4.3).

Table 4.3: Gender disaggregated data on livestock ownership in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Livestock ownership	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Cattle	2.8	1.1	1.9	0.9	4.1	1.3	2.2	0.9
Goats	9.3	5.3	4.1	2.8	10.9	4.5	5.9	2.9
Poultry	9.2	4.7	5.4	4.0	10.9	7.0	6.9	4.1
Sheep	1.6	1.4	1.1	1.1	1.7	1.4	1.4	1.4
Others	4.6	1.8	2.8	1.9	5.3	2.3	3.5	2.6

Key: MHHs: Male headed households: FHHs: Female headed households. Source: field data results

These results are corroborated by a study conducted in the East African Highlands, which found that male headed households owned more livestock than female headed households. Large animals like cattle were owned and managed by male household heads while small animals like poultry and goats were largely managed by women though ownership still reverted to men. However, in female headed households, the female household heads owned livestock, which in most cases were few in number (Lekasi et al., 2001). These results could signify that female headed households adopted fewer technologies and got less income from their livestock, which may have had an impact on their level of agricultural productivity.

4.2.5 Socio-economic Characteristics

In this section, socio-economic factors that had been hypothesized to influence adoption either positively or negatively were subjected to descriptive analysis to observe initial trends and differences by gender of household head.

4.2.5.1 Marital Status

For both the adopter and non-adopter male-headed households, over 90% were married, while for female headed households, over 80% were widows. The rest were separated/divorced, single or widowers (Table 4.4).

Table 4.4: Marital status of farmers in Meru South District disaggregated by gender as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Marital status	No.	%	No.	%	No.	%	No.	%
Married	32	91.4	0	0	33	94.3	0	0
Single	1	2.9	4	11.4	2	5.7	6	17.1
Divorced/separated	0	0	1	2.9	0	0	1	2.9
Widow	0	0	30	85.7	0	0	28	80
Widower	2	5.7	0	0	0	0	0	0
Total	35	100	35	100	35	100	35	100

Key: MHHs: Male headed households: FHHs: Female headed households. Source: field data results

Gladwin et al. (2002) and Fort (2007) reveal that male headed households in most cases are better endowed with regard to land, livestock, labor and financial resources compared to female headed households. As such, they are better able to invest their resources and time in optimal agricultural productivity. Female headed households on the other hand, due to resource constraints are limited in their ability to farm optimally (Mwangi et al., 1996 and Tiruneh et al., 2001). Based on these findings, it is probable that female headed households invest less in agriculture due to lack of resources and this may have an impact on adoption of soil fertility enhancing technologies.

4.2.5.2 Access to Formal Education

Formal education was considered as primary to tertiary level education. The results indicated that female household heads were generally less educated in comparison to male household heads. Also, adopter households were slightly more educated than non-adopter households as shown in Table 4.5.

Table 4.5: Gender Disaggregated Access to Formal Education among Male and Female Headed Households in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Formal education	No.	%	No.	%	No.	%	No.	%
Has formal education	28	80	24	68.6	30	85.7	26	74.3
Has no formal education	7	20	11	31.4	5	14.3	9	25.7
Total	35	100	35	100	35	100	35	100

Key: MHHs: male headed households; FHHs: female headed households. Source: field data results

Previous studies have indicated that education enhances capacity for creativity and innovation, by broadening horizons beyond habits and traditions of individuals. As a result, through education, an individual becomes more critically aware of the need for social change. Farmers who are educated are more likely to adopt soil fertility enhancing technologies than those who are not (Adesina and Chianu, 2002). Since female household heads in Africa are generally less educated in comparison to male household heads (Chinangwa, 2006), it follows then that they are likely to adopt soil fertility improving technologies in lesser numbers than male headed households.

4.2.5.3 Gender Division of Labor

Clearly, women bore the brunt of domestic labor in both male and female-headed households. On average, adult females spent a total of 13.5 hours per day on domestic, farm and community activities while adult males spent a paltry 5.5 hours per day on the same activities. Women worked longer (6 hours per day) on farm than men (3 hours per day), while women in female headed households worked for more hours than those in male headed households (Table 4.6).

Table 4.6: Gender Disaggregated Division of Labor among Male and Female Headed Households in Meru South District as of April 2007

	Non-adopters (N=70)				Adopters (N=70)			
	Number of hours household members spend daily on household activities							
Household activities	**MHHs (N=35)**		**FHHs (N=35)**		**MHHs (N=35)**		**FHHs (N=35)**	
Farm activities	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male adult	4.5	1.9	0.9	1.9	5.4	1.7	2.3	2.9
Female adult	4.9	1.9	5.3	0.9	6.5	1.0	7.1	1.1
Male child	0.5	1.1	0.6	1.2	2.1	1.7	2.4	2.3
Female child	0.2	0.8	1.4	1.7	2.3	2.4	2.3	2.7
Domestic activities								
Male adult	2.2	1.6	0.9	1.5	2.4	1.1	1.3	2.3
Female adult	6.5	2.3	6.9	1.1	7.2	2.4	6.9	2.0
Male child	1.4	1.7	2.4	1.6	2.1	2.0	2.1	2.4
Female child	1.8	2.1	3.5	2.4	3.4	3.5	3.0	3.6
Community activities								
Male adult	0.1	0.3	0.1	0.5	1.4	1.5	0.8	0.9
Female adult	0.1	0.7	0.7	0.7	1.6	0.7	1.7	0.6

Key: MHHs: male headed households: FHHs: female headed households. Source: field data results

Saito and Spurling (1994) show that in Africa women now constitute the majority of smallholder farmers, provide most of the labor and manage farms on a daily basis. Similarly, in Malawi, it was found that female-headed households on average had fewer economically active household members and were in a disadvantageous position relative to their male counterparts in deploying family labor for own-farm production (Takane, 2007). These results support the earlier proposition that women provide most of the labor required for agricultural production in rural areas. This can hinder their active participation in agricultural development related initiatives and may affect their ability to adopt soil fertility improving technologies.

4.2.5.4 Use of Hired Labor

The results indicate that more male-headed households than female-headed households hired labor (Table 4.7). Majority of farmers reported that they hired labor very rarely and only when it was extremely necessary. Hired labor was limited to peak periods of the year for activities such as land preparation, planting, weeding and harvesting. Labor was paid for in cash or kind (food).

Table 4.7: Gender Disaggregated Data on Farmer's Use of Hired Labor in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Use of hired labor	No.	%	No.	%	No.	%	No.	%
Hired labor	29	82.9	25	71.4	31	88.6	26	74.3
No hired labor	6	17.1	10	25.7	4	11.4	9	25.7
Total	35	100	35	100	35	100	35	100

Key: MHHs: male headed households; FHHs: female headed households. Source: field data results

Franzel (1999) reports that labor is often a major limiting resource for many farmers, in particular female heads of households. As a result, farmers will only change their traditional practices in cases where the alternatives represent a more rational use of their money and time. The findings of this study indicated that female headed households were more constrained with regard to hiring of labor. This may have cascading effects on the number and types of soil fertility enhancing technologies adopted. The difficulty is partly greater with use of biomass transfer technologies, where several tons of biomass are required per hectare. This is extremely labor intensive and expensive if the farmer has to hire labor.

4.2.5.5 Security of Tenure

For purposes of this study, security of tenure was regarded as possession of a title deed in the farmer's name. Title deeds are a form of security that enables individuals secure loans from banks and other money lending institutions. More male headed households possessed title deeds in comparison to their female counterparts. Further, higher number of adopter households had security of tenure in comparison to non-adopter households (Table 4.8).

Table 4.8: Gender disaggregated data on security of tenure in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Security of tenure	No.	%	No.	%	No.	%	No.	%
Has title deed	25	71.4	12	34.3	27	77.1	15	42.9
Has no title deed	10	28.6	23	65.7	8	22.9	20	57.1
Total	35	100	35	100	35	100	35	100

Key: MHHs: male headed households; FHHs: female headed households. Source: field data results

In support of these results, Mwaipopo-Ako (1994) in a study done in Mbeya region of Tanzania, found that males had more secure rights to land and other resources than female members in the family. In male headed households, female spouses were granted secondary rights to land by their husbands, although as heads of households, women's rights to land were greater. The implication of these results is that if men are largely the legal owners of land, land titling may strengthen their rights to land at women's expense. For women, insecurity of tenure can be a barrier to increased productivity, diminishing their incentives to sustain resource use over time.

