

**FARMERS' DECISION-MAKING IN THEIR PREFERENCE FOR
SOIL NUTRIENT REPLENISHMENT TECHNOLOGIES IN THE
CENTRAL HIGHLANDS OF KENYA //**

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**A thesis submitted in partial fulfillment of the requirements for the degree of
Master of Environmental Studies (Agroforestry and Rural Development) in the
School of Environmental Studies and Human Sciences of Kenyatta University**

OCTOBER 2006

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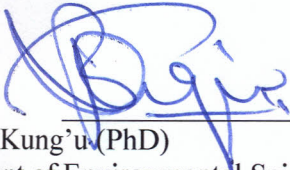
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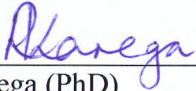
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DEDICATION

To my parents Mr. and Mrs. Muriu, for their prayers, love and encouragement, throughout my studies.

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ABSTRACT

Soil erosion, reduced land productivity, population pressure on land, low income, inappropriate and inadequate use of farm inputs such as fertilizers are some of the interrelated problems experienced and affecting smallholder farmers in Kirege location of Meru South District. These problems have culminated in increased food insecurity in the area over the years. In an effort to address these problems, soil nutrient replenishment technologies have been introduced in the area through collaborative research. Positive results have been reported from the use of tithonia, calliandra, leucaena, mucuna and crotalaria biomass. Some farmers have adopted the introduced soil nutrient replenishment technologies; others have tested and opted out over the years while others have never attempted using the technologies. The main objective of this research was to establish the criteria used by farmers in their decision to reject, abandon or adopt the above-mentioned soil nutrient replenishment technologies. Data were collected using key informant interviews, structured interview schedules and focus group discussions. The sample comprised of 74 respondents, 45% male and 55% female. Of those interviewed, 61% were between the age of 31-50 years. The research generated both qualitative and quantitative data. Means, percentages, spearman rank correlation and ANOVA were utilized for analysis. Results show that leucaena tree biomass was used as incorporation materials by 7% of the respondents as compared to 16% who used it as fodder supplement. Preference for calliandra had increased from 7% at the testing stage to 18%. There was a clear gender effect on the criteria used by farmers' in taking up soil nutrient replenishment technologies. Marketing, fodder value, fuel value, labour requirement and land availability were found to differ significantly ($P < 0.05$) in their rating between male and female farmers. The need to closely monitor the adoption and adaptation of soil nutrient replenishment technologies was noted, as the success in the acceptability of the soil nutrient replenishment technologies is dependent on socio-economic constraints of the target group. This is demonstrated using tithonia which was seen to have lost popularity among farmers dropping from 29% at the testing stage to 22% at the adoption stage; however, another 18% of the farmers were utilizing it as mulch or cattle bedding for quality manure without incorporating it directly into the soil as was first introduced.

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ABBREVIATIONS AND ACRONYMS

TSBF	Tropical Soil Biology and Fertility
CIAT	International Centre of Agriculture and Technology
MoA	Ministry of Agriculture
LCDs	Less Developed Countries
KARI	Kenya Agricultural Research Institute
WAC	World Agroforestry Centre
VLIR	Flemish Interuniversity Council
FAO	Food and Agriculture Organisation
CIMMYT	International Maize and Wheat Improvement Centre
WHO	World Health Organisation
SPSS	Statistical Package for Social Sciences
SNRT	Soil nutrient replenishment technologies

OPERATIONAL DEFINITION OF TERMS

- Food security: A situation in which all people at all times have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preference for an active and healthy life (FAO, 1999)
- Household size: Number of individuals who rely on the household head for livelihood excluding employees
- Cultivated land: Land under food crop production at the time of research
- Soil nutrient replenishment technologies: These are farming practices which have been researched and passed on to farmers as appropriate practices for improved soil fertility and increased food security

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Declining soil fertility has led to a marked decline in land productivity. For this reason, land users are being encouraged to adopt soil improvement technologies (Franzel *et al.*, 2002a). Researchers have identified the use of grain legume cover crops and biomass transfer technologies as potential nutrient replenishment technologies. This is due to their cost effectiveness, appropriateness, simplicity and multipurpose nature in meeting the needs of the resource poor farmers. The soil nutrient replenishment technologies have however not been adopted by the farmers as anticipated by the researchers (Adiel, 2004).

Several syntheses of biophysical aspects of soil nutrient replenishment technologies exist, however, such is not adequate on the socio-economic aspects of preference by farmers (Franzel *et al.*, 2002a). To understand the choices farmers make, it is important to determine their decision-making process in their adoption or rejection of soil nutrient replenishment technologies. It is also important to establish the criteria farmers use in their preference for specific nutrient replenishment technologies. This was investigated in this study. The criteria used by farmers in their decision-making and the influence of socio-economic factors on the farmers' preference for soil nutrient replenishment technologies were vital to the study.

1.2 Statement of the problem

Decline in crop yield is a major problem facing farmers in Kenya. In the Central Highlands of Kenya, this problem is exacerbated by rapid population growth (Republic of Kenya: Ministry of Finance and Planning, 2002). A lot of information on soil improvement technologies has been generated through collaborative research work between Kenyatta University and other research institutions such as Kenya Agricultural Research Institute (KARI), Tropical Soil

Biology and Fertility Institute of CIAT (TSBF-CIAT) and World Agroforestry Centre (WAC) in Meru South District. Despite these efforts, soil fertility decline and consequently food insecurity continues to be a major problem among resource poor smallholder farmers. The process that lead farmers to either adopt or reject given nutrient replenishment technologies within different households is not clearly understood. There is increasing emphasis on targeting the interventions towards poor farmers in the Central Highlands of Kenya; few adoption studies have been conducted to assess the uptake of new practices by farmers (Phiri, 2004). This study sought to determine why the level of uptake of soil nutrient replenishment technologies introduced to farmers is low contrary to the researchers expectation.

1.3 Research questions

The study sought to answer the following questions:

1. What criteria do farmers use in their decision to take up soil nutrient replenishment technologies?
2. Do different criteria vary in importance among male and female farmers in their decision to take up soil nutrient replenishment technologies?
3. How have the criteria influenced the uptake of various soil nutrient replenishment technologies by farmers?
4. How does the cultivated land size, size of the household, gender and household labour availability influence the uptake of soil nutrient replenishment technologies by farmers?
5. How does the level of influence on household decision-making of the individual trained on soil nutrient replenishment technologies influence uptake of a given soil nutrient replenishment technology?

1.4 Objectives of the study

The general objective of the study was to determine socio-economic factors influencing smallholder farmers' decision-making process in their adoption of soil nutrient replenishment technologies in the Central Highlands of Kenya.

The specific objectives of the study were:

1. To determine the criteria used by farmers in their decision to adopt soil nutrient replenishment technologies
2. To determine the relative importance of various criteria used by male and female farmers in their decision to take up soil nutrient replenishment technologies
3. To determine the relationship of the various criteria to overall preference for the soil nutrient replenishment technologies taken up by farmers
4. To assess the effect of Cultivated land size, size of the household and household labour availability in farmer's uptake of different soil nutrient replenishment technologies
5. To determine the extent to which the level of influence on household decision-making of the person trained has on uptake of soil nutrient replenishment technologies in the household

1.5 Research Premises

1. There are various criteria used by farmers in their decisions to take up soil nutrient replenishment technologies and the criteria have varying rating in importance
2. Criteria for taking up soil nutrient replenishment technologies vary in importance between male and female farmers
3. Different criteria influence preference of different soil nutrient replenishment technologies differently
4. Cultivated land size, size of the household, gender and household labour availability influence uptake of different soil nutrient replenishment technologies
5. There is low level of uptake of soil nutrient replenishment technologies in households where the person trained has low or no influence in the household decision-making processes

1.6 Justification for the study

The primary role of agricultural research is to enrich the understanding of the interaction and interdependence between production systems and farming communities. This requires a holistic approach to problem identification, analysis and solution finding. It is inevitable that scientists will dominate research and in this context it is important to stress that such research is unlikely to incorporate the full range of farmers' management practices. There are soil

nutrient replenishment technologies, which have been proven beneficial and economically viable by researchers. These technologies have not been taken up by farmers as anticipated by the researchers. The current study set out to determine the criteria used by farmers in their preferences for soil nutrient replenishment technologies and how household characteristics affect the taking up of introduced soil nutrient replenishment technologies.

1.7 Significance of the study

Determining farmers' decision-making processes in their preference for soil nutrient replenishment technologies has a significant impact on various stakeholders involved in improving livelihood of smallholder farmers. Researchers will report progress in meeting their objectives, understand the impact of technologies, provide feedback on the problems encountered and integrate lessons learnt in the process towards enhancing the adoption of soil nutrient replenishment technologies. This understanding will help in improving approaches used in 'selling' the technologies. This in turn will lead to increased willingness among farmers to test and eventually adopt soil nutrient replenishment technologies beneficial to them depending on their diverse needs and varied circumstances.

The research findings are expected to help extension workers and researchers in modifying their messages to encourage a higher participation rate of target farmers. The study will also identify the farm and household characteristics that influence technology preference and help researchers and extension staff in identifying and targeting farmers who are likely to adopt and spread a given technology, leading to high rates of technology uptake.

1.8 Conceptual framework

There are specific phases of decision-making and problem solving. The first phase involves recognition and definition of the prevailing issues. Problems may never be solved because

they are not recognized soon enough or at all. For example, farmers continue to increase soil acidity through inappropriate use of inorganic fertilizers because they do not recognize the association between decreased land productivity and fertilizer use. The second phase is gathering information about the problem; in this case information on improving soil productivity.

The third phase is the formation of tentative conclusions. This represents the solution to the problem identified, for instance increased appropriate use of organic and inorganic fertilizers. At this stage, many plausible solutions are formulated. The solution is exemplified as the various soil nutrient replenishment technologies. The fourth phase is testing the tentative conclusions. At this stage the tentative conclusions are assessed to test their reliability. The fifth stage is evaluation and decision-making. This is where the farmers would adopt and adapt or reject the technologies they already tested (Rogers and Shoemaker, 1971; Denning, 2001). The conceptual framework (Figure 1.1) represents the farmers' decision-making process, which may lead to the adoption or rejection of soil nutrient replenishment technologies (SNRTs).

According to the framework in Figure 1.1, from the demonstration site, the farmer learns of the soil nutrient replenishment technologies developed through research work. They then form an attitude on whether the technologies will work or not as influenced by the socio-economic factors. This could lead to the immediate rejection of the soil nutrient replenishment technologies or the need to test the soil nutrient replenishment technologies. The farmers select what to try on their farms subject to their socio-economic status and criteria of interest. The tested soil nutrient replenishment technology could then be abandoned or accepted as learnt from the demonstration site or adapted to the socio-economic characteristics of the farmers. The adopted technologies may then become part of the

household farming practice. This eventually leads to improved soil fertility and increased food security.