4.2.5.7 Off-farm Employment

More male-headed households were employed off the farm (in menial jobs, white-collar jobs or self employment) in comparison to female-headed households. Additionally, more adopters were employed off the farm than non-adopters as shown in Table 4.9.

Table 4.9: Gender Disaggregated on Off-farm Employment in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Off-farm employment	No.	%	No.	%	No.	%	No.	%
No off-farm employment	27	77.1	28	80	24	68.6	26	74.3
Off-farm employment	8	22.9	7	20	11	34.4	9	25.7
Total	35	100	35	100	35	100	35	100

Key: MHHs: male headed households; FHHs: female headed households. Source: field data results

Ayuk (1997), in a study conducted in Burkina Faso reported that off farm employment served as a source of income for farming households and encouraged adoption of agro forestry technologies. This was so because farmers were able to purchase labor and other inputs required on the farm. He however, noted that off farm employment income was only channeled to adoption when the farmer perceived the introduced technology as profitable and worth investing time and finances into. These results may have the same effect on adoption for this study.

4.2.5.8 Perception of Soil Fertility Problem

Within the female-headed households, a larger number of non-adopters reported that their soils were infertile, in comparison to adopters. However, across board, more non-adopters than adopters reported that they perceived soil infertility as a problem (Table 4.10)

Table 4.10: Gender Disaggregated Data on Perception of Soil Fertility Problem by Farmers in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Perception of soil fertility	No.	%	No.	%	No.	%	No.	%
Soil fertility problem	23	65.7	28	80	21	60	26	74.3
Soil is fertile	12	34.3	7	20	14	40	9	25.7
Total	35	100	35	100	35	100	35	100

Key: MHHs: Male headed households; FHHs: Female headed households. Source: field data reuslts

Franzel (1999), in a study on the adoption potential of soil fertility enhancing technologies in Africa reported that if farmers did not think that soil fertility was a problem, they were unlikely to invest their labor and capital into introduced innovations. In Southern Africa, Takane (2007) found that more female headed households than male headed households perceived soil fertility as a problem. These findings corroborate this study's assertions and may have a subsequent effect on adoption of soil fertility enhancing technologies.

4.2.5.9 Participation in Project Activities

Participation rates were higher for adopter households in comparison with non-adopter households as shown in (Table 4.11) below.

Table 4.11: Gender Disaggregated Ownership of Livestock by Farmers in Meru South District as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Participation in project activities	No.	%	No.	%	No.	%	No.	%
Farmer participates	18	51.4	16	45.7	27	77.1	27	77.1
Farmer does not participate	17	48.6	19	54.3	8	22.9	8	22.9
Total	35	100	35	100	35	100	35	100

Key: MHHs: Male headed households: FHHs: Female headed households. Source: field data results

Researchers in previous studies noted that there is a strong link between participation in agricultural development initiatives and increased farm productivity (Quimbuising et al.. 1995 and IFPRI. 2005). Further. Quimbuising et al. (1995) recognized that women participated less in agricultural development programs due to their heavy farm and domestic workloads. making attendance of meetings a lower priority for them. Some also cited lack of transport to venues or inability to understand the language of communication. thereby inadequate participation. As a result. agricultural productivity suffered because they produced food yet had limited knowledge of sound production processes. For this study. participation by men was only slightly higher than that of women. This may be as a result of women becoming more enlightened on the need to seek new information to help them improve their households' food security.

4.2.6 Institutional Characteristics

4.2.6.1 Access to Credit

More male-headed households had access to credit in comparison to female-headed households. Notably, 62.9 % of female-headed households did not get access to credit either through formal or informal means. Most of the farmers who had access to credit mainly got it through informal means such as group membership, in which short loans were offered to members (Table 4.12).

Table 4.12: Access to Credit by Farmers in Meru South District Disaggregated by Gender as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Access to credit	No.	%	No.	%	No.	%	No.	%
Formal credit	6	17.1	1	2.9	7	20	0	0
Informal credit	0	0	6	17.1	13	37.1	13	37.1
No credit	29	82.9	28	80	15	42.9	22	62.9
Total	35	100	35	100	35	100	35	100

Key: MHHs: Male headed households; FHHs: Female headed households. Source: field data results

In Malawi, Gladwin et al. (1997) found that in most farmers' credit lending institutions, women comprised only 25% of credit receivers while the rest were men. Married women were at a higher advantage compared to female household heads because they could receive credit through their husbands. Farmer groups that offered informal credit sources were found to provide miniscule amounts of money which was not sufficient to meet farming expenses. For this study, limited access to credit by female headed households may have had serious ramifications on ability to purchase inputs such as labor and fertilizers and subsequently adoption of soil fertility enhancing technologies.

4.2.6.2 Access to Extension Services

No major differences in access to extension services were noted between male and female-headed households, among adopters and non-adopters. However, female-headed households received slightly fewer extension visits in comparison to male-headed households (Table 4.13).

Table 4.13: Access to Extension Services by Farmers in Meru South District Disaggregated by Gender as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35)		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Access to extension services	No.	%	No.	%	No.	%	No.	%
Has access	28	80	25	71.4	29	82.9	25	71.4
Has no access	7	20	10	28.6	6	17.1	10	28.6
Total	35	100	35	100	35	100	35	100

Key: MHHs: Male headed households; FHHs: Female headed households. Source: field data results

Mukhophadhyay and Pieri, (1999) indicated that agricultural extension strategies traditionally focused on increasing production of cash crops by providing men with training, information, and access to inputs and services. This male bias was illustrated in farmer training centers, which had been established to provide residential training on technical subjects. Further, in the overwhelming majority of countries, extension services had been staffed predominantly by men, denying women access to much needed information and training.

Despite this trend, the study found that only slightly more male headed households received extension services in comparison to female headed households. This can be viewed as a positive development in agricultural growth in Kenya and an opportunity for researchers and other stakeholders to collaborate and synergize their efforts with local extension agents in order to achieve greater impact.

4.2.6.3 Farmer Group Membership

Group membership varied markedly among adopters and non-adopters. In female-headed households, 71.4% adopters were group members while 37.1 % non-adopters were group members. This trend was also noted among male-headed households, where 71.4% adopters were group members whereas a paltry 25.7% non-adopter male household heads belonged to a group (Table 4.14).

Table 4.14: Membership in farmers' group in Meru South District disaggregated by gender as of April 2007

	Non-adopters				Adopters			
	MHHs (N=35		FHHs (N=35)		MHHs (N=35)		FHHs (N=35)	
Group membership	No.	%	No.	%	No.	%	No.	%
Member	9	25.7	13	37.1	25	71.4	25	71.4
Non member	26	74.3	22	62.9	10	28.6	10	28.6
Total	35	100	35	100	35	100	35	100

Key: MHHs: Male headed households; FHHs: Female headed households. Source: field data results

Place et al., (2002) found that groups provided a means of collective action for farmers, providing resources such as credit, labor, and information. Groups allowed farmers to obtain new technologies, benefit from economies of scale, enter into stable relationships with suppliers, and set rules for natural resource management. In another study conducted by Kariuki and Place (2005) in the Central Kenya region, women and men appreciated the importance of farmer groups and joined the groups for different reasons. However, they did not observe major differences in group membership between male and female farmers. The same was noted for this study. It is apparent therefore that group membership may have a significant positive impact on adoption of soil fertility enhancing technologies given that farmers recognize that group membership enables access to information and resources.

4.3 Gender Differentials in Frequency of Participation in Soil Fertility Related Projects

The study found gender differences in the frequency of participation between male and female-headed households, with male headed households participating in higher numbers than female headed households. Results of t-tests indicated that participation in problem diagnosis meetings, field days and village training workshops was statistically significant while participation in nursery groups was not (Table 4.15).

Table 4.15: Gender Disaggregated Participation in Project Activities by Farmers in Meru South District as of April 2007

	MHHs (N=70)		FHHs (N=70)		
Frequency of participation	**Mean**	**SD**	**Mean**	**SD**	**P-value**
Problem diagnosis (once a year)	0.6	0.41	0.41	0.52	0.03
Field days (twice a year)	0.96	0.84	0.63	0.66	0.01
Village workshops (twice a year)	1.04	0.88	0.74	0.74	0.03
Nursery groups (once a week)	1.51	1.73	1.54	1.60	0.92

Key: MHHs: Male headed households; FHHs: Female headed households. Source: field data results

However, female household heads participated in larger numbers in group meetings in comparison to their male counterparts, even though this difference was not significant.