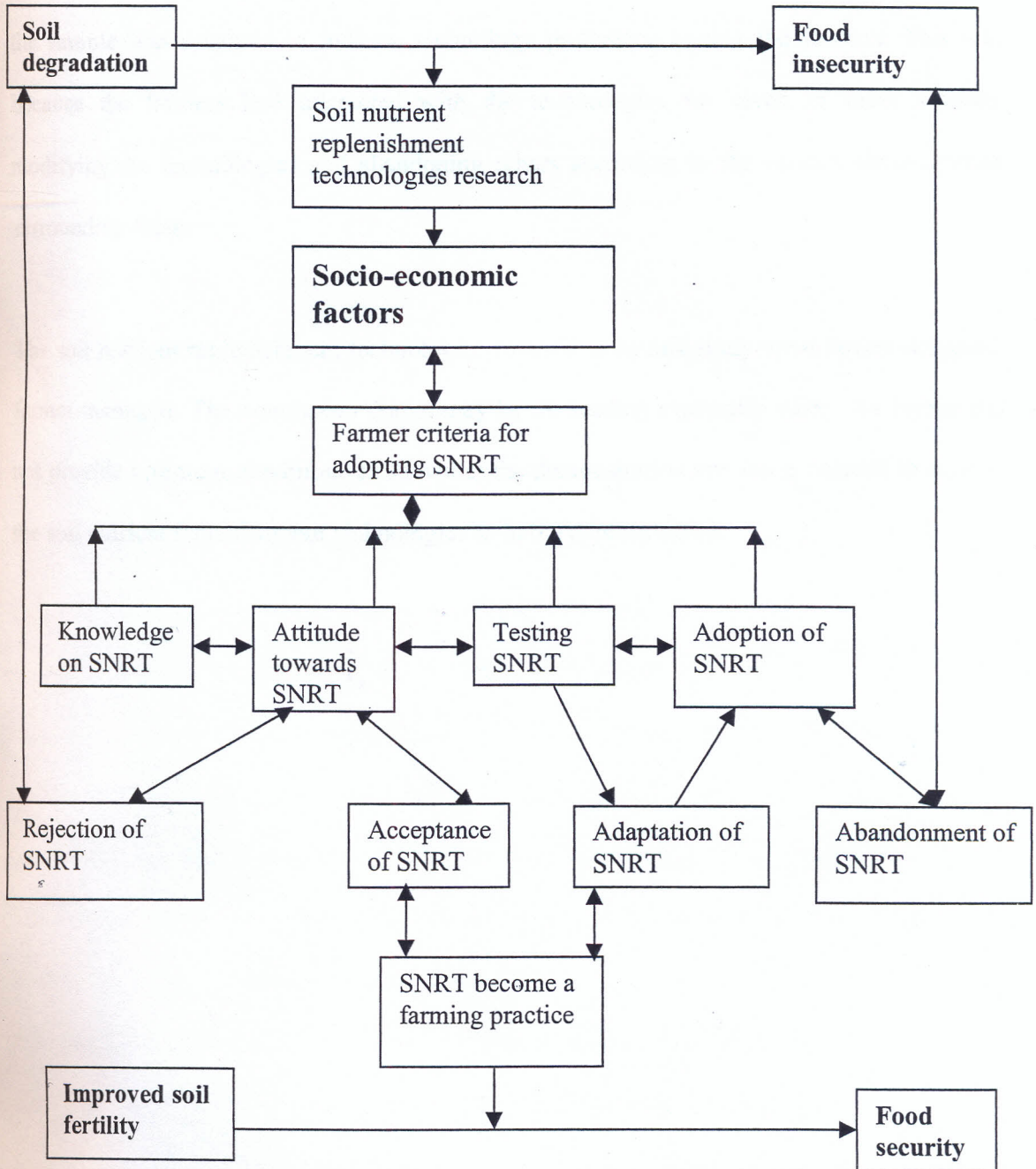


Figure 1.1: Conceptual framework of farmers' decision-making process in their preference for soil nutrient replenishment technologies in Kirege location

1.9 Limitations of the study

The farmers under study gave multiple responses in relation to the technologies being tested. Most farmers had tested more than one soil nutrient replenishment technology. While some technologies were widely tested, others were rarely tested. The technology representation in the sample was assumed to indicate technology preference among the farmers. This was because the farmers had interacted with the technologies for seven or more seasons, modifying the technologies and abandoning others according to the various circumstances surrounding them.

The soil nutrient replenishment technologies referred to in this study were farmer-designed, farmer-managed. The conclusion drawn may be misleading especially where the farmer did not provide optimum conditions as shown at the demonstration site but continued to refer to the soil nutrient replenishment technologies as in the demonstration.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

In many agricultural based economies of developing countries, environmental degradation mainly takes the form of soil nutrient depletion and loss of food production potential. Reversal of soil productivity decline and ensuring adequate food supplies to the fast growing population in the country poses a formidable challenge. There are complex inter-linkages between poverty, population growth and environmental degradation

(Shiferaw and Holdes, 1998).

Majority of the poor people in most developing countries, live in rural areas depending on agriculture for livelihood. According to FAO (1999) concerns for food security stem from unacceptability of the current levels of food insecurity, and the recognition that agriculture, will have to feed an increasing human population. Although the rate of population growth is increasing steadily, the increase in absolute numbers of people to be fed may be such that the carrying capacity of the agricultural land could soon be reached with the use of current technologies. Expanding food production to feed this increasing population while alleviating poverty through gainful employment in agriculture is a formidable challenge. Forno (1999) observes that experts agree that food needs in the developing countries will almost double but land and water are becoming increasingly scarce. Most new land brought under cultivation is marginal and ecologically fragile. It cannot make up for land being removed from cultivation each year due to urbanization and land degradation. Agricultural intensification is therefore critical if we are to feed the world from current existing agricultural land.

According to FAO (1997), national research organizations which include universities, research institutes and national agricultural research centres have made tremendous achievements in agricultural research. They have substantially added to some of the successes

that have contributed to increased and diversified food production. Among the long-standing problems faced by national agricultural research systems is dissemination of research findings. Few countries have formalized links between researchers, extension workers and farmers.

FAO (1997) notes that there is reason to believe that much of the earlier research work, which generated relevant data, is still retained within the agricultural research institutions. This means extension workers continue to impart outdated information and inappropriate messages to farmers. All over Africa, the traditional food supply system involving shifting cultivation is disappearing as population pressure results in shorter fallow period which lead to inadequately regenerated soils, and consequently reduced crop yield that culminate in food shortage and hunger (FAO, 1997).

Researchers have noted that there are few signs of technological progress in rural areas in Less Developed Countries (LDCs) with most farmers still unable to adopt highly mechanized tools, chemical input, high-yielding crop varieties, modern irrigation systems and other industrial techniques supplied by the green revolution. Ade'gbidi and Gandonuo (2004) noted that the extremely low adoption rate for these new methods, techniques and tools especially in less productive areas in Africa has renewed the interest of development workers and researchers in farmer-oriented innovation.

Land users are being encouraged to adopt soil improvement technologies that have the potential of resolving land degradation and food insecurity problems at minimal costs (Franzel *et al.*, 2002b). The use of grain legume cover crops and biomass transfer technologies have been identified by researchers as potential nutrient replenishment technologies due to their cost effectiveness, appropriateness, simplicity and multipurpose

nature in meeting the needs of the resource poor farmers. As a result, several soil nutrient replenishment technologies such as the use of organic fertilizer (green and farmyard manure) and tree planting are already being implemented intensively to combat soil erosion and improve soil fertility (Ade'gbidi and Gandonuo, 2004; Franzel *et al.*, 2002a; Mucheru, 2003).

2.2 Criteria for adopting soil nutrient replenishment technologies

To promote an increase in soil nutrient replenishment technologies for substantial increase in food production and environmental protection, it is important to understand the nature of limited-resources on family farms. In order to increase the acceptability and promote wider adoption, it is important to identify and analyse factors that affect adoptability of soil nutrient replenishment technologies by farm and households with differing characteristics such as household composition and gender of the household head (Franzel, 1999).

According to IPRA and CIAT (1991) agricultural research programmes oriented towards improving crop yield on smallholder farms focus their efforts on the search for improved technological alternatives. These take into account criteria such as yield, low agro-chemical input requirement, and resistance to diseases and once these promising technologies leave the demonstration site for example calliandra, they may prove unsatisfactory while technologies that did not appear promising in the demo site may be more acceptable to the farmers. The two parties (farmers and researchers) use different criteria. These criteria form the basis for establishing opinions or defining what is "ideal". IPRA and CIAT (1991) further notes that when a research programme defines the objectives for improving food security and when farmers make decisions, they use their own criteria as a basis for selecting from among different alternatives.

It is very important to know what farmers perceive as benefits and drawbacks in order to provide feedback to researchers and extension agents for redefining their approaches

(CIMMTY, 1993). Studies directed at the adoption of innovations by farmers have enumerated several factors as the most likely to affect adoption. These include; biophysical adaptation of the innovation to the farmers environment, return to land and labour, farmers' awareness of the innovation, access to land, labour and water, access to social capital especially where group action is needed, availability of essential inputs particularly seeds, access to financial capital and the degree of risk and uncertainty (Franzel, 1999; Place and Dewees, 1999; Denning, 2001; Mucheru, 2003). In assessing the adoption potential of improved fallows in Eastern Zambia, Franzel *et al.* (2002b) highlighted wealth level and gender as the most important variables influencing adoption of the technology. The study also noted labour availability as another important variable that researchers need to monitor carefully in studying farmers uptake and appropriateness of a technology for different types of farmers decision.

In discussing the importance of establishing farmers' criteria, IPRA and CIAT (1991) outlined the possible achievements of this exercise. First, we are able to capture farmers' practical knowledge about their environment and incorporate it in their selection. This will enhance compatibility between researchers and farmers in their interpretation of the farmers' environment. Secondly, we understand the farmer's different priorities among these criteria. Even when farmers' criteria agree with those of researchers, there can be differences in the priority or weight assigned to the same criterion, which will cause different decisions to be made about technology.

Thirdly, we understand farmer's decision-making process when faced with alternative technologies i.e. why and how a farmer makes a decision when faced with choices. Fourthly we understand what terms such as "better", "improved" and "increased" mean to farmers. This gives a guide to farmers' expectations, which play an important role in their initial motivation and farmers' decisions when confronted with new technologies.

Finally, we are able to detect opportunely criteria unknown to researchers and the important changes that occur in the farmer's priorities for these criteria. In the face of seasonal climatic changes, new market conditions, population movements, or shift in family organization, a farmer could change from market production to producing for household consumption. Consequently the criteria for choosing will undergo substantial modifications. Establishing farmers' criteria makes it more likely that improved or recommended technologies arising from research will correspond to farmers needs more accurately.

Franzel (1999) concluded that the conventional criterion in technology evaluation of comparing yield per hectare might not work in smallholder farms because it implies land as the most limiting resource on the farm. However, this is not always the case, nor is the same criterion necessarily equally important for different crop. Other criteria such as labour and niche were seen to constrain overall farm production and influence farmers' decision-making in their adoption of new technologies. In a recent study, Franzel *et al.* (2002b) notes that farmer designed and managed trials were important for determining farmers' evaluation criteria and obtaining farmers assessment of each technology across the criteria. He (Franzel *et al.*, 2002b) further noted that, labour availability did not appear to constrain farmers from testing improved fallow technology.

2.2.1 Evaluation of criteria for adopting Soil nutrient replenishment technologies

While net return to land is most relevant to farmers whose most scarce resource is land, the net return to labour is most relevant for those who lack household labour (Swinkel *et al.*, 2002). There is oppressive division of labour and patriarchy ideology that perpetuates and subordinates the status of a woman in agriculture. Women play a key role in ensuring food

security through their role in food production through farm and non-farm activities, which generate income for food purchase.

2.3 Types of soil nutrient replenishment technologies

The two most widespread and limiting nutrients to food production in Africa are nitrogen (N) and phosphorus (P). Research carried out in the Central Highlands of Kenya has shown deficiencies to be at the level of 57% and 26% for N and P respectively (KARI, 1994). These deficiencies are replenished by the use of inorganic fertilizers and cattle manure. However, use of inorganic fertilizers in the Central Highlands of Kenya is as low as 20 kg N and 10 kg P ha⁻¹. (Muriithi *et al.*, 1994). This is due to high cost of the inorganic fertilizer as well as the low quality and quantity of manure used (Kihanda, 1996). As a result, soil nutrient replenishment technologies have been developed. They are mainly organic in nature and they include the use of farmyard manure, *Tithonia diversifolia*, *Leucaena tricandra*, *Calliandra calothyrsus*, *Mucuna pruriens* and *Crotalaria ochroleuca* and their combination with inorganic fertilizer (Mucheru, 2003).

2.4 Soil nutrient replenishment technology ranking/scoring by farmers

Participatory enquiry enables the interviewer to elicit spontaneous response from the farmers regarding the criteria that they use in evaluating new technologies. According to Abeyasekere *et al.* (2002), evaluation can be made using all the criteria that the farmers regard as important. This is based on a range of scores for instance one to five with one representing very poor and five representing very good. This system allows a 1-5 score to be given to each variety resulting in a set of independent assessments which meets the requirement for most statistical analyses. This is different from the restricted form of scoring used by Fielding and Riley (2000) where the items to be evaluated are fixed and a predetermined number of votes distributed among them.