Most female household heads reported that they had no time to attend project meetings as they were either busy tending their farms or in their homes attending to domestic chores. These findings can be explained by the fact that based on this study's findings, on average, women spend far more hours (13.5 hours) per day on farm, domestic and community activities in comparison to men (5.5 hours). Additionally, these findings were reiterated by the men and women's focus groups discussions held to discuss the issue as shown in the following statements.

[Women's focus group discussion held in Mukuuni Location on 20th April 2007]:

"Participation in project activities is very important because it helps farmers learn more about the technologies. Women do not participate equally as men due to the fact that they are the main laborers in their households. Men do not put in many hours in labor in the households and thus have more free time to go to meetings. It is important to encourage women's participation in order to enhance food security since they do most of the farm work. Our men really like idling around in the market centers or going to meetings so as to escape farm labor".

To the contrary, most men enjoyed participating in field days for various reasons as articulated below by the members of the men's focus group.

[Men's focus group discussion held in Mukuuni Location on 20th April 2007]:

"Men enjoy field days and are always very eager to attend them. They like forums where they can express themselves and meet their peers. In most cases, their wives are left in the homes attending to farm, domestic and reproductive activities".

These findings also coincide with Kariuki and Place (2005) who reported that in most project activities, women participated in lesser numbers compared to men due to labor demands in the households. According to Njuki (2001), men mainly participated in project activities, thus women who provided much of the labor did not receive sufficient training required to implement the technologies on their farms.

4.4 Gender Differentials in Choice of Technologies for Adoption

In this section, descriptive and bi-variate analysis of gendered choices of technologies for adoption was done by use of bar graphs, percentages and chi-square tests.

4.4.1 Section Overview

Gender differences were found in the choices of soil nutrient replenishment technologies by male and female headed households, with male-headed households selecting more technologies for adoption than female headed households. Generally, male-headed households adopted technologies in higher numbers than female-headed households. This finding has been observed in studies in Central Kenya by Franzel and Wambugu (2004). Individual technologies (i.e. tithonia, leucaena, calliandra, cattle manure and mineral fertilizers) were then evaluated against gender of household head using chi-square to test for significance. Results were as follows:

4.4.2 Choice of Tithonia for Adoption

Tithonia was the most widely used technology at 80% usage for female headed households and 82.9% for male-headed households. The reasons farmers gave for their preference of tithonia were that it improved soil fertility, crop yields and controlled pests.

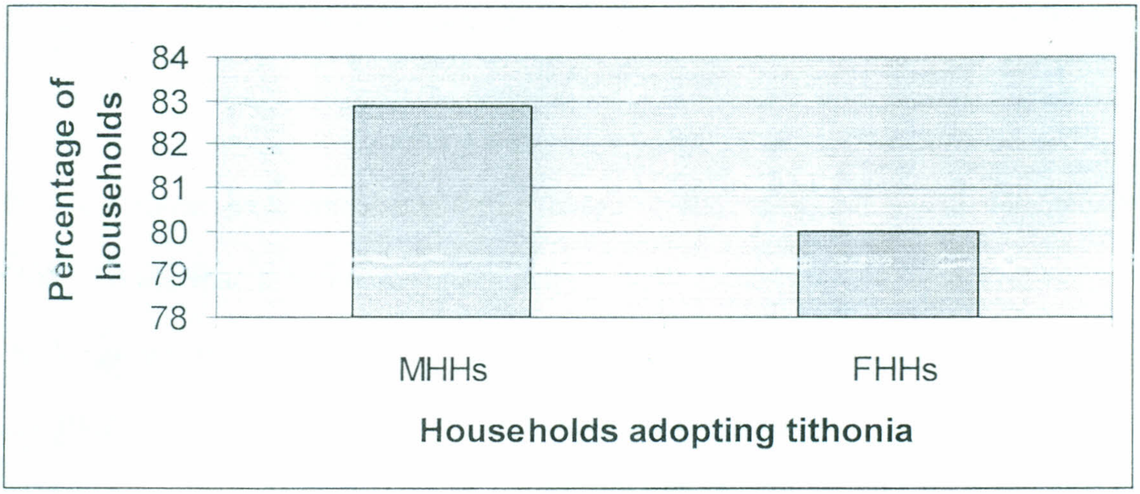

Figure 2.2: Choice of Tithonia for Adoption by Male and Female-Headed Households in Meru South District as of April 2007. Source: field data results

The chi-square test did not reveal any significant relationship between gender of the household head and the choice of tithonia for adoption ($\chi^2 = 0.094$, $P = 0.759$). This was mainly because tithonia was very popular with both male and female headed households. However, despite tithonia's popularity, majority of the households reported that the technology was labor intensive and had high management requirements.

Key informants, namely Jane Kainda and Eliphas Musyoka supported these findings as shown in the following statements.

[Jane Kainda: Female tree nursery group leader in Mukuuni Location]:

"Tithonia is the most popular technology in this area. They call it 'kirurite' which is the local name for the bitter shrub. Tithonia has almost replaced fertilizer use especially in female-headed households, where fertilizer is not frequently used due to financial constraints. However, the use of the technology requires a lot of labor which is a constraint particularly in female headed households".

[Eliphas Musyoka: adopter male household head in Mukuuni Location]:

I have adopted tithonia. Tithonia is a very good technology since it works better than fertilizer and is cheaper due to its local availability. Most of us have planted tithonia as a *hedge on our farms However, one disadvantage with tithonia is that requires a lot of labour to cut, carry and incorporate into the soil. Labour is not always available and hiring it is an extra expense on the family.*

Previous studies have corroborated this study's results. In central Kenya, Mucheru et al. (2002) found that tithonia was very popular with farmers in the area because it was locally grown along boundaries and roadsides. Further studies in the area by Mugendi et al. (1999) and Mutuo et al. (1998) reported positive results from use of tithonia for soil fertility improvement. In the Western highlands of Kenya, Gachengo (1996) and Jama et al. (2000) identified tithonia as an effective source of nutrients for maize. They reported that the green biomass of tithonia were higher in nutrients such as Nitrogen, Phosphorous and Potassium as compared to green biomass of other shrubs or trees.

Despite this positive response for tithonia, it is worth noting that the high labor requirements associated with the technology is a constraint (Jama et al., 1996). Tiruneh et al. (2001) in a study conducted in Ethiopia, noted that female-headed households would be disadvantaged if the technologies being developed were labor intensive.

4.4.3 Choice of Leucaena and Calliandra for Adoption

In the study region, farmers plant fodder shrubs, especially *Calliandra calothyrsus* and *Leucaena trichandra*, for use as feed for their stall-fed dairy cows. The farm-grown fodder increases milk production and can substitute for relatively expensive purchased dairy meal, thus increasing farmers' income (Franzel et al., 2003). Calliandra was the most popular fodder shrub in the area. Adoption of calliandra at household level was found to be higher among male-headed households than female-headed households 71.4% and 54.3% respectively (Figure 4.3).

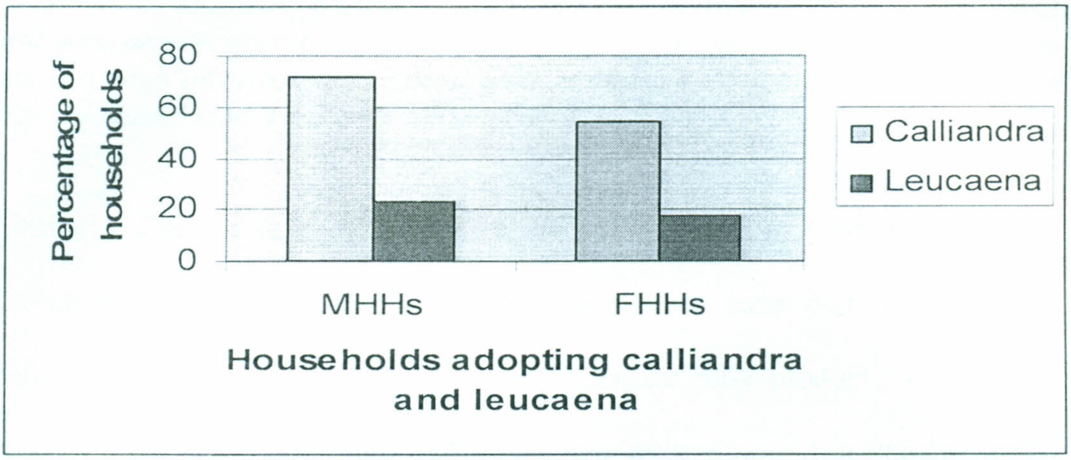

Figure 4.3: Choice of calliandra and leucaena for adoption by male and female headed households in Meru South district as of April 2007
Source: field data results

The respondents attributed its popularity to the fact that once fed to livestock, there was higher milk production and that it took a short time to decompose once incorporated into the soil, in comparison to leucaena. Calliandra was also noted as a source of fuelwood. However, there was no significant relationship between gender of household head and adoption of calliandra ($\chi^2 = 2.203$, $p = 0.138$).