There is need for comparison of technologies as per farmers' evaluation on the basis of individual criteria and as well as farmers' overall preference for the soil nutrient replenishment technologies. This can be achieved by asking the farmers directly or by use of matrix ranking where the rank are averaged or totalled across the criteria to determine overall preference (Grandin, 1994; Nyende and Delve, 2004). Abeyasekere *et al.* (2002) suggests the use of weighted index to overcome the limitations of methods currently used. The procedure involves multiplying the score (1, 2, 3, 4, 5) for each criterion which may include; yield, speed of maturation, taste, marketability, disease and pest resistance and drought tolerance, by its corresponding weight. There may be reasonable ground or arbitrary choice for instance, 10, 8, 6, 4, 2 for farmers' 1st, 2nd, 3rd, 4th or 5th spontaneous response respectively. The results are then added across the criteria and finally dividing the answer by the sum of the weights. Weights can also be produced using farmers' collective view on the importance of the different criteria.

2.5 Influence of socio-economic factors on preference for soil nutrient replenishment technologies

The result of many rural development projects aimed at improving the living standards of the rural populations in the developing countries have often been poor. This is largely because, agricultural innovations propagated to increase agricultural productivity are not adopted by smallholder resource-poor farmers, as would be expected (Jürgen, 1993).

Smallholder farmers use a wide range of agro-ecological management techniques, resource management practices, and production strategies specific to their environment. These include; intensified agriculture, expanded market-orientation and increased capital and labour investment (Nyende and Delve, 2004). These are aimed at minimizing risk, enabling them to cope with changes and manage the environment (ecological, social and economic) in which they operate.

According to Franzel and Scherr (2002) adoption potential can be taken to mean feasibility, profitability and acceptability of a practice as viewed from the farmers' perspective. This means more than biophysical performance and profitability. Farmers are better involved if presented with a fairly broad number of options as far as species and systems are concerned as opposed to standard designs and programs. Availability of options enable farmers to choose those most suited to their household needs, resources and circumstances. Requirement and availability of land, labour and capital appear to influence adoption as much as or more than profitability does (Scherr, 1995).

Feasibility and acceptability are considered together because the feasibility of a technology is dependent on its value as perceived by farmers. It also depends on resource availability (land, labour and capital), availability of information and skills required and their ability to cope with any problems that may arise in the course of implementation. Acceptability includes profitability, feasibility and other range of factors difficult to quantify such as risk, general compatibility with farmers' values and farmers valuation of benefits which may include; ornamental trees, shade trees and boundary markers.

Abeyasekere *et al.* (2002) clearly illustrates the presence of gender effect in determining farmers' preference for various bean varieties where on average female farmers gave higher scores than the male farmers. Phiri *et al.* (2004) results indicate insignificant association between taking-up of improved tree fallows technology and gender though he reports evidence of association between takings up of the technology by farmers and their household wealth status. He (Phiri *et al.*, 2004) further notes that whereas the use of mineral fertilizers is strongly associated with high-income, male farmers, improved fallow system has been observed to be a gender-neutral and wealth-neutral technology. The diverse observations on influence of socio-economic factors on farmers' decision-making process call for an

understanding of these factors in relation to adoption and rejection of soil nutrient replenishment technologies.

2.6 Decision-making processes among farmers

There are specific phases of decision-making and problem solving. These are recognition and definition of the issues at stake, gathering of information about the problem, formation of tentative conclusions, testing of the tentative conclusions, and finally evaluation followed by decision-making.

Rogers and Shoemaker (1971) and Denning (2001) explain adoption by individuals as an innovation-decision process consisting of four stages. This is knowledge, where the individual is exposed to the existence of the knowledge and gains some understanding on how it functions. In the case of soil nutrient replenishment technologies, this would be the stage where the technologies are demonstrated on-station and farmers are given a chance to view them and are also trained on how to use them. Second stage is persuasion, where the individual forms a favourable or unfavourable attitude towards the innovation. Third stage is decision, where the individual engages in activities that would lead to a choice to either adopt or reject an innovation and finally, confirmation where the individual seeks reinforcement for the innovation decision with the option of reversing that decision based on increased experience with the innovation.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This research was carried out within an on-going project titled 'Integrated Soil Fertility Management for Improved Food Security in the Central Highlands of Kenya.' The soil nutrient replenishment technologies demonstration site at Kirege primary was set up in year 2000 and is still in existence. There are 14 (fourteen) soil nutrient replenishment technologies being demonstrated in the project. These are *Mucuna pruriens* (mucuna) alone, *crotalaria ochroleuca* (crotalaria) alone, cattle manure, *Tithonia diversifolia* (tithonia), *Calliandra calothyrsus* (calliandra), *Leucaena tricandra* (Leucaena), a combination of mucuna and fertilizer, a combination of crotalaria and fertilizer, a combination of tithonia and fertilizer, a combination of leucaena and fertilizer, cattle manure in combination with fertilizer, fertilizer full rate and a control experiment (Mucheru, 2003).

During the short rains season of 2001, 82 farmers had volunteered to test various technologies of their choice on-farm (Adiel, 2004). The farmers selected the technologies after observing them at the demonstration site. This was done during field days when farmers visited the experimental plots. During these field days farmers would be divided into groups of 10-15. A resource person who explained the treatment in each experimental plot accompanied each group. The farmers then evaluated the maize (the test crop) and rated the colour, vigour, height and size of the comb. They were then asked to choose at least one soil nutrient replenishment technology that they wished to test on their farms.

By the short rains season of 2002, the soil nutrient replenishment technologies being tested by the farmers on their fields had increased to 20 from the initial 14 as the farmers modified the technologies on their farms to suit their circumstances. Initially, the technologies were

researcher-designed farmer managed. At the time of this research, the technologies on the farmer's field were farmer-designed, farmer managed.

3.2 Description of the study area

The study was carried out in Kirege sub-location, Mugwe Location, Chuka Division, in Meru South District. The district is in Upper Midland Zone 2 and 3 (UM2 and UM3) and is a predominantly maize growing area, which is also referred to as main coffee agro-ecological zone. The altitude is approximately 1500 m above sea level. Annual mean temperature is about 20°C and annual rainfall varies between 1200 and 1500mm. The rainfall pattern is bimodal, falling in two seasons: long rains, (March-June) and short rains (October-December). The soils are Humic Nitisols, deep, well weathered with moderate to high inherent fertility (Jaetzold and Schmidt, 1983).

The farming system in the study 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. The major cash crops grown in the area are coffee (*Coffea arabica*) and tea (*Camelia sinensis*). Food crops include maize (*Zea mays*) and beans (*Phaseolus vulgaris*). Other food crops include potatoes (*Solanum tuberosum*), sweet potatoes (*Ipomea batata*), cassava (*Manihot esculanta*), bananas (*Musa spp*), various fruits and vegetables.

Most of the land is demarcated and owned individually under freehold system of land tenure. According to Republic of Kenya: Ministry of Finance and Planning (2002), Chuka Division is a high agricultural potential area. The area is also densely populated with 327 persons per square Kilometre; there is high pressure on land resources and intense competition between various farming enterprises in the area. Figure 3.1 shows the location of the study area.

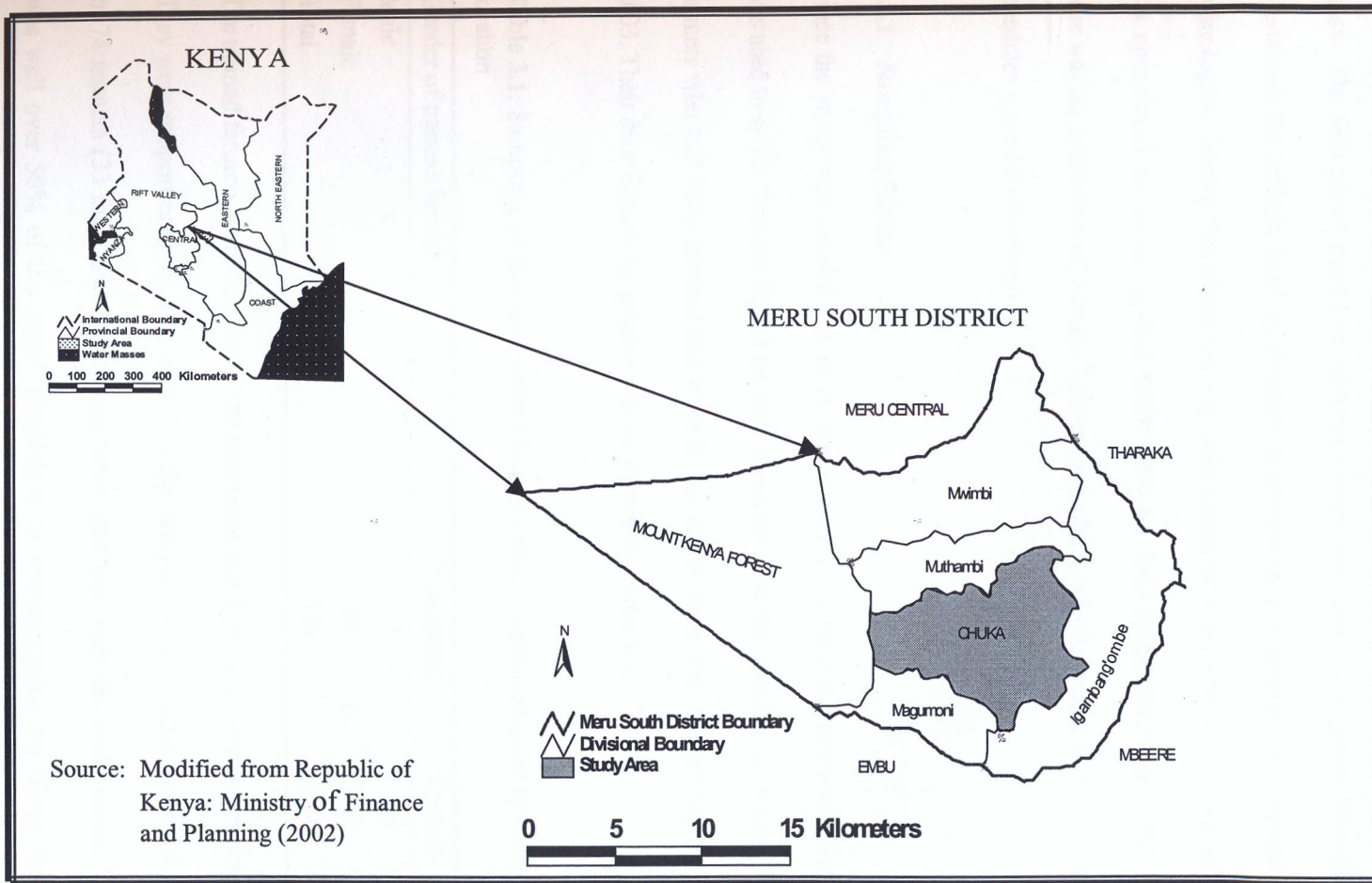


Figure 3.1: Location of Chuka Division in Meru South District, Eastern Province

3.3 Data collection

The study used both primary and secondary sources of data. The data were collected in two phases. The first phase used key informant interviews and focus group discussions. This was to establish the criteria used by farmers in accepting or rejecting soil nutrient replenishment technologies. During this phase the key informants were used to ensure that the sample frame was operational by ensuring that there were no individuals from the same household and there was no repetition of names. The second phase was the main survey in which interview schedules were administered.

3.3.1 Sampling frame

Since the study was carried out in an already existing project, purposeful sampling method was used to select farmers based on their attendance of the training activities. There were 156 farmers who had been trained and were trying out at least one technology by the end of year 2003. Their distribution by gender was as shown in Table 3.1.

Table 3.1: Sampling of farmers trained in soil nutrient replenishment technologies in Kirege location

Gender of trained farmer	Population	Sample	%
Male	70	33	45
Female	86	41	55
Total	156	74	100

The trained farmers were first stratified into male and female to ensure gender representation. They were proportionately represented in the sample i.e. 45% male and 55% female. A total of 74 farmers (33 male and 41 female) were selected from the study areas. The sample size was well over 50% of the target population as recommended by Mugenda and Mugenda (2003). Simple random sampling was used to obtain the final sample. The sample frame comprised farmers who had attended at least three field days and had tried at least one technology. The two strata (trained male farmer, and trained female farmers) were separately

given unique numbers. Using random numbers, 33 farmers were picked for male trained farmers and 41 farmers for female trained farmers.