The men and women's focus groups reiterated these findings as shown by the following statements.

[Women's focus group held on April 20th 2007 in Mukuuni Location]:

"Leucaena is not very popular here because farmers have learnt that calliandra, which is also a fodder shrub, is more advantageous to use. Leucaena's lack of popularity as a fodder crop is because it does not produce many branches compared to calliandra, the milk produced is not of as high quantity as when animals are fed with calliandra. Once

leucaena is exposed to the sun, it has a bad taste and animals do not like it. Calliandra's taste is not affected by sunlight".

[Eustus Njagi: adopter male household head in Mukuuni Location]:

"I do not like leucaena because it takes very long to decompose once incorporated in the soil. Leucaena is also not as good as calliandra since milk yields from cattle fed on it are not very high as compared to those from calliandra. My cattle produce more milk these days because I feed them with calliandra".

Similarly, Franzel et al. (2003) in a study conducted in Central Kenya, found that Calliandra was nutritive both as a supplement to the basal diet and as a substitute for dairy meal. Calliandra was also found to increase milk production. Surveyed farmers reported that Calliandra not only increased milk output but its cream levels too. Calliandra's other benefits were noted as soil amelioration and conservation, provision of fuelwood and also cost saving since farmers could substitute it with dairy meal.

In contrast, leucaena was the least used technology by both male (22.9%) and 17.1 % of female-headed house holds (Fig. 4.3). However, this difference was not significant (χ^2 = 0357, p 0.550). Most respondents reported that leucaena biomass took long to decompose once incorporated into the soil. Other reasons given were that it produced fewer branches (thus less fodder) than calliandra, had a bad taste once exposed to sunlight, and that milk produced by animals fed with leucaena was lower in quantity as compared with that for animals fed on calliandra.

Gutteridge et al. (1999) and Middleton et al. (1995) report that in Australia and other tropical countries, adoption of leucaena by farmers was low. This was due to the perceived high cost of establishment, the high rate of establishment failure due to weed competition and insect predation, the persistence of 'myths' concerning the hazards associated with leucaena and low returns on milk and beef production leading to non-profitability of the technology.

4.4.4 Choice of Cattle Manure for Adoption

Gender differences were observed in adoption of manure. Manure was more widely used in male-headed households (65.7%) than in female-headed households (40%) as shown in Figure 6. Majority of the female household heads associated the low manure usage to lack of adequate labor, which was as a result of lack of finances to purchase it. A small number of these female household heads attributed the unavailability of cattle manure to their lack of cattle, hence its low usage.

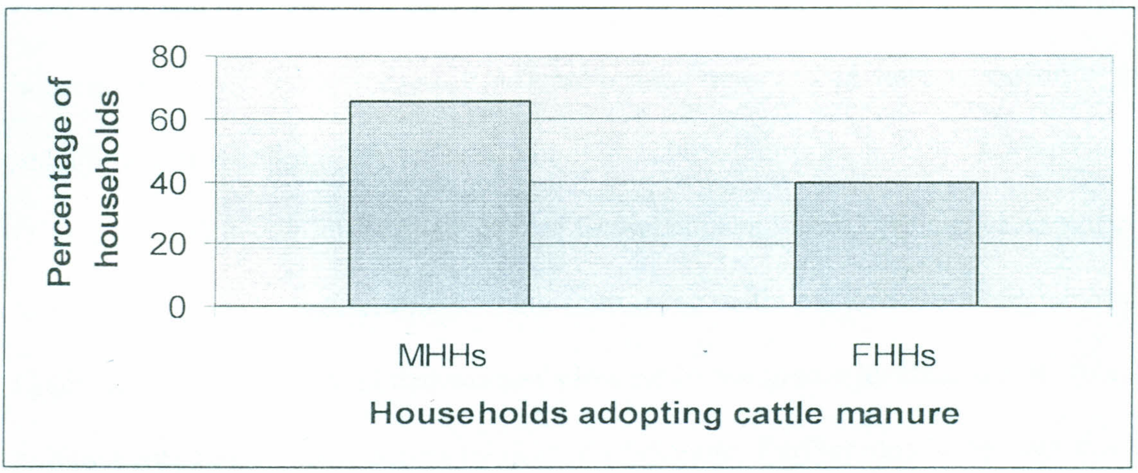

Figure 4.4: Choice of cattle manure for adoption by male and female-headed households in Meru South District as of April 2007. Source: field data results

A chi-square test revealed a significant relationship between gender of the household head and adoption of cattle manure ($\chi^2 = 4.644$, $p = 0.031$). This suggests that male-headed households were more likely to use cattle manure than female-headed households.

Statements made by a key informant who was interviewed supported these findings were as follows:

[Mureithi Rintira: Assistant Chief of Mukuuni Location]:

"Manure is good because it is locally available. It increases soil fertility when incorporated into the soil and this can lead to high crop yields. However, it is laborious to use and if one has a big farm, it is not cost saving to. Many male-headed households may use manure because they own cattle and may also have labor to apply it. The same is not so for female headed households who have no or fewer cattle, and lack sufficient labor required to apply the manure or are not able to buy it from those who sell".

Additionally, Lekasi et al. (2001) in a study conducted in Central Kenya, where it was found that more male headed households than female headed ones used manure as a soil fertility enhancing strategy. This was explained as because fewer female headed households owned cattle compared to male headed ones and as such accessibility of the manure was low (Njuki, 2001, Gachimbi et al., 2003, Ouma et al., 2002). Murwira et al. (1998) in Zimbabwe found female headed households had limited financial resources and labor shortages, which discouraged them from using cattle manure. Similarly, in Malawi, Gladwin et al. (1997) found that women's low cattle ownership levels and manure's labor requirements limited their access to and use of manure. Further, due to the fact that most female headed households had fewer adults working on farm, labor shortages were rife thus discouraging some female headed households from using manure. In addition, most female headed households across Africa were poor and therefore lacked cash to procure manure or hire labor for use in its application.

4.4.5 Adoption of Mineral Fertilizer

More male-headed households (74.3%) used fertilizer compared to 37.1% female-headed households (Figure 4.5). Majority of the female-headed households reported their inability to afford fertilizer.

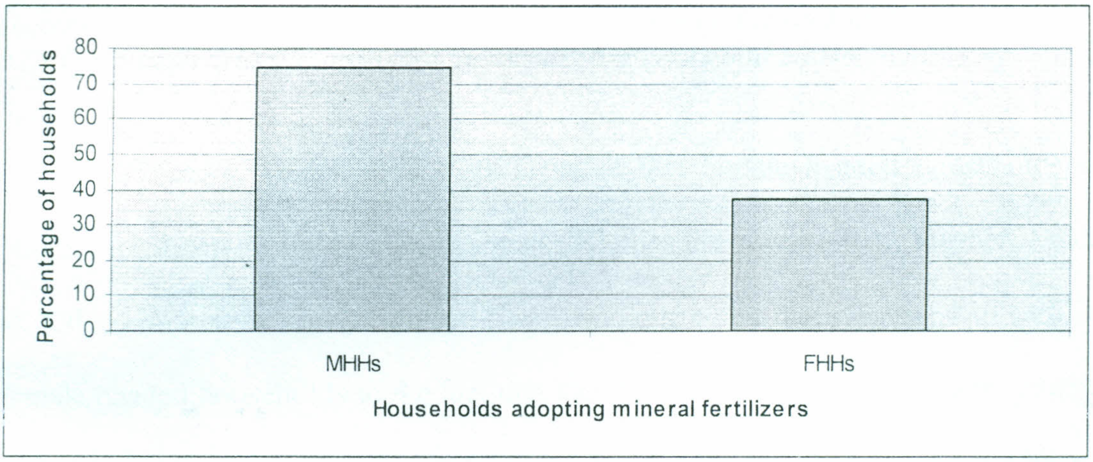

Figure 4.5: Choice of mineral fertlizer for adoption by male and female headed households in Meru South District as of April 2007
Source: field data results

Results showed that there was a significant relationship between adoption of mineral fertilizers and the gender of the household head ($\chi^2 = 9.785$, $p = 0.002$). These results suggest that male-headed households were more likely to use mineral fertilizers on their farms in comparison to female-headed households.