3.3.2 Training of research assistants

Two research assistants were selected and trained on basic data collection skills. The ability to translate English to the local language was an important criterion for recruitment. Each item in the interview schedule was discussed in detail. This ensured they understood the intended meaning of the question. Training was also done on approaches for sensitive questions like the number of children, age and marital status. The procedures of facilitating focus group discussions and recording the discussions were also discussed.

3.3.3 Pre-testing the research instruments

A pilot study was conducted to test the suitability of the interview schedule. A sample of 5 trained farmers were randomly selected and interviewed. These farmers were excluded in selecting the final sample.

3.3.4 Key informant interviews

A sample of eight group leaders was selected from the farmers who had been involved in project activities at group leadership level. The study area was clustered into eight villages and a group leader was interviewed from each village. This was done using snowball sampling (referral) where the first group leader was identified from the village near the demonstration site (convenience sampling). He/she was asked to give a name of a group leader highly involved in the project activities from the neighbouring village. The gender of the leader from the next village was specified to arrive at a sample of 4 female and 4 male leaders. The key informants were used in convening the focused group discussions.

3.3.5 Focus Group Discussions (FGDs)

All those who participated in the focus group discussions came from the 156 farmers who had gone through the project training. The focus groups comprised men and women separately for comparison of the criteria for selecting soil nutrient replenishment technologies by gender.

The key informants were used to invite the farmers for the focus group discussions. Each key informant was asked to select from the list at least fifteen names of people of their gender who they could conveniently invite for the focus group discussions depending on their geographical location. They were to invite 12 of the 15 and confirm participation of at least 8. To avoid individuals being invited more than once, each key informant was given a list of names depending on the location. They were then asked to choose a convenient time within a period of two weeks when they could invite the farmers to the venue of the discussion. Some chose public places while others chose individuals' farms.

The discussions began with an introduction, where the purposes of the discussions were explained to the participants. Each participant introduced himself /herself to the rest of the group. This was followed by the discussions guided by the listed questions as shown in Appendix 1.

During the focus group discussions, the farmers were asked to discuss the criteria they use in adopting soil nutrient replenishment technologies. A research assistant conversant with the local language took notes of farmers' contribution, while the other facilitated the discussion. Individual farmers used these criteria in the main survey to score and rank the technologies.

3.3.6 Structured interview schedules

The structured interview schedule (Appendix 2) was prepared based on the objectives of the study. In this schedule both qualitative and quantitative data were collected face-to-face using a combination of open-ended and close-ended questions. This comprised the main survey. The interview schedule was administered to 75 respondents.

After selection of the respondents, careful administration of the questionnaire was carried out. A tentative work-plan was drawn. Each respondent was allocated a day and time tentatively when they would be interviewed. The research assistant was asked to confirm with the respondent and adjust the timing to the farmer's convenience. A total of three interviews were carried out per day. In each of the interviews, a research assistant gave directions on how to move from one area to another and assisted in case of difficulties in communication between the researcher and the respondent.

3.4 Data analysis

The first stage of data analysis was data cleaning. The questionnaire was examined to ensure it was complete and had been consistently filled in. The data were then coded and summary tables prepared on all the responses. Frequencies, percentages, range, mean and standard deviation, were derived from the responses.

The correlation between the gender, age, size of the household, cultivated land size and preference for soil nutrient replenishment technologies was carried out to determine how these socio-economic factors influence the decisions of the farmers to adopt soil nutrient replenishment technologies. This was done using Statistical Package for Social Sciences (SPSS). Table 3.2 shows a summary of the study objectives, variables, methods of data collection and analysis.

Table 3.2: Summary of variables, data collection methods and analysis tools used in the study

Objective	Variables	Method of data collection	Analysis tools
Determine criteria used by farmers in their decision to take up SNRTs	Criteria/Score	FGDS	-Averages -Percentages
Determine the level of importance criteria used by farmers in their decision to take up SNRTs	Criteria average score by technology /overall score of the SNRTs	Interview schedule	-Regression analysis -ANOVA
Determine relative importance of various criteria by gender Assess the effect of:	Gender/Average score	FGDS	ANOVA
a) Cultivated land size	SNRT/Cultivated land size	Interview schedule	ANOVA
b) Size of the household	SNRT/ Size of household	Interview schedule	ANOVA
c) Gender	SNRT/ Gender	Interview schedule	Spearman correlation ANOVA
d) Household labour availability	SNRT/ Labour hours per month	Interview schedule	ANOVA
Level of influence on household decision-making of the person trained has on uptake of SNRTs	Level of influence/SNRT	Interview schedule	Spearman correlation

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter contains a detailed presentation and discussion of the results of the study. These include, the characteristics of the respondents, household characteristics, and farmers' criteria for adopting soil nutrient replenishment technologies by gender. Farmers' preference for choosing soil nutrient replenishment technologies tested and adopted, technologies abandoned, and technologies never tried are also discussed. Farmers' rating for soil nutrient replenishment technologies according to identified criteria, effect of technologies on labour use and availability and influence of household members on decision-making processes are also presented and discussed.

4.2 Characteristics of farmers interviewed

4.2.1 Gender and age group of the respondent

In this study, the respondents were the farmers who had attended training by the VLIR project and had taken up at least one of the introduced soil nutrient replenishment technologies. There were more female (55%) than male (45%) respondents interviewed (Table 4.1). Majority of the respondents were between the age of 31-50 years, which made up 61% of the total respondents.

Table 4.1: Age group and gender of the trained farmers of Kirege location

Gender of the respondent	Age groups (years)										Total	
	21-30		31-40		41-50		51-60		> 60		n.	%
	n.	%	n.	%	n.	%	n.	%	n.	%		
Male	4	12	11	33	10	30	2	6	6	18	33	45
Female	6	15	15	37	9	22	5	12	6	15	41	55
Total	10	14	26	35	19	26	7	10	12	16	74	100

As shown in Table 4.1, there were more female farmers between the age of 31-40 years (37%) than the male farmers (33%) while there were more male farmers between the age of

41-50 years (30%) as compared to female farmers (22%). The findings of this study are in agreement with the work of other researchers such as Ayuk (1997), Adesina and Chianu (2002) and Adiel (2004) who reported that younger and energetic farmers were likely to adopt soil nutrient replenishment technologies as compared to older farmers.

In Peterson *et al.* (2004), testers and non-testers of technologies came from a wide range of age groups. However, the testers of soil nutrient replenishment technology tended to be middle-aged (30-45 years old). This was found to be true in this study where majority of the individuals practising at least one of the soil nutrient replenishment technologies were between the age of 31 and 50 years for both male (63%) and female (59%) respondents. These are highly productive farmers, and this may indicate that they perceive the soil nutrient replenishment technologies as economically viable and socially acceptable. The high percentage of young respondents could also be attributed to the willingness of younger people to learn and accept change as compared to the old. The results may also indicate that there is sustainability unlike if the soil nutrient replenishment technologies were popular among the older farmers as they are likely to cease being involved in active farming activities within a short period.

4.2.2 Nature of household headship

In this study, household head refers to the overall decision-maker within the homestead. As shown in Table 4.2, 82% of the households were male-headed while 18% were female-headed. In total, 12.2% of the households were female-headed mainly as a result of separation, death, or single-hood. Only 5.4% of the households were female-headed with the husbands present, of whom 2.7% were women from polygamous families.

Table 4.2: Nature of the household headship in Kirege location

Status of the household head in the household	Gender of the household head			
	Male (N = 61)		Female (N = 13)	
	n.	%	n.	%
Wife	-	-	2.0	15.2
Husband	54.0	88.5	-	-
Co-wife	-	-	2.0	15.4
Widower	3.0	4.9	-	-
Widow	-	-	7.0	53.8
Unmarried son	2.0	3.3	-	-
Unmarried daughter	-	-	1.0	7.7
Polygamous husband	2.0	3.3	-	-
Separated female	-	-	1.0	7.7

The nature of household headship in the study area agreed with Sullivan (2004) who reported that cases of female-headed households were extremely rare in the study carried out among rice farmers in Southern Senegal. However, in the present study area, widows become household heads, unlike in Southern Senegal, where widows had the option of re-marrying the husband's brother or other relatives, returning to their village or being part of adult children.

4.3 Criteria for choosing soil nutrient replenishment technologies

In this section, objectives one and two whose intentions were to determine the criteria used by farmers in their decision to adopt soil nutrient replenishment technologies, determine the importance of these criteria and determine gender disparity in the importance of these criteria were examined

The criteria for adopting technologies were derived from farmers themselves during focus group discussions. The farmers were given a rating scale of 1-5, representing the level of importance/influence, very high (5), high (4), medium (3), low (2) and very low (1). This scale was adapted from Abeyasekere *et al.* (2002). Improved soil fertility, soil erosion control, fodder value, pests and diseases resistance and the niche where the technology is

practised on the farm were the leading criteria for farmers' preference for soil nutrient replenishment technologies (Table 4.3).

Table 4.3: Farmers' criteria for choosing soil nutrient replenishment technologies in Kirege location

Rank	Farmer's criteria	Total groups average score
1	Green colour/vigour/yield	4.9
2	Soil erosion control	4.8
2	Other farmers experience	4.8
2	Dark colour, improved soil fertility	4.8
3	Fodder value	4.7
4	Pest and diseases resistance, survival rate, invasiveness	4.6
5	Availability (seeds, biomass)	4.5
6	Food values	4.2
6	Niche on the farm	4.2
7	Fuel	4.0
8	Marketability	3.8
9	Labour requirement	3.0
10	Land availability	2.8

The farmers scored crop performance very highly (4.9) and marketability was scored medium importance (3.8). This was because farmers hardly had enough to eat before they could consider selling. During the discussions, the farmers viewed land availability as a constant factor, which they were not in control of; hence it was not an influential criterion in their decision on choosing soil nutrient replenishment technologies. They also argued that since most of these trees used for soil nutrient replenishment grew as hedges, they did not take up cropland. In line with these arguments, the farmers scored the niche where the technology was being practised as very important (4.2) while land availability was of medium importance (2.8).

In this study, fodder value, availability of seeds and fuel production were very important criteria as was the case in Lapar and Ehui (2004). However, criteria or reasons for choice of a soil nutrient replenishment technology are specific to a people according to their socio-economic circumstance. For this reason some of the criteria mentioned in Lapar and Ehui (2004) were not mentioned in this study. These include, provision of shade, father's

recommendation and utilization as source of silkworm feed. In Mureithi *et al.* (1998), farmers were found to be aware of profitability of different farm enterprises, and to a large extent they used the perceived profitability as a criterion in allocation of labour and land resource. This was also established in the current study where increased yield was a very important criterion for choice of soil nutrient replenishment technologies.

Parents who saw the promising aspects of soil nutrient replenishment technology as a source of work for idle youth scored labour (3) medium importance. They argued that increased land productivity would lead to increased interest in land activities on the part of young people, who were fast taking up the technologies and using them in the production of horticultural products for commercial purposes.

As shown in Table 4.3, the experience of other farmers (4.8) was a very important criterion for the farmers taking up soil nutrient replenishment technologies in this study. These findings agree with Triomphe and Sain (2004), Gachene (2004), Peterson *et al.* (2004) and Gladwin *et al.* (2002). Triomphe and Sain (2004) established that abonera system (fertilizer bean), which was a farmers' name for the farming system, which used mucuna for soil improvement, was developed and diffused, without the intervention of formal extension services or formal incentive programmes, because farmers learnt from other farmers experience.

According to Gachene (2004), a number of farmers indicated that they adopted *marejea* after being pressured by their peer, especially women who indicated that they were highly influenced by other members in the women groups in which they were members. Peterson *et al.* (2004) observed that farmers who were not successful with their first attempt to test the soil nutrient replenishment technology continued to use the technologies after visiting other farmers because they were convinced that the technologies were working.