These results were supported by members of the men and women's focus groups as in the statements below.

[Men's focus group discussion held in Mukuuni Location on 20th April 2007]:

"Fertilizer is a good technology. We have been taught on how to use it appropriately and precisely. It is expensive though and most farmers, especially female-headed households may not afford it. As a result, some farmers use it in the wrong quantities and apply it poorly. More male headed households than female-headed households use fertilizer".

[Women's focus group discussion held in Mukuuni Location on 20th April 2007]:

"During project meetings, we are taught on how to apply mineral fertilizer on our farms. However, fertilizer is very expensive and most female household heads cannot afford it. Those of us whose spouses can afford mineral fertilizer use it. Sometimes the recommended quantities for application cannot be met due lack of money. Most of us mix a little fertilizer with tithonia and the results are very good maize yields".

In Central Kenya, Lekasi et al. (2001) noted that female headed households adopted mineral fertilizers in lower numbers than male headed households. Further, Mudhara et al. (2006) in a study carried out in Zimbabwe, attributed the low usage of fertilizers by female headed households to the fact that they had fewer financial resources compared to male headed households. Given that most female headed households did not have secure land tenure rights, access to credit was very limited thereby reducing their purchasing power.

Findings from other studies reveal the same trend. In Malawi, Gladwin et al. (1997) reported that in Africa, the use of mineral fertilizer by women was low when compared to men. The average female-headed household used 34 kg ha^{-1} of fertilizer as compared to 51 kg ha^{-1} in male-headed households. For resource poor subsistence farmers especially women the cost of fertilizer is always a limiting factor. Estimates show that if productive inputs like fertilizer, manure, and labor could only be reallocated within the African household from men's to women's crops, in some societies the results could mean an increase in the value of household output of 10-20% (Gladwin et al., 2002).

4.5 Bi-variate Analysis of Factors Influencing Adoption of Soil Fertility Replenishment Technologies

4.5.1 Demographic, farm, and livestock factors influencing adoption

Table 4.16 below shows results of t-test run to determine significance of demographic (age, household size, number of adults), farm (farm size, land under food crops, land under cash crops) and livestock factors (number of goats, cattle, sheep, poultry, other domestic livestock) with adoption of soil fertility enhancing innovations.

Table 4.16: Results for Demographic, Farm and Livestock Factors Influencing Adoption in Meru South as of April 2007

	Male-headed households(N=70)			Female headed households (N=70)		
Variables	Non-adopters	Adopters		Non-adopters	Adopters	
Demographic factors	Mean	Mean	P-value	Mean	Mean	P-value
Age	45.2	46.9	0.88	47.5	47.1	0.52
Household size	3.5	4	0.12	3.2	3.5	0.22
Number of adults	1.9	2.7	0.00	1.2	1.7	0.00
Farm factors						
Farm size	1.1	1.3	0.01	0.8	0.8	0.38
Land under food crops	0.5	0.6	0.13	0.4	0.5	0.16
Land under cash crops	0.2	0.3	0.11	0.2	0.3	0.01
Livestock ownership						
Number of goats	9.3	10.9	0.16	4.1	5.9	0.001
Number of cattle	2.8	4.1	0.00	1.9	2.2	0.15
Number of sheep	1.6	1.7	0.73	1.1	1.4	0.26
Number of Poultry	9.2	10.9	0.24	5.4	6.9	0.13
Other livestock	4.7	5.3	0.28	2.8	3.5	0.21

Key: MHHs: Male headed households: FHHs: Female headed households. Source: field data results

4.5.1.1 Demographic Factors Influencing Adoption

Results showed no significant connection between the mean age of household heads and adoption for both male and female-headed households. The implication of this was that the age of the household head did not influence adoption in this study. This could have been because majority of farmers were above 45 years (as shown in Section 4.2), therefore there were no major differences in age among them.

As well, there was no significant association between the mean household sizes and adoption for both male and female-headed households. This implies that for both male and female headed households, the household size was unlikely to influence uptake of soil fertility improving technologies. However, there was a significant relationship between the means of the number of adults working on farm with adoption for both male and female-headed households. This suggests that the more the number of adult household members working on the farm, the higher the likelihood that those households would adopt. Mwangi et al. (1996) in a similar study conducted in Tanzania reported that the number of adults working on farm significantly and positively influenced adoption. Statements made by a key informant as below supported these results.

[Justin Mate: Extension officer in charge of Mukuuni Location]:

"The number of adults working on the farm is a determinant of adoption because it signifies the availability of family labor. Male-headed households have more adults working on the farm than female-headed households, thus more labor at their disposal. As a result, female headed households are less likely to adopt than male headed households due to labor constraints".

4.5.1.2 Farm Characteristics Influencing Adoption

As shown in Table 4.16, a significant link was noted between the mean farm sizes and adoption for male-headed households, while no significant association was noted for female-headed households. This suggests that the larger the farm sizes among male-headed households, the higher the likelihood of adoption. In a similar study in Ethiopia, Tiruneh et al. (2001) reported that male-headed households had relatively larger farm sizes than female-headed households, and that farm size had a positive and significant impact on adoption for male-headed households. Contrastingly, no significant difference was noted between the mean size of land under food crops with adoption for both male and female-headed households.

Additionally, there was a significant association between the mean of size of land under cash crops and adoption for female and male headed households. However, this was not so for male-headed households. The implication of this was that the larger the size of land under cash crops a female household head had, the more likely they were to adopt. In a similar study done in Central Kenya, Irungu et al. (1998) reported that the area of land under cash crops influenced adoption of soil fertility innovations significantly and positively. In addition, a statement from one female household head supported these results as follows:

[Ciamwari Roland: adopter female household head in Mukuuni Location]:

"Coffee is the most popular cash crop in this area. Cash crops are good because they earn farmers income. I have planted coffee on 1 acre of farmland. It helps me generate income when I sell it. I use some of this money to buy inputs and hire labor which is very useful on the farm. Cash crops provide income that enables me adopt other technologies".

4.5.1.3 Livestock Ownership

The study found no significant links between the mean number of sheep, poultry and other domestic livestock a household owned with adoption for both male and female-headed households. However, there was a significant association between the means of number of cattle and adoption for male-headed households but not so for female-headed households. In addition, for female headed households, there was a significant relationship between goat ownership and adoption. This was not so for male-headed households. This suggests that the more cattle a male-headed household owned, the higher the likelihood of adoption while the higher the number of goats owned by a female headed household, the more likely it was to adopt. Further, statements below supported these findings.

[Men's focus group discussion held in Mukuuni Location on 20th April 2007]:

"Most male-headed households here own cattle. Cattle require huge financial investments to purchase and feed. Female-headed households may not be able to meet the financial requirements associated with rearing cattle. They prefer keeping goats. Goats are cheaper to maintain and do not require huge sums of money to purchase and rear".

Similarly, in Tanzania, Mwangi et al. (1999) found that the number of cattle owned had a positive influence on adoption of soil fertility improvement technologies while Lapar and Ehui (2003) in a study done in West Africa reported that fodder providing technologies were more likely to be adopted by farmers with goats and cattle.

4.5.2 Socio-economic and Institutional Factors Influencing Adoption

Table 4.17 below represents chi-square test results for socio-economic and institutional factors influencing adoption of soil fertility enhancing technologies.