4.3.1 Rating of criteria for choosing soil nutrient replenishment technologies by gender

Gender effect was established in the current study where female farmers considered food, fodder and fuel value of the technology more important criteria in the adoption of soil nutrient replenishment technology as compared to the male farmers. Land availability was scored 2.2 (low importance) among male farmers and 3.5 (medium importance) among female farmers. Marketability was scored 4.7 (very high) by male farmers and 2.7 (medium) by female farmers. Green colour and vigour were scored highest (4.9) among male farmers, while food and fodder value were scored highest (5.0) among the female farmers (Table 4.4).

Table 4.4: Rating of farmers' criteria for choosing soil nutrient replenishment technologies by gender in Kirege location

Criteria for choosing soil nutrient replenishment technology	Groups average score		Significance level
	Male	Female	
Green colour/vigour/yield	4.9	4.8	0.599
Soil structure/moisture retention, dark colour, improved fertility	4.8	4.8	0.341
Erosion control	4.8	4.7	0.549
Food values	4.7	5.0	0.145
Niche on the farm	4.7	4.5	0.687
Pest and diseases resistance, survival rate, invasiveness	4.7	4.5	0.599
Availability (seeds, biomass)	4.7	4.3	0.418
Marketability	4.7	2.8	0.010*
Fodder value	4.3	5.0	0.010*
Other farmers' experience	4.0	4.3	0.515
Fuel value	3.3	4.7	0.018*
Labour requirement	3.0	3.0	1.000
Land availability	2.2	3.5	0.006*

Note: * Significant at $P < 0.05$

The higher scoring of fuel value, food value and fodder value by women as compared to men is because women are the ones who gather fuel wood, cut animal fodder and are directly responsible for providing food for the family. Fuel wood and its availability is a determinant of how fast food is prepared and how fast it is consumed. These have implication on the woman's time hence their effectiveness and efficiency in playing their role. While marketability was a very important criterion (4.7) to the male farmers, it was of medium

importance (2.8) to the female farmers. The female farmers were more interested in soil nutrient replenishment technologies that would directly improve household food security.

It was interesting to note that female farmers considered land availability more important criteria in rating soil nutrient replenishment technologies as compared to the male farmers. This is because land ownership and control are usually in the hands of men and women have to seek their approval on the activities they carry out on the land and on specific plots.

4.3.2 Scoring of soil nutrient replenishment technologies by criteria

The farmers used 10 of the 17 criteria generated during focus group discussions to score the soil nutrient replenishment technologies they used (Table 4.5). There were significant differences in criteria scoring among the technologies ($P < 0.05$). This indicates that uptake of different soil technologies is influenced by different farmers' criteria differently. There was significant difference ($P < 0.05$) between using no inputs (control) and using fertilizer in combination with manure, tithonia alone, calliandra alone and mulching with tithonia in regard green colour and increased yield.

The soil erosion control criterion was significantly different between fertilizer alone and tithonia alone, calliandra alone, leucaena alone, leucaena as fodder, incorporation with mucuna and mulching with tithonia. The overall rating was significantly different between using no inputs and using fertilizer in combination with manure and also tithonia incorporation.

Table 4.5: Average scoring of soil nutrient replenishment technologies by different criteria in Kirege location.

Soil nutrient replenishment technology	Criteria										
	1	2	3	4	5	6	7	8	9	10	11
Control	1b	1.2cd	0.8c	0.8b	0.0c	0.0d	2.5a	0.7c	0.0d	4.3a	1.5b
Fertilizer plus manure	4.5a	1.6bcd	2.8ab	3.0ab	0.3c	0.3cd	3.2a	0.7c	0.1d	2.7a	4.5a
Fertilizer alone	3.8a	0.8d	3.1ab	1.8ab	0.1c	0.3cd	3.8a	0.9bc	0.1d	4.2a	3.9ab
Manure alone	3.6a	1.4cd	2.2bc	3.4a	0.0c	0.3cd	3.9a	1.0bc	0.0d	3.0a	3.6ab
Crotalaria	2.8ab	1.3cd	2.3bc	2.0ab	0.3c	2.5abc	2.5a	1.3abc	0.0d	2.3ab	2.5a
Mulching with tithonia	4.3a	3.8a	3.7ab	4.2a	1.3bc	3.3ab	2.8a	2.0abc	1cd	3.2a	2.8ab
Mucuna incorporation	3.4a	2.8abc	3.8ab	3.6a	3.6ab	2.2abcd	2.0a	2.4abc	2.1ab	2.8a	3.6ab
Tithonia incorporation	4.4a	3.7a	4.2a	4.3a	2.3abc	4.4a	2.9a	3.3abc	1.1bcd	2.8a	4.4a
Leucaena as fodder	3.4a	3.3ab	4.0ab	3.9a	4.3a	1.7bcd	1.9a	3.4ab	3.1a	3.4a	4.1ab
Leucaena incorporation	3.7a	3.7a	3.7ab	3.0ab	2.3abc	1.7bcd	2.7a	3.7a	2.7ab	2.3a	3.7ab
Calliandra alone	4.3a	3.9a	4.3a	4.1a	4.5a	2.0bcd	2.3a	3.7a	2.9ab	2.1a	3.8ab

Notes: Numbers in each column followed by the same letter are not significantly different at $P < 0.05$

1 = Green colour/vigour/yield, 2 = Erosion control, 3 = Other farmers experience, 4 = Soil structure/moisture retention, dark colour, improved fertility, 5 = Fodder value, 6 = Pest & diseases resistance, survival rate, invasiveness 7 = Availability (seeds, biomass), 8 = Niche on the farm, 9 = Fuel value, 10 = Labour requirement, 11 = Overall score

Farmers showed high preference for soil nutrient replenishment technologies, which as shown in Table 4.5 they considered to be highly demanding on labour. These technologies include calliandra, alone which rated low (2.1) in labour requirement and high (3.8) in overall rating. Manure in combination with fertilizer was rated medium (2.7) in labour requirement and high (4.5) in overall rating. This study also concurs with Franzel *et al.* (2002b) in that though there was a negative correlation between labour requirement and the overall rating of the soil nutrient replenishment technology, this relationship was not significant ($P < 0.05$). In this study, there was a significant difference ($P < 0.05$) in the rating of the various criteria as it relates to the different soil nutrient replenishment technologies. This conclusion varied from the conclusions of Swinkel *et al.* (2002) that farmers' assessment of hedgerow intercropping technology for improving soil fertility in Western Kenya was less reliable. This was evidenced by disparities in their opinion on yield response, appreciation of the practice and willingness to plant new hedges. He noted that farmers' assessment was biased towards positive assessment as criticism was considered impolite in their culture and also because positive assessment would lead to increased favours from the researchers. Swinkel *et al.* (2002) also argued that the farmers compared the technologies with other technologies they use instead of "with" or "without" the technology scenario; this was also established in this study.

From the above discussion, the hypotheses that criteria for taking up soil nutrient replenishment technologies vary in importance between male and female farmers; different criteria have varied levels of importance to farmers in their decisions to take up soil nutrient replenishment technologies and, different criteria influence uptake of different soil nutrient replenishment technologies differently failed to be rejected.

4.4. Farmers' preference for soil nutrient replenishment technologies

In this section, objective three whose intentions were to determine overall preference for the soil nutrient replenishment technologies and the influence of gender, labour availability and land size on the farmers' preference for the soil nutrient replenishment technologies was examined. The study established that farmers' first preference was fertilizer used together with manure, as was the case at the testing stage (Table 4.6).

Table 4.6: Comparison of current farmers' preference for soil nutrient replenishment technologies and the practices during 2001-2002 testing stage in Kirege location

Soil nutrient replenishing technologies	Testing stage						Adoption stage	
	Oct, 01		March, 02		Oct, 02		Oct, 04	
	N.	%	N.	%	N.	%	N.	%
Calliandra alone	-	-	2	1.3	8	3.9	7	9.5
Calliandra + fertilizer	-	-	3	1.8	5	2.4	3	4
Calliandra + leucaena	-	-	1	0.6	1	0.4	2	2.7
Calliandra + manure	-	-	3	1.8	-	-	1	1.4
Calliandra as fodder	-	-	-	-	-	-	15	20.3
Crotalaria + fertilizer	-	-	3	1.8	2	1	2	2.7
Control	6	7.3	4	2.5	-	-	5	6.8
Crotalaria	3	3.7	7	4.3	6	2.7	-	-
Fertilizer + manure	21	25.6	30	18.4	62	30.1	34	45.9
Fertilizer alone	13	15.9	32	19.6	23	11.2	18	24.3
Leucaena + fertilizer	2	2.4	2	1.3	6	3	3	4
Leucaena alone	-	-	1	0.6	3	1.5	2	2.7
Leucaena as fodder	-	-	-	-	-	-	12	16.2
Manure alone	6	7.3	5	3.1	15	7.3	31	41.9
Mucuna	3	3.7	8	4.9	9	4.4	1	1.4
Mucuna + fertilizer	3	3.7	9	5.5	7	3.4	1	1.4
Mucuna + fertilizer + manure	-	-	2	1.3	1	0.4	1	1.4
Mulching with tithonia	-	-	-	-	-	-	4	5.4
Tithonia + fertilizer	12	14.6	25	15.3	30	14.6	2	2.7
Tithonia + manure	5	6.1	8	4.9	5	2.5	3	4
Tithonia alone	8	9.8	18	11	23	11.2	11	14.9
Tithonia as manure	-	-	-	-	-	-	10	13.5
Total	82	100	163	100	206	100	74	100

Note: Testing stage data (October 2001, March 2002 and October 2002) was adapted from Adiel (2004)
Adoption stage data (October 2004) was collected in this study

Manure alone and fertilizer alone were consistently ranked among the highly practised soil nutrient replenishment technologies. This is associated to the low opportunity cost of

practising these soil nutrient replenishment technologies in terms of time since they are not new to the farmers in the area. They have only learnt more efficient ways of doing what they have been practising over the years.

4.4.1 Modification strategies for calliandra, leucaena and tithonia for incorporation

Calliandra, leucaena and tithonia were introduced in the demonstration sites mainly as sources of biomass for the purpose of incorporating into the soil for improved soil fertility. Farmers were also taught that calliandra and leucaena are used as sources of fodder. Among the notable modifications of the soil nutrient replenishment technologies were the use of calliandra and leucaena solely as sources of fodder and the use of tithonia as mulch or cattle bedding without incorporating them into the soil. The use of calliandra and leucaena as incorporation material either alone or with other inputs had increased since the testing stage, while the use of tithonia for incorporation had decreased (Table 4.7).

Table 4.7: Preference for calliandra, luecaena and tithonia as incorporation materials compared to other uses in Kirege location

Season	Calliandra		Leucaena		Tithonia	
	Incorporation	Fodder	Incorporation	Fodder	Incorporation	Mulching/manure
	(%)	(%)	(%)	(%)	(%)	(%)
Oct, 01	-	-	2.4	-	30.5	-
March, 02	5.5	-	1.9	-	31.2	-
Oct, 02	6.7	-	4.5	-	28.7	-
Oct, 04*	17.6	20.3	6.7	16.2	21.6	18.9

Note: Testing stage data (October 2001, March 2002 and October 2002) was adapted from Adiel (2004)
Adoption stage data (October 2004) was collected in this study

The study established that, 20% of the respondents used calliandra as a source of fodder while 18% incorporated it directly into the soil, either alone or in combination with other inputs. Tithonia alone or in combination with other inputs was incorporated directly into the soil for the purpose of improving soil fertility by 22% of the respondents while 19% used it either as cattle bedding to improve the quality of manure or for mulching. The use of tithonia

alone or in combination with other inputs for incorporation had declined in popularity, with only 22% of the respondents practising it in the current study compared to 29% on average at the testing stage.

The increased popularity of calliandra and leucaena as fodder and tithonia as mulch or cattle bedding material is explained by the little or no extra time taken up from the available household labour hours to search for fodder or cut cattle beddings for use in farmyard manure preparation. These were part of the household activities even before the introduction of the soil nutrient replenishment technologies. Another explanation for the popularity of calliandra and leucaena as sources of fodder is; that they serve as protein supplement for cattle and goats hence farmers do not have to buy dairy meals.

In this study incorporation of tithonia alone showed a decline in popularity, which contrasts the findings in Adiel (2004), who reported that tithonia alone increased in popularity over the seasons and recorded the highest benefit cost ratio followed by tithonia used together with fertilizer in a study in the same area. She associated this with lack of knowledge on the utility of the shrub in soil nutrient cycle. This was not the case in the current study since even those who found incorporating tithonia into the soil laborious, were using it as a farmyard manure ingredient or as a mulching material with the hope of reaping the benefit of increased yields demonstrated by tithonia when used as green manure.

Table 4.8: Reason for continued use of soil nutrient replenishment technologies by farmers in Kirege location

Reason practising soil nutrient replenishment technology	% farmers giving the reason for continued practice											
	1		2		3		4		5		6	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
Available during dry season	8	53	-	-	-	-	-	-	-	-	1	9
High crop yield	2	13	6	60	8	42	15	44	8	53	5	45
Improved soil structure	1	7	3	30	-	-	6	18	-	-	1	9
Improved soil fertility	2	13	6	60	3	16	10	29	8	53	9	82
Easy to use	5	33	3	30	8	42	7	20	13	87	1	9
High fodder value	12	80	5	50	-	-	-	-	-	-	1	9
Readily available	3	20	-	-	4	21	21	62	11	73	6	55
Reduce erosion	7	47	6	60	-	-	-	-	-	-	-	-
Nice fence	-	-	3	30	-	-	-	-	-	-	-	-
Pest control	-	-	-	-	-	-	-	-	13	87	4	36
Total farmers	15	100	10	100	19	100	34	100	15	100	11	100

Note: 1 = Calliandra as fodder, 2 = Calliandra as green manure, 3 = Fertilizer alone, 4 = Fertilizer in combination with manure, 5 = Mulching with tithonia, 6 = Tithonia alone

The study established that farmers had modified the technologies to suite their circumstances.

They reported using calliandra as fodder instead of incorporating the biomass into the soil as was being done at the demonstration site. Majority of the respondents using calliandra as fodder (80%) gave high fodder value as the main reason for the modification (Table 4.8).

Other reasons cited were reduced ease to use 33% while incorporating it into the soil. This study was in agreement with Adiel (2004), Lapar and Ehui (2004) and Peterson *et al.* (2004) who reported that modification of luecaena and calliandra as fodder ranked high in preference. The reasons given by the farmers were that there was prevalent lack of fodder in the area and calliandra and luecaena formed a rich source of fodder at no extra demand on available labour.

Control of soil erosion was also given as a reason for continued use of calliandra (47%) and luecaena (33%). Availability during dry season was given as a reason for using calliandra as fodder by 53% of the respondents. These findings were in agreement with Stur *et al.* (2002)

who established that, the species of calliandra and leucaena were preferred because they remained green and available during drought and responded to soil conservation needs in the farming system.

Lapar and Ehui (2004) argue that unlike natively occurring forage species (in this case equated to technologies familiar to the farmers such as fertilizer and manure) such as native grasses, planted forages (in this case equated to the newly introduced soil nutrient replenishment technologies such as calliandra) requires some capital. Capital use is required at the start of the establishment, in the form of seeds for propagation, labour to establish them on farm and other costs associated with initial establishment of the technology.

Extension services are also necessary to provide technical assistance in proper management of the technologies. This could to a large extent explain why the preference for manure used together with fertilizer had remained highest over the years in the study area. It could also explain why the modifications of the soil nutrient replenishment technologies are eliminating the requirement for incorporation of materials, which is highly demanding on labour.

Majority (62%) of the farmers using fertilizer in combination with manure reported they continued to use the technology, because the inputs were readily available as opposed to 21% who reported fertilizer alone to be readily available. This was mainly because fertilizer requires to be purchased using cash which is scarce compared to manure that is locally prepared by farmers, as majority of them keep cattle in their farms.

4.4.2 Preference for soil nutrients replenishment technologies by gender

Fertilizer plus manure was the most prevalent soil nutrient replenishment technology for both male (45%) and female respondents (47%) followed by manure alone (42%) for both male

and female respondents. Fertilizer alone followed these for the male farmers (35%) and calliandra as fodder for female farmers (35%) (Table 4.9).

Farmers practised more than one technology in their farms, hence, the total number of technologies practised were more than the total number of farmers interviewed. The use of calliandra as fodder was more prevalent among female farmers (35%) compared to male farmers (26%). The same case applied to use the leucaena as fodder, which was reported by 19% of the female farmers compared to 13% of the male farmers. This was because feeding cattle is mainly the responsibility of the women.

Use of fertilizer alone was more prevalent among the male farmers with 35% of the male farmers preferring fertilizer alone compared to 16% of the female farmers. This was because men manage most financial transactions and women have to request from the men and it is not always that their requests are a priority to the men. Use of tithonia for incorporation into the soil was reported by 26% of the male farmers compared to 14% of the female farmers. This was because the female members of the family spend a lot of time on reproductive role and they are also expected to make an input in productive roles; hence they have little time to spare for additional activities such chopping and incorporation of tithonia.

Use of manure alone had equal preference among the male and female farmers (42%) because manure is mainly prepared within the household and therefore it is readily available to both male and female members of the household.

Table 4.9: Farmer preference for soil nutrient replenishment technologies by gender in Kirege location

Soil nutrient replenishment technology	Gender of the farmer practising the soil nutrient replenishment technology					
	Male		Female		Total	
	N.	%	N.	%	N.	%
Fertilizer alone	11	35	7	16	18	24
Manure alone	13	42	18	42	31	42
Fertilizer + manure	14	45	20	47	34	46
Tithonia incorporation	8	26	6	14	14	19
Calliandra incorporation	4	13	7	16	11	15
Leucaena incorporation	1	3	4	9	5	7
Calliandra as fodder	8	26	15	35	23	31
Leucaena as fodder	4	13	8	19	12	16
Mucuna incorporation	2	6	1	2	3	4
Crotalaria incorporation	1	3	1	2	2	3
Tithonia as mulching	8	26	6	14	14	19
Control	2	6	3	7	5	7
Total farmers	31	100	43	100	74	100

According to this study, when women had control over resources, they tended to use them differently from the men in their choice of cropping activities. Male and female farmers were exposed to the same training but utilised the knowledge acquired differently. This was indicated by varying levels of prevalence of the soil nutrient replenishment technologies between genders.

Fertilizer in combination with manure was the most prevalent soil nutrient replenishment technology among the male (45%) and female farmers (46%) while fertilizer alone was more prevalent among the male farmers (35%) compared to the female farmers (16%). In studying the adoption of fertility technologies by women farmers in Southern Senegal, Sullivan (2004) found out that use of chemical fertilizer was uncommon among all farmers and extremely rare among female farmers.

4.4.4 Influence of farm size and household size on the soil nutrient replenishment technology practised

As shown in Table 4.10, the average total farm size for the study sample was 0.65 hectares with a wide range of 0.36-1.38 hectares. On average 0.36 hectares was utilized on cash crops (coffee and tea) compared to 0.2 hectares for food crops. The average household size was 4 individuals. There was no significant relationship ($P < 0.05$) between the technologies practised and farm size or size of the household (Table 4.10). This was because the size of household did not necessarily indicate labour availability, as there were those who were too young or had other occupations other than farming. There were also farmers who had other sources of labour other than the household for instance hired labour.

Table 4.10: Average farm size and household size for farmers practising different soil nutrient replenishment technologies in Kirege location

Soil nutrient replenishment technologies	Average farm size (ha)			Average size of household
	Total	Cultivated with food crops	Cultivated with cash crop	
Fertilizer alone	0.60	0.20	0.36	3.9
Manure alone	0.57	0.16	0.32	4.3
Fertilizer + manure	0.57	0.20	0.32	3.9
Tithonia alone	0.65	0.20	0.32	3.9
Calliandra alone	0.77	0.24	0.40	3.9
Leucaena incorporation	0.77	0.28	0.45	3.3
Leucaena as fodder	0.36	0.12	0.24	4.3
Mucuna incorporation	0.61	0.20	0.36	4
Crotalaria	0.69	0.20	0.36	2
Mulching with tithonia	1.38	0.24	0.77	4.2
Control	0.60	0.16	0.32	3.7
Total	0.65	0.20	0.36	3.9
P	0.357	0.862	0.446	0.524

According to the study, there was no relationship between the soil nutrient replenishment technology practised and land size or size of the household. This concurs with the findings of Franzel *et al.* (2002b) who reported that farm and household size were not very useful in explaining farmers' rating of interest in planting soil improvement species. Ayuk (1997) found out that the number of individuals in the household affected the adoption of soil

nutrient replenishment technologies, stating that an increase in the number of people in the household resulted in a decrease of the probability of adoption. This relationship was not established in this study.

In discussing the adoption of planted forages by smallholder dairy farmers in the Coastal Lowlands of Kenya, Mureithi *et al.* (1998) observed that farmers rented in land for planting forages but fodder trees could not be planted in the rented land. This was associated to the permanent nature of these trees, which included *Leucaena leucocephala* and *Gricidia sepium*.

In Triomphe and Sain (2004), subsistence workers accessing land primarily through rental agreements had the lowest adoption rates. In contrast, ranchers and medium-scale farmers (two groups relatively free of land constraints) had a high rate of adoption. This clearly showed that the security of access to land was a fundamental condition for investing in the newly introduced system. In the study area, farmers practised the technologies on the land they owned mainly through inheritance.

4.4.5 Abandonment of soil nutrient replenishment technologies by farmers

To capture technologies abandoned over time, only farmers who had tested and abandoned a given technology responded to this question. As shown in Table 4.11, a total of 8 soil nutrient replenishment technologies had been tried and abandoned by some farmers. In total leucaena and calliandra incorporation into the soil were the most highly abandoned technologies (14%). Calliandra alone was the highest abandoned technology by the male farmers (10%) and leucaena alone by the female farmers (19%). The high rate of abandonment by female respondents was because female farmers have less control over household and hired labour. It could also be because female members of the family are highly constrained on time as they

put many hours to household chores making activities that take up additional time undesirable.

Table 4.11: Soil nutrient replenishment technologies abandoned by farmers in Kirege location

Soil nutrient replenishment technology abandoned	Gender of the farmer					
	Male		Female		Total	
	N.	%	N.	%	N.	%
Calliandra alone	3	9.7	7	16	10	14
Crotalaria	2	6.5	2	4.7	4	5.4
Leucaena alone	2	6.5	8	19	10	14
Tithonia + manure	1	3.2	1	2.3	2	2.7
Tithonia alone	1	3.2	3	7	4	5.4
Mucuna	1	3.2	4	9.3	5	6.8
Control	1	3.2	-	-	1	1.4
Leucaena + manure	1	3.2	-	-	1	1.4
Total farmers	31	100	43	100	74	100

4.4.6 Reason for abandoning soil nutrient replenishment technologies

Since the project on which the study is based works with the farmer-groups, farmers who did not actively participate in-group activities gave failure of participation as a reason for abandoning leucaena (80%) and calliandra (20%), as they could not access seedlings or enhance their skills in practising the soil nutrient replenishment technologies. All the farmers who had abandoned use of tithonia alone gave the reason for abandoning as lack of enough time to chop and incorporate the biomass while 30% indicated that calliandra biomass was not available for incorporation during planting because they used the biomass as fodder during dry seasons. Some farmers 25% indicated that the neighbours cut (steal) the tithonia since it grows along the fences by the roadside (Table 4.12).