Table 4.17: Results for socio-economic and institutional factors influencing adoption in male and female headed households in Meru South as of April 2007

	Male headed households (N=70)			Female headed households (N=70)		
	Non-adopters	Adopters	P-value	Non-adopters	Adopters	P-value
Socio-economic factors	No. (N=35)	No. (N=35)		No. (N=35)	No. (N=35)	
Had security of tenure	25	27	0.79	12	15	0.46
Used hired labor	29	31	0.58	25	26	0.78
Had off farm employment	8	11	0.42	7	9	0.57
Had formal education	28	30	0.75	24	26	0.70
Participated in project activities	18	27	0.025	16	27	0.007
Perceived soil fertility as a problem	23	21	0.62	28	26	0.79
Institutional factors						
Received credit	6	20	0.003	7	13	0.11
Received extension services	28	28	0.76	25	25	0.75
Member of farmer's group	9	25	0.00	13	25	0.004

Key: MHHs: Male headed households; FHHs: Female headed households. Source: field data results

4.5.2.1 Socio-economic Factors Influencing Adoption

As indicated in Table 4.17, there was no significant relationship between security of tenure and adoption for both male and female headed households. Security of tenure thus was not a factor that influenced a farmer's decision to invest in soil improvement technologies. This can be explained by the fact that the main leguminous shrubs used to enhance soil fertility such as tithonia, calliandra and leucaena were mainly grown along farm boundaries and therefore took up very little farm space to warrant any major land use problems. Also, since the technologies had been widely promoted by scientists and local agricultural officers, farmers were generally receptive and ready to try them security of tenure notwithstanding.

More over, no significant relationship was noted between the use of hired labor and adoption in both male and female-headed households. These findings were in spite of the fact that a large number of farmers hired labor (Section 4.2). It is worth noting however, that labor was hired mainly during three peak periods of the year (planting, harvesting and weeding) and that hiring labor was only done to complement existing family labor in times of dire need. This means that the farmers in the area largely depended on family labor for agricultural operations throughout the year. Even though labor was hired, this was done very rarely and only when it was extremely necessary. It is worth noting, therefore, that family labor is a key driver of agricultural production in the area.

Further, there was no significant association between adoption and off farm employment for both male and female-headed households. Even though studies in other parts of Africa indicate that off farm employment has a positive influence on adoption (Ayuk, 1997 and Adesina and Chianu, 2002), this was not the case for this study. This may be attributed to the fact that very few adopter and non-adopter households in the study area earned an income off the farm. As such, the difference in numbers was too small to result in significance. This signifies that majority of household heads were full time farmers and relied heavily on subsistence farming as an economic activity. Further, income generated through farming was ploughed back to cater for input costs (e.g. labor, fertilizer) required during succeeding farming seasons. This consolidates previous research findings that the bulk of rural farmers rely solely on subsistence farming, thus the need for deliberate investments by governments and development partners in the agricultural sector to support subsistence farming thereby guaranteeing the survival of rural families.

In addition, as indicated in Table 4.17, the study found no significant link between adoption and access to formal education for both male and female-headed households. This implies that education did not influence adoption of soil nutrient replenishment technologies by both male and female-headed households. This may have been primarily because farmers were consistently trained by project scientists and area agricultural officers on the application of the introduced technologies in their farms. Further, training sessions were held in the local language and farmer groups were formed in villages to further exchange knowledge and practice the use of the technologies as a group.

However, a significant relationship was noted between participation in project activities (such as field days, problem diagnosis meetings, group meetings and village training workshops) and adoption for both male and female-headed households (Table 4.17). This suggests that participation in project activities by both male and female-headed household increased the likelihood of adoption. This was so because during project meetings, farmers were trained on the use of introduced technologies by project scientists and agricultural officers. Similarly, a study conducted in Cameroon by Adesina (1996), showed that the Northwest province had the highest level of adoption of alley farming following initial exposure of farmers to the technology. It thus followed that exposure to information about the technology had a significant and positive effect on its adoption.

Finally, a farmer's perception of soil fertility as a problem was not found to be significantly associated with adoption for both male and female headed households. This implies that perception of soil fertility as a problem did not significantly affect a farmer's decision to adopt. This was possibly because these were farmer's individual perceptions and not scientists' perceptions, which farmers tended to listen to more. Farmers were also more likely to invest in soil fertility replenishment strategies if advised to do so by scientists and if scientists availed resources to access these technologies.

4.5.2.2 Institutional Factors Influencing Adoption

As indicated in Table 4.17, there was a significant relationship between access to credit and adoption for male headed households but not so for female-headed households. This indicates that access to credit increased the likelihood of adoption by male headed households. Credit was mainly used to purchase farm inputs and hire labor. Since most adopter households were able to access credit through formal and informal (mainly farmer groups) means, they had a comparative advantage over non-adopters in application of labor intensive technologies like tithonia on their farms. Similar studies in Kenya reported that farmers who had access to credit were more likely to adopt soil fertility improving technologies in Western Kenya (Wekesa et al., 2003). In Malawi, access to credit was noted as a key determinant of adoption by farmers (Mudhara et al., 2006).

Further, there was no significant association between access to extension services and adoption for both male and female-headed households. This indicates that access to extension services did not influence households' decisions to adopt. Contrary to findings of other studies, these results may be explained by the fact that majority of the households in the area received extension services but the difference was not large enough to be significant. In addition, visits by extension agents could not possibly influence adoption because the technologies were disseminated and taught to farmers by project scientists during field days and village training workshops organized by project personnel.

However, as shown in Table 4.17, the study found a significant link between membership in a farmers' group and adoption for both male and female headed households. This implies that membership in a farmers' group positively influenced a farmer's decision to adopt. Similar studies by Franzel and Scherr (2002) and Tenge et al. (2004) affirm that membership in a farmers' association or group, led to better access to technical information thereby increasing adoption of soil fertility improving innovations. These results were further supported by a key informant interview as below.

[Mr. Mbaka: adopter male household head in Mukuuni Location]:

"I am a member of a farmer's group. Our group is very active and we learn a lot through it. Through the group, we are taught a lot on how to implement the various technologies on our farms. We also obtain seedlings and other inputs from the group nursery and leaders respectively. I have found groups to be very helpful because they also offer soft loans to members to enable them purchase inputs and hire labor".

4.6 Logistic Regression Analysis of Factors Influencing Adoption in Male and Female Headed Households

4.6.1 Factors influencing adoption in female-headed households

The results of logistic regression analysis of multiple factors influencing adoption in female headed households are as shown in Table 4.18. Factors included in the model were those that were found to significantly influence adoption in Section 4.5

Table 4.18: Logistic Regression Parameter Estimates of Factors Influencing Adoption by Female-Headed Households in Meru South District as of as of April 2007

Predictor variables	β	S.E	Wald	df	P-value	Exp (β)
Number of goats	.32	.15	4.67	1	0.03	1.37
Membership in farmer group	2.12	.79	7.26	1	0.007	8.30
Land size under cash crops	1.89	1.03	3.49	1	0.06	6.63
Farmer participation	1.45	.72	4.03	1	0.04	4.25
Number of adults	2.67	.83	10.20	1	0.001	14.25
Constant	-7.43	1.65	16.08	1	0.000	0.000
Model summary	Model chi-square = 37.6, $p<0.001$ Overall cases predicted = 82% Sample size = 70					

Key: β (Beta): S.E: (standard error): Exp (β): (exponential beta): Wald: wald statistic. df: degree of freedom. Source: field data results

Logistic regression analysis was employed to predict the probability that a male or female headed household would adopt at least one soil fertility enhancing technology. The wald statistic and the corresponding p-value test the significance of each of the independent variables in the model. The ratio of the logistic co-efficient (β) to its standard error (S.E), squared, equals the wald statistic. If the wald statistic is significant (i.e. less than 0.05) then the parameter is significant in the model. The exponential beta or Exp (β) is the odds ratio of the independent variable with the dependent variable. It is the predicted change in odds for a unit increase in the corresponding independent variable.

The model's dependent variable was adoption while the predictor or independent variables were: number of goats owned, farmer group membership, land size under cash crops, participation in project activities and number of adults working on farm. A test of the full model versus a model with intercept (constant) only for female headed households was statistically significant at $p<0.001$ according to the model's chi-square statistic ($\chi^2 = 37.6$, $p = 0.00$). Further, the model predicted 82% of the responses correctly.

From the results in Table 4.18, adoption of soil fertility replenishing technologies by female headed households was significantly and positively influenced by: number of goats owned, group membership, land size under cash crops, participation in project activities and number of adults.

The model predicted that a unit increase in the number of goats owned by a female household head was 1.4 times likely to increase adoption of soil nutrient replenishment technologies. This may have been so because most female household heads could not afford to purchase and rear cattle and mainly fed their leguminous fodder technologies to goats. In a similar study, Gachimbi et al. (2003) found that goats were cheaper to purchase and more risk averse. Goats were also noted to occupy less space and were less demanding in terms of feeding compared to cattle. Additionally, a study of high potential areas in Kenya showed that on small farm sizes where farmers had no access to credit and inputs, goats were more profitable and less risky than dairy cattle (IFPRI, 2005). Fort (2007) indicated that in many societies, cattle and larger animals were owned by men, while smaller animals, such as goats were more women's domain.

More over, a farmer's membership into a group increased the odds in favor of adoption by a factor of 8.3, implying that the more farmers that joined groups, the higher the possibility of taking up technologies. This was because farmers were able to access legume seedlings and also received adequate training and skills in groups. Similarly, Adesina and Chianu (2002) found that soil improvement innovations had higher chances of adoption when soil fertility management projects worked through farmers' groups. In addition, Lule et al. (2007) in a study conducted in Tororo, Uganda indicated that social capital in the form of farmers' groups was crucial for adoption of soil fertility management technologies as it provided social networks, relationships and linkages that enable poor people to cooperate, coordinate, share information and resources, and act collectively.

Further, if land sizes under cash crops were increased, the odds in favor of adoption increased by a factor of 6.6. This may have been because income generated from cash crops was ploughed back into purchase of inputs required for farming. To corroborate this, in Western Kenya, Wekesa et al. (2003) found that the size of land under cash crops influenced adoption significantly and positively, and thus a farmer's ability to invest in soil fertility improvement technologies was greatly boosted.

Further, the odds in favor of adoption increased by a factor of 4.2 for households that participated in project activities. This could be attributed to the fact that through participation, farmers became aware of the technologies, were trained on their use, and could also visit project demonstration plots to learn more. These results are corroborated by Njuki (2001) and Pound et al. (2003), who reported that farmers who participated in farmer training courses were more likely adopters than those who did not.

Moreover, an increase in the number of adults working on the farm was likely to have a resultant 14.2 times increase in adoption. This was because most households in the area relied on family labor and with the free primary education initiative by the government, labor from children was unreliable as more children enrolled in schools. These results are corroborated by Ayuk (1997), who found that households with a higher number of adults working on farm were more likely to adopt soil fertility enhancing technologies compared to those with fewer adults. Miiro et al. (2001) in a study conducted in Eastern Uganda also found that households had to reduce the number or size of their fields in order to adjust to labor constraints in cases where adult labor was low.

4.6.2 Factors Influencing Adoption in Male-Headed Households

The results of logistic regression analysis of multiple factors influencing adoption in male headed households are as shown in Table 4.19.

Table 4.19: Logistic Regression Parameter Estimates of Factors Influencing Adoption by Male-Headed Households in Meru South District as of April, 2007

Predictor variables	β	S.E	Wald	df	P-value	Exp (β)
Number of adults	2.10	0.75	7.78	1	0.005	8.19
Access to credit	2.48	1.10	5.06	1	0.02	11.88
Membership in farmer group	3.11	1.08	8.35	1	0.004	22.36
Number of cattle owned	1.32	0.46	9.18	1	0.002	3.75
Farm size	0.31	0.44	0.49	1	0.48	1.36
Farmer participation	1.38	1.01	1.91	1	0.17	4.01
Constant	-13.34	1.82	15.21	1	0.00	0.00
Model summary	Model chi-square = 55.9, p<0.001 Overall cases predicted = 87.1% Sample size = 70					

Key: β (odds ratio); S.E: (standard error); Exp (β): (exponential beta); Wald: wald statistic; df: degree of freedom

Source: field data results

A test of the full model versus a model with intercept (constant) only for male headed households was statistically significant at $p<0.001$ according to the model chi-square statistic ($\chi^2 = 55.9$, $p = 0.00$). Further, the model predicted 87.1% of the responses correctly. The model's dependent variable was adoption while the predictor or independent variables were: number of adults working on farm, access to credit, membership in farmers' group, and number of cattle owned, farm size and farmer participation in soil related project activities. Results of the model indicate that number of adults, access to credit, membership in farmers' group and number of cattle owned significantly and positively influenced adoption.

As shown in Table 4 19, if the number of adults working on farm was increased, the odds in favor of adoption increased by a factor of 8.2. This may have been due to the fact that most households in the area mainly relied on family labor, which was readily available and cheap. Similarly, Takane (2007) in a study conducted in Botswana found the number of adults in the household as significantly influencing adoption. In Zimbabwe, smallholder farmers typically used family labor, which was allocated to different tasks, to maximize the contribution of each member. As such, the number of adults in the household working on the farm was a significant factor influencing adoption decisions (Mudhara et al., 2006).

Further, farmers who accessed credit were 11.9 times more likely to adopt than those who did not. This may have been possibly because financial access translated to access to purchasable inputs, including hired labor. In other studies, Place et al. (2003) reported that access to credit by male-headed households encouraged adoption of soil fertility improving technologies in Western Kenya. According to FAO (2005), access to credit affected household welfare outcomes and adoption of soil fertility enhancing innovations. Further more, easing potential capital constraints through credit access reduced the opportunity costs of capital intensive assets relative to family labor, thus encouraging adoption of labor saving, higher yielding technologies and thereby land productivity (Diane and Zeller, 2007).

In addition, unit increase in group membership was found to favor the odds adoption by a factor of 22.4. The reasons for this may have been that farmers who were group members could access legume seedlings, receive training and access short loans. In relation to this, Kariuki and Place (2005) found that a farmer's membership in a group increased adoption, as farmers exchanged information and obtained resources through groups. Likewise, in a study conducted in Uganda by CIAT (2002), it was noted that farmer group membership was an effective mechanism to disseminate knowledge intensive technologies, build social capital within the community, and to achieve greater impact in adoption.

As well, a unit increase in the number of cattle was likely to have a resultant 3.7 times increase in adoption. The explanation for this was that cattle ownership was a sign of wealth and thus well to do farmers could also afford to buy other inputs and also hire labor required to implement labor intensive technologies. Similarly, in Southern Africa, Sullivan (2000) found that the number of cattle owned encouraged adoption, especially in male-headed households. In Botswana, Takane (2007) reported that the number of heads of cattle owned was an indicator of wealth, collateral for agricultural credit and a significant determinant of adoption of soil fertility innovations.

Finally, even though farm size and participation in project activities significantly influenced adoption at bi-variate analysis level in section 4.5 of this chapter, these variables did not significantly affect adoption decisions at multi-variate level. However, though not significant, their influence was positive as shown by their beta (β) co-efficients in Table 4.19.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter Introduction

In this chapter, the major conclusions and recommendations emanating from the results of this study have been presented.

5.2 Conclusions

The results of this study affirm the need for gender consideration in adoption of soil nutrient replenishment technologies. The first objective sought to investigate whether the frequency of participation in project activities differed between male and female-headed households. From the results, there were gender differences in the frequency of participation in project activities by male and female-headed households with male headed households participating in significantly larger numbers in field days, village training workshops and problem diagnosis meetings than female headed households. These results demonstrate the need to ensure the equal participation of women and men in project activities in order to increase the likelihood of adoption.

Secondly, the study focused on determining whether the choices of technologies for adoption differed between male and female-headed households. More male than female headed households adopted mineral fertilizers and cattle manure. There is a need to ensure that more female-headed households adopt cattle manure and mineral fertilizers, as this would subsequently increase food security in these households.

The third objective sought to examine how factors influencing adoption of soil nutrient replenishment technologies differed between male and female-headed households. Factors significantly influencing adoption in male headed households were found to be access to credit, membership in a farmer's group, number of adult household members working on the farm, and the number of cattle owned. Those that significantly influenced adoption in female headed households were found to be: participation in project activities, membership in a farmer's group, and area of land under cash crops, number of goats owned, and the number of adult household members working on the farm. The implication of this is that if these household specific factors encouraging adoption were promoted and proper support systems availed to farmers, the likelihood of adoption of soil nutrient replenishment technologies would increase.

5.3 Recommendations

Based on these findings, future success in adoption of soil fertility replenishment technologies requires deliberate and pragmatic efforts from project implementers, farmers, policy makers, and extension agents. The results of this study indicate that participation significantly influences uptake of soil fertility enhancing innovations by female headed households in spite of the fact that women participate in lesser numbers than men. As such, interventions by project implementers need to be targeted at women, and should take into consideration women's available time, not just for new activities, but also to participate actively in project activities, particularly field days, village training workshops and problem diagnosis meetings. Women groups are an important form of social capital through which collective action and participation can be promoted.