Table 4.12: Reasons for abandoning soil nutrient replenishment technologies use in Kirege location

Reason for abandoning soil nutrient replenishment technology	Number of farmers giving the reason for abandoning the practice													
	1		2		3		4		5		6		7	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Competition	3	30	-	-	-	-	3	30	2	40	-	-	-	-
Preferred as fodder	3	30	-	-	-	-	3	30	-	-	-	-	-	-
No effect in the short run	-	-	1	25	-	-	-	-	-	-	-	-	-	-
Land limitation	-	-	1	25	-	-	7	70	1	20	3	75	-	-
Decreasing yield	-	-	-	-	1	100	-	-	-	-	-	-	-	-
Lack of enough time	2	20	2	50	-	-	7	70	2	40	4	100	2	100
No enough biomass	3	30	3	75	-	-	7	70	4	80	3	75	2	100
Stolen by neighbour	-	-	-	-	-	-	-	-	-	-	1	25	-	-
Lack of knowledge to use	-	-	-	-	-	-	2	20	-	-	-	-	-	-
No established hedges	-	-	-	-	-	-	2	20	2	40	2	50	-	-
Low survival in the farm	-	-	-	-	-	-	4	40	-	-	-	-	-	-
Not in a group	-	-	-	-	-	-	8	80	1	20	1	25	-	-
Total farmers	10	100	4	100	1	100	10	100	5	100	4	100	2	100

Note: 1 = Calliandra alone, 2 = Crotalaria, 3 = control, 4 = Leucaena alone, 5 = Mucuna, 6 = Tithonia alone, 7 = Tithonia + manure

In this study, mucuna was introduced as an intercrop planted together with maize and was not recommended as either a source of fodder or food in the study area, but only as a soil nutrient replenishment technology. Some of the reasons given for abandoning mucuna included lack of enough incorporation biomass (80%) and competition with food crops (invasiveness) (40%). The competition leads to reduced maize yield per unit area and increased demand for labour especially when intercropped with maize because farmers have disentangle the maize plant. These findings contrast the findings in Triomphe and Sain (2004), where thousands of smallholder farmers were found to substitute their traditional maize based on shifting cultivation for one in which maize was grown in rotation with mucuna; the abonera (the farmers' name for *Mucuna pruriens*) system.

Peterson *et al.* (2004) established that mucuna, especially when sown early, overly competed with maize because of its aggressive climbing growth habits, reducing maize yield by 60%. It

was therefore recommended to be better suited for rotational system. In Peterson *et al.* (2004) all the farmers surveyed used mucuna for food; often boiling it for over 8 hours, while 71% of the respondents reported that mucuna improved soil fertility. He recommended improving mucuna recipe, both in safety as a source of food and ease to prepare as a way of promoting large-scale adoption.

A number of factors cause the abandonment of soil nutrient replenishment technologies. According to Gachene (2004), abandonment of *marejea* (local name for *Crotalaria ochroleuca*) soil nutrient replenishment technology were outlined as discontinuation of seed purchase and other incentives which had been made available to the farmers at the testing stage. Use of the technology was as a result of promotion through the mass media, involvement of prominent personalities and incentives, especially the exchange of seeds for inorganic fertilizer. Gachene (2004) noted that though 60% of the farmers had earlier indicated that improved soil fertility was the most dominant driving force for using *marejea*, and that they would continue using the soil nutrient replenishment technology even after the incentives were discontinued, almost none of the farmers visited the seed bank after the incentives were withdrawn. These reasons were not indicated in the current study, as the farmers had not been exposed to any incentives, there was no media promotion or involvement of prominent people but the farmers learnt by being part of the process.

In discussing contour hedge raw technology in the Philippines Uplands, Lapar and Ehui (2004) observed that among the initial research farmers, 25% considered the technology ineffective and subsequently abandoning it, while the rest maintained the hedgerow with some modification and/or adaptation from the original technology that was introduced.

Adaptations enabled farmers to produce wood, fodder, and other products of economic value while at the same time reducing labour cost (Garrity, 1994; Peterson *et al.*, 2004). Gladwin *et al.* (2002) reported that farmers who had been trained on incorporating *Tithonia diversifolia* and *Lantana camara* for improved soil fertility felt they needed the shrubs more as a source of fodder or medicine than for soil fertility improvement. This scenario was observed in the current study where 30% of the farmers who had abandoned the incorporation of leucaena and calliandra technologies indicated that they preferred the shrubs as sources of fodder.

4.4.7 Soil nutrient replenishment technologies that farmers never tried

Data used in Table 4.13 was obtained from those respondents who had already formed an opinion on the technology hence not trying them out with reasons. A total of seven soil nutrient replenishment technologies were discussed as having not been tried among the farmers. As shown in Table 4.13, 55% of the male respondents and 48% for female respondents never tried calliandra alone. There were more female respondents who had never tried the use of tithonia alone (39%) compared to male respondents (23%). This was because tithonia is highly demanding on labour and women usually have less time to spare due to their reproductive roles. The men also have an upper hand in the control of household resources, which include labour.

Table 4.13: Soil nutrient replenishment technologies never tried by farmers in Kirege location

Soil nutrient replenishment technology	Gender of the farmer who reported not to have tried the soil nutrient replenishment technology					
	Male		Female		Total	
	N	%	N	%	N	%
Tithonia alone	7	23	17	39	32	19
Calliandra alone	17	55	21	48	51	30
Leucaena alone	16	52	19	43	47	27
Mucuna	9	29	8	18	23	13
Calliandra as fodder	-	-	1	2.3	1.4	0.8
Leucaena as fodder	1	3.2	2	4.5	4.1	2.3
Crotalaria	7	23	2	4.5	12	7
Total farmers	31	100	44	100	100	100

4.4.8 Reasons for not trying some of the soil nutrient replenishment technologies in Kirege location

Lack of seeds was a major reason for not trying some of the soil nutrient replenishment technologies. Of those who never tried calliandra 42% indicated that they lacked seeds and consequently they also lacked biomass. Seeds in the area were available to organised groups that expressed interest for free. The indicated lack of seeds and biomass by farmers indicate complexity in community relations where some community members were unwilling to work with others in groups or they were rejected. It also indicated misconception by some of the farmers as they would want everything to be provided for them, including labour and other input that go with nursery establishment and management. This was so because even those who did not participate in project activities purchased from those in groups. The farmers who had not tried tithonia alone indicated that its biomass formed a reliable source of fodder during dry months and therefore it was not available for incorporation just before the onset of rains, the recommended time for incorporation (Table 4.14). Of the farmers who had never tried calliandra alone, 24% reported that the process of obtaining the trees, taking care of

them in the farms and finally incorporating the biomass was very involving, and they had not acquired adequate knowledge to carry out all the activities involved.

Table 4.14: Reasons for not trying soil nutrient replenishment technologies among respondents in Kirege location

Reason for not trying the soil nutrient replenishment technologies	Farmers giving the reason for not trying the soil nutrient replenishment technologies											
	1		2		4		5		6		7	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
Lack of enough time	14	37	1	11	14	40	-	-	2	12	13	54
Land scarcity	1	3	-	-	7	20	-	-	5	29	7	29
Lack of biomass /seeds	16	42	6	67	17	49	2	67	16	94	13	54
No hedges established	7	18	-	-	2	6	1	33	-	-	-	-
Not in a nursery group	9	24	-	-	17	49	2	67	-	-	-	-
Not readily available	6	16	-	-	4	11	-	-	-	-	-	-
The trees are not mature	3	8	-	-	1	3	-	-	-	-	2	8
Too expensive	1	3	-	-	-	-	-	-	-	-	-	-
Low survival rate	2	5	-	-	1	3	-	-	-	-	-	-
Lack of enough knowledge	9	24			6	17	1	33	1	5	-	-
Total farmers	38	100	9	100	35	100	3	100	17	100	24	100

Note: 1 = Calliandra alone, 2 = Crotalaria, 3 = Fertilizer alone, 4 = Leucaena alone, 5 = Leucaena as fodder, 6 = Mucuna, 7= Tithonia alone

4.5 Labour availability in the study area

4.5.1 On-farm labour availability

The average total labour hours spent working in the farm per month were higher for male farmers (278 hours) than for female farmers (251 hours) as shown in Table 4.15. Male and female farmers between the age of 51-60 years had the highest time available while female farmers between the age of 21-30 years and the male farmers between the age of 41-50 years had the lowest person-hours available. This is because most of the young female farmers have very young children and their husbands may be working away from the farm. There was no significant difference ($P < 0.05$) between the total time available to the male respondents and the female respondents of different age groups.

Table 4.15: Household labour available in Kirege location by gender

Age group of the farmer	Gender of the farmer	Average labour hours available per month
21-30	Male	249.0
	Female	163.2
31-40	Male	278.1
	Female	235.6
41-50	Male	248.4
	Female	307.4
51-60	Male	411.0
	Female	339.3
> 60	Male	334.0
	Female	216.6
Total	Male	278.1
	Female	251.9

Note: Total man hours * Gender Significance level = 0.475

4.5.2 Total time available to farmers practising different soil nutrient replenishment technologies in Kirege location

The total average time available was highest among farmers using leucaena as fodder (336 hours) with the highest standard deviation of 222 hours, followed closely by farmers using crotalaria (334 hours). The farmers using no inputs had the lowest average time available (183 hours) with the least standard deviation of 61 hours (Table 4.16).

Table 4.16: Total average time available to farmers practising soil nutrient replenishment technologies in Kirege location

Soil nutrient replenishment technology	Average labour hours available per month	Significance level
Fertilizer alone	269	0.153
Manure alone	276	0.545
Fertilizer + manure	248	0.45
Tithonia incorporation	264	0.979
Calliandra incorporation	305	0.328
Leucaena incorporation	246	0.804
Calliandra as fodder	282	0.466
Leucaena as fodder	336	0.073
Mucuna incorporation	281	0.84
Crotalaria incorporation	334	0.512
Tithonia as mulching	294	0.411
Control	183	0.232

Farmers indicated labour constraint as one of the reasons for not taking up soil nutrient replenishment technologies; however, there also no significant difference ($P < 0.05$) in the time available to a farmer preferring one soil nutrient replenishment technology to the other. The lack of a significant relationship is because household may also have access to casual labour depending on their financial capability. This was also indicated in Beweket (2003), households with less labour constraint were more willing to adopt land degradation and conservation technologies, while households with more labour constraints were unable and less willing though there was no significant relationship between farmers' preference for land degradation and conservation technologies and time availability, farmers gave lack of enough time as one of the reasons for not trying or abandoning some of the technologies.

4.5.3 Availability of hired labour by gender

Most of the respondents (44% of the male and 43% of the female) hired casual labour from time to time. A few of the respondents, (3% and 2% for male and female respectively) reported that they always hired casual labourers (Table 4.17). There was a weak association between gender and hiring of casuals X^2 (2.166).

Table 4.17: Hiring casual labour by gender in Kirege location

Gender of the respondent	How often casuals are hired											
	Do not hire		Rarely		Some times		Usually		Always		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Male	13	41	2	6	14	44	2	6	1	3	32	100
Female	13	31	7	17	18	43	3	7	1	2	42	100
Total	26	35	9	12	32	43	5	7	2	3	74	100

In the current study, farmers explained that they hired labour for tea picking and during peak activities such as digging, planting and weeding. None of the respondents was found to hire labour for management of the trees used in soil nutrient replenishment technologies.

These findings are in agreement with those of Mureithi *et al.* (1998) where it was established that the main source of labour was household members, though hired labour was also available. The farmers allocated labour first to growing food crops particularly maize and little labour was allocated to managing the trees. Mureithi *et al.* (1998) further established that labour demand for mixed farming farm management practice was high throughout the season. It however increased during dry seasons as forage was scarce and farmers practising zero-grazing had to walk long distances in search of forage.

4.5.4 Effect of soil nutrient replenishment technologies on labour by gender

Table 4.18 represents the perceived effect of different soil nutrient replenishment technologies on labour demand. As shown in Table 4.18, all the respondents (both male and female) reported that using calliandra and leucaena for soil nutrient replenishment increased demand for labour. All the female respondents reported a decline in labour when leucaena was used as fodder and 75% of the female respondents reported a decline in labour when calliandra was used as fodder. For inorganic fertilizer use, 60% of the male respondents reported that it decreased demand for labour while 40% of the female respondents shared the same view.