Given that adoption of cattle manure and inorganic fertilizers is lowest in female headed households, project implementers, researchers, development agents and the government ought to implement measures and strategies that will increase access to cattle manure and mineral fertilizers by female-headed households especially in scenarios where this would prove profitable. This may be done through offering loans to women for purchases such as labor required in the use of cattle manure and credit to buy mineral fertilizers. Rotational labor arrangements among women would further encourage sharing of each other's labor to reduce required labor loads in manure use.

As well, owing to the fact that this study has designed a predictive understanding of factors influencing adoption of soil nutrient replenishment technologies by male and female-headed households; this can be applied to predict adoption patterns in the study area and Central Kenya in general, where almost similar household, demographic, climatic and farm conditions exist. Efforts geared towards strengthening these factors with a view to increasing adoption would be a plus for successful project implementation. Scientists also need to consider gender-targeted design of technologies so as to meet the needs of both male and female farmers and design technologies that would not unnecessarily overburden women. This may be done through the active involvement of both gender groups in the design and development of these technologies.

5.3.1 Suggestions for further research

Future researchers interested in studying adoption patterns should also consider investigating gender differentials in adoption of soil fertility enhancing technologies by *de facto* female-headed households which were not investigated so as to draw comparisons with results obtained by this study. Coupled with that, it may be necessary to investigate households in which the man and woman live permanently on the farm but the woman provides all in terms of supporting the household financially and makes most of the decisions regarding household and farm issues. A term to classify these 'female supported' households need to be coined.

In addition, future researchers need to further investigate whether farmers who participate in project activities disseminate the information to other farmers and also establish the accuracy of information disseminated. This can be achieved through the development of a local knowledge base system to trace farmer's local knowledge on soil fertility replenishing technologies, adaptations made to those technologies and their practicability at farm level. This evaluation would help assess adoption processes hence inform decision-making and action.

Moreover, there is also need for a study to be undertaken in the study area, focusing on evaluating the benefits farmers, in particular resource constrained female headed households can accrue from innovations such as fertilizer micro dosing/precision application, which has been applied and found to be successful in increasing food production for resource constrained farmers in Southern Africa. In light of this, a profitability analysis of these technologies is necessary to determine whether they have high returns on farmers' labor and time investments to warrant their adoption on a large scale. Finally, policy makers, extension personnel, researchers and project implementers require sensitization on the need to be gender literate in order to ensure that gender considerations are taken into account in policy making, design and dissemination of soil fertility replenishment technologies and in the formulation and implementation of soil and agriculture related projects.

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APPENDICES

Appendix 1: Farmer interview schedule

Farm Identification

Interview schedule No.__________ Name of Interviewer ________________

Farm Location ________________ Sub location ________________________

Village ______________________

1. Background household information

1. Name of Respondent ________________________________

2. Gender of Respondent: Male ☐ Female ☐

3. Age ______________

Household Headship

4. Gender of HH head: Male ☐ Female ☐

5. Age of HH ____________

Nature of Household Headship (Tick Appropriately)

6. Male Adult Headed ☐

7. Female Adult Headed ☐

8. Female Child Headed ☐

9. Male Child Headed ☐

10. Elderly Male Headed (Above 60 yrs) ☐

11. Elderly Female Headed (Above 60 yrs) ☐

Marital status of Household head

1=Single 2=Married 3=Divorced/Separated 3=Widow 4=Widower

Farm characteristics and farming system

13.Farm size (Acres) In this area__________________

14.How was the land acquired? 1=Inherited 2=Purchased 3= Rented/Leased

15. Size cultivated with food crops__________________

16.Size cultivated with cash crops__________________

17.Is soil Fertility a constraint in your farm? 1=Yes 2= No

18. If yes, what are the main causes of soil infertility?

____

____

19. Do you own livestock? 1=Yes 2=No

20. Fill in the table below:

Type of Livestock	Number
Cattle	
Goats	
Poultry	
Sheep	
Other specify	

2. Adoption of Soil Nutrient Replenishment Technologies

1. List the SNRTs you have adopted, abandoned or not tried at all in your farm and the reasons in the tables

Technology	Rank	Reason for Adoption

2. Have the technologies improved your soil? 1=Yes 2= No

3. If yes, how?

____

____

4. Have the technologies improved your crop yields? 1=Yes 2=No

5. Are there any of the technologies you plan to abandon? 1=Yes 2=No

6. If yes, which ones and why? Fill in the table below

Technology	Reason for abandonment

3. Non-Adoption of Soil Improvement Technologies

1. If yes, which of the SNRTs have you tested and for what reasons. Fill in table.

Technologies tested	Reasons for testing

2. Which ones did you abandon and for what reasons? Fill in table.

Technologies abandoned	Reasons

3. Which technologies didn't you test despite knowing them? Fill in table

Technology never tested	Reasons

4. Why haven't you adopted any of the technologies? Fill in table

Technology not adopted	Reason

5. Do you intend to adopt them in the future? 1=Yes 2=No

6. What recommendations would you give in order to increase the adoption of rejected technologies?

____

____

4. Access to and Control of Resources Profile

RESOURCES	ACCESS		CONTROL	
	WOMEN	**MEN**	**WOMEN**	**MEN**
Land resources				
Financial resources				
Labor resources				
Physical resources				

5. Division of Labor Profile

Household Size: Male adult members________ Female adult members________

Fill in the table below appropriately

Member	Farm activities No. of hrs/ day	Domestic activities No. of hrs/day	Community activities No. of hrs/day
Male adult			
Female adult			
Male child			
Female child			
Elderly male			
Elderly female			
Hired laborer			

3. Do you hire casuals? 1=Yes 2= No

4. If Yes, how Often? 1=Rarely 2=Occassionally 3=Always 4=Everyday

5. For what activities do you hire labor?

____

____

____

6. Do you work elsewhere as a casual/ Employed? 1=Yes 2=No

Where____________________ Why____________________________________

7. How many days in a month do you work away from your farm____________________

6. Decision Making Profile

1. What rights do you have over the land? 1=Title deed 2=Customary rights 3= User

2. Is your land registered? 1=Yes 2=No

3. Under whose name is the land registered 1= Husband 2= Wife 3=Both 4= Other specify

4. Who is the farm manager? 1= Male manager 2= Female manager 3=Both 4= Hired manager

5. Who makes decisions on SNRTs to be adopted? 1=Male HH head 2=Female HH Head 3=Male HH member 4=Female HH member

6. Whose ideas and opinions carry the greatest weight during decision-making?
   1=Man 2=Woman 3=Both

7. Extension services

1. Do you receive any extension advice? 1=Yes 2=No

2. If Yes, how often? 1=Occasionally 2=S/times 3=Always
   4=Every day

3. What is mainly the gender of the extension officers? 1=Men 2=Women

8. Participation and Inclusion

1. How did you know about the technologies?

2. Do you attend project meetings/FGDs/Field Days? 1=Yes 2= No

3. If Yes, How many? a) Field days/yr________ b) village training w/shops ________
   c) Problem diagnosis meetings/yr_______ d) nursery group meeting/month ________

4. What are the reasons of your attendance trend?

____

____

10. Access to Credit

1. Do you get access to money lending facilities? 1=Yes 2=No

2. If yes, which credit lending institutions?

____

____

3. What do you use the credit for?

____

____

4. Does the money support your adoption of SNRTs? 1=Yes 2=No

b) If No, Why? ______________________________

5. If you do not receive credit, what are the reasons?

____

____

6. Does your lack of credit affect your ability to adopt SNRTs? 1= Yes 2=No

7. If Yes, how? ______________________________

11. Level of Education

1. What is your level of education? Tick appropriately. 1= None 2=Lower Primary 3=Upper primary 4=Lower Secondary 5=Upper secondary 4=Tertiary

2. Does your level of education influence your understanding of SNRTs? 1=Yes 2=No

3. If Yes, Which specific technologies are you not able to take up due to your level of education and why?

____

____

4. What would you recommend for easier learning and understanding of technologies?

____

____

12) Farmers' groups

1. Do you belong to any project group? 1=Yes 2=No

2. If yes, how does your membership improve your understanding of SNRTs?

____

____

Appendix 2: Gender daily labor calendar

WOMEN		MEN	
TIME	**ACTIVITY**	**TIME**	**ACTIVITY**

Appendix 3: House holds resources access to and control profile

RESOURCES	ACCESS		CONTROL	
	WOMEN	**MEN**	**WOMEN**	**MEN**
Land				
Inputs				
Income				
Farm Equipment				
Labor				
Capital				
Credit services				
Livestock				