Table 4.18: Effect of soil nutrient replenishment technologies on male and female labour in Kirege location

Soil nutrient replenishment technology	Male respondents						Female respondents					
	Increase		Decrease		No effect		Increase		Decrease		No effect	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
Calliandra	9	100	-	-	-	-	18	100	-	-	-	-
Calliandra fodder	1	25	1	25	2	50	-	-	3	75	3	25
Control	-	-	1	33	2	67	-	-	-	-	-	-
Fertilizer	-	-	3	60	2	40	1	20	2	40	2	40
Fertilizer + manure	8	73	-	-	3	27	6	60	-	-	4	40
Leucaena	5	100	-	-	-	-	15	100	-	-	-	-
Leucaena fodder	-	-	-	-	-	-	-	-	4	100	-	-
Manure	16	89	-	-	2	11	10	71.4	-	-	4	29
Mucuna	2	67	-	-	1	33	-	-	-	-	-	-
Tithonia	6	86	1	14	-	-	15	100	-	-	-	-
Tithonia as manure	1	25	-	-	3	75	-	-	-	-	-	-

In the current study, soil nutrient replenishment technologies which were viewed as increasing labour by both male and female respondents, for instance calliandra and leucaena, had the highest rate of abandonment and had been modified to technologies that were perceived as less demanding on labour such as the use of calliandra and leucaena for fodder.

These findings are in agreement with Semgalawe (1998) who argued that farmers refrain from adopting new technologies if their labour requirement was thought to be too high relative to the capacity of the household. Wildner *et al.* (2004) stated that farmers would not adopt any technology that increases manual labour whether in man-hours or the arduousness of the task. They (Wildner *et al.*, 2004) noted that, while under conventional tillage farming system the use of green manure increased overall labour requirement, there was reduced labour demand in reduced-tillage green manure/cover crop system. This reduction in labour was a result of reduced hallowing and ploughing, which was found to be the single most important factor in the farmers' adoption of reduced-tillage green manure/cover crop system.

From the above discussion, the hypotheses that cultivated land size and size of the household influences uptake of different soil nutrient replenishment technologies were rejected while the hypothesis that gender influence uptake of different soil nutrient replenishment technologies was not rejected.

4.6 Farmers' perception of the soil nutrient replenishment technologies

The farmers' perception of the soil nutrient replenishment technologies was positive in terms of improving soil fertility and increasing crop yield therefore the farmers were willingness to continue using the technologies (Table 4.19). Using no inputs (control) was perceived as ineffective in improving soil fertility and increasing crop yield; however, 67% respondents who reported they were not using any input indicated that they would continue farming without using input. This represents the influence of the farmers' socio-economic status on their decision to adopt soil nutrient replenishment technology where non-adoption or low rate of adoption may not represent rejection of the soil nutrient replenishment technology but the effect of constraints such as lack of enough time or lack of enough finances.

All respondents who reported using fertilizer in combined with manure indicated that the technology improved soil fertility and increased crop yield. None of the farmers using mucuna, crotalaria and control were willing to increase the area under these technologies, while all the farmers using calliandra as fodder and tithonia as mulch were willing to expand use of the technology.

Table 4.19: Farmers perception of the soil nutrient replenishment technologies in Kirege location

Soil nutrient replenishment technology	Response																			
	Improve soil fertility				Increased crop yield				Continue technology use				Increased plot size				Intend to increase plot			
	Yes		No		Yes		No		Yes		No		Yes		No		Yes		No	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
Tithonia alone	15	100	-	-	14	93	1	7	15	100	-	-	9	60	6	40	10	67	5	33
Mulching with tithonia	5	100	-	-	5	100	-	-	5	100	-	-	5	100	-	-	5	100	-	-
Mucuna	2	67	1	33	2	67	1	33	1	33	2	67	1	33	2	67	-	-	3	100
Manure alone	30	94	2	6	32	100	-	-	32	100	-	-	9	28	23	72	14	44	18	56
Leucaena as fodder	8	100	-	-	8	100	-	-	8	100	-	-	7	88	1	12	6	86	1	14
Leucaena alone	7	100	-	-	7	100	-	-	5	72	2	28	3	43	4	57	4	57	3	43
Fertilizer + manure	36	100	-	-	36	100	-	-	36	100	-	-	21	58	15	42	19	53	17	47
Fertilizer alone	11	55	9	45	14	70	6	30	19	95	1	11	7	35	13	65	7	35	13	65
Control	1	17	5	83	-	-	6	100	4	67	2	33	-	-	6	100	-	-	6	100
Crotalaria	2	100	-	-	1	50	1	50	-	-	2	100	-	-	2	100	-	-	2	100
Calliandra alone	14	100	-	-	14	14	-	-	11	79	3	21	6	43	8	57	8	57	6	43
Calliandra as fodder	9	100	-	-	9	100	-	-	9	100	-	-	7	78	2	22	9	100	-	-

From the farmer-focus group discussions, farmers strongly considered land size a criterion in their decision to adopt soil nutrient replenishment technologies. The farmers agreed to rate it as of medium importance; however, farmers indicated that they had not increased the size of the plot they started with and they had no intension of increasing it, citing lack of space as the main reason.

4.7 Influence of the gender of the trained farmers on decision related to practising soil nutrient replenishment technologies

In this section, objective four whose intensions were to establish the importance of the influence of the trained person in the decision-making processes in the household was examined.

As noted earlier, the study was carried out in a society where household headship is the role of the male adult; 74% of the male-headed households had the male adults highly influencing decision-making. In the same households, 24% of the female adults had high influence too while 37% had low influence (Table 4.20).

Table 4.20: Individuals in male-headed household influencing decision-making on adoption of soil nutrient replenishment technologies by age and gender in Kirege location

	N = 4		N = 19		N = 21		N = 7		N = 10		N = 62	
High influence	21-30		31-40		41-50		51-60		> 60		Total	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
Male adult	4	100	17	89	12	57	5	71	7	64	44	74
Female adult	-	-	2	11	8	38	2	29	3	27	15	24
Low influence												
Male adult	-	-	1	5	5	24	1	14	3	27	9	17
Female adult	1	25	10	53	6	29	4	57	2	18	23	37

The highest numbers of female adults (38%) highly influencing decision-making process in the male-headed households were found among household with heads aged between 41-50 years. None of the households with the head aged 21-30 years had the female adult highly influencing decisions. As shown in Table 4.21, majority (92%) of the female-headed households had the female adults highly influencing the decisions on farming practices.

Table 4.21: Individuals in female-headed households influencing decision-making on adoption of soil nutrient replenishment technologies by age and gender in Kirege location

	N = 0		N = 3		N = 1		N = 3		N = 5		N = 12	
	21-30		31-40		41-50		51-60		> 60		Total	
	N.	%	N.	%	N.	%	N.	%	N.	%	N.	%
High influence												
Male adult	-	-	1	33	-	-	-	-	-	-	1	8
Female adult	-	-	2	67	1	100	3	100	5	100	11	92
Low influence												
Male adult	-	-					1	33			1	8
Female adult	-	-	1	33							1	8

In this study though most of the households were found to be male-headed, women were found to be highly empowered, and were well represented in decision-making especially in the issues relating to adoption of soil nutrient replenishment technologies. It was a common comment among male respondents that the female adults in the household (their wives) concentrated on all decisions regarding food crop production in the farm. Gladwin *et al.* (2002) established that some women in male headed households had no authority over decisions to plant improved fallows for improved soil fertility. Women in female-headed households were found to be more likely to adopt improved fallows than the women or the men in male headed households. This relationship could not be established in the study, as households were generally male-headed, except in special circumstances as earlier discussed.

According to FAO (1997), women do more than half of the agricultural work. In some cases they are found to be 70% and in others 80% involved in food production. However, the position of women especially, in the rural areas, is undermined, resulting in oppression and lack of participation in decision-making. Kajembe (1994) established that men were the heads of the households and in most case they were the decision makers on key land use issues. In this study the Level of influence of the trained farmer in the household decision-making process did not significantly influence the uptake of the soil nutrient replenishment technologies (Table 4.22). This was because other members of the household, other than the household head influence the decision-making processes as earlier established.

Table 4.22: Level of influence of the trained farmer in the household decision-making process and the soil nutrient replenishment technologies practised by farmers in Kirege location

Soil nutrient replenishment technology	Significance level	
	High influence	Low influence
Fertilizer alone	0.732	0.944
Manure alone	0.089	0.194
Fertilizer plus manure	0.436	0.845
Tithonia incorporation	0.825	0.466
Calliandra incorporation	0.771	0.280
Leucaena incorporation	0.661	0.929
Calliandra as fodder	0.540	0.987
Leucaena as fodder	0.625	0.760
Mucuna incorporation	0.241	0.360
Crotalaria incorporation	0.342	0.458
Tithonia as mulching	0.682	0.159
Control	0.661	0.308

Note: Correlation is significant at $P < 0.005$

From the above discussion, the level of uptake of soil nutrient replenishment technologies is not significantly associated with the level of influence of the trained farmer in the household decision-making processes. Any willing member of the household willing to learn should be trained on the soil nutrient replenishment technologies regardless of their decision-making status in the household.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of Findings and Conclusion

This study was carried out with an intention of determining the socio-economic factors influencing smallholder farmers' in their decision to adopt soil nutrient replenishment technologies in the Central Highlands of Kenya.

It can be concluded that there are different factors considered by farmers in taking up soil nutrient replenishment technologies. These factors vary in importance with yield, soil erosion control, other farmers experience with the technology, soil fertility improvement, fodder value, resistance to pest and diseases, availability of seeds and biomass and food value being rated very important. The different factors vary in importance between gender, with marketability of the products, fodder value, fuel value, and land availability being significantly different in importance between male and female farmers.

Different technologies are rated differently by criteria, for instance; use of fertilizer together with manure is significantly different from mulching with tithonia in relation to soil erosion control. Yield level, other farmers' experience with the technology, fodder value and pest and diseases resistance significantly influence the overall rating of the soil nutrient replenishment technologies.

In the study, there is no significant relationship between the land under food crops, land under cash crops, average size of the household and average labour hours available within the household with the soils nutrient replenishment technology taken up by the farmer. Likewise,

the level of influence of the trained person on household decision-making was not found to significantly influence the uptake of soil nutrient replenishment technologies in Kirege location.

5.2 Recommendations

- It is important to factor in gender disparity in introducing soil nutrient replenishment technologies to farmers, for instance; soil nutrient replenishment technologies with products of high market appeal should target male members of the household, while those with high fodder value and fuel value should target the female members
- The specific criteria should be put into consideration as they significantly influence the overall appeal of the soil nutrient replenishment technology to the farmers
- Calliandra and leucaena should be scaled out as source of fodder as the study clearly shows they are very popular with farmers
- The soil nutrient replenishment technologies should be introduced to all farmers regardless of the size of the farm, household size and labour availability within their household, as these factors were not found to significantly influence the uptake of the soil nutrient replenishment technologies
- Finally, any member of the household could be trained on the soil nutrient replenishment technologies regardless of their level of influence in the decision-making processes in the household. This is because the level of influence in decision-making was found not to significantly influence the uptake of the technologies

5.3 Further Research

- Research on actual time use (as opposed to recall) should be carried out to establish the relationship between access to labour and adoption of soil nutrient replenishment technologies

- A study targeting female-headed households in the study area to have a better comparison between the performances of the technologies under various household headship
- Further research on farmers' modifications as these may represent the sustainable soil nutrient replenishment technology among the target farmers. This is because constraints which may be overlooked by researchers at the experimental stage come into play when farmers implement the technologies on their farms and in countering these constraints the farmers come up with more acceptable modifications of the technologies

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APPENDICES

Appendix 1: Focus Group Discussion checklist

- Introduce the research work to the farmers
- List the technologies they are practising
- List the criteria used by the farmers in their uptake of soil nutrient replenishment technologies
 - 1)
 - 2)
 - 3)
 - 4)
 - 5)
 - 6)
 - 7)
 - 8)
 - 9)
 - 10)
 - 11)
 - 12)
 - 13)
 - 14)
 - 15)
 - 16)
- Score the listed criteria

Criteria for taking up soil nutrient replenishment technology	Score
1)	
2)	
3)	
4)	
5)	
6)	
7)	
8)	
9)	
10)	
11)	
12)	
13)	
14)	
15)	
16)	

Appendix 2: Farmer Interview Schedule

Background information

- 1) Farm location
 - a) Sub-location _____ b) Village _____
- 2) Name of the respondent.....
 - a. Gender of the respondent Male Female
 - b. Age.....
 - c. Relationship to the household head.....
(Answer 3 if respondent is not the h/h if same go to (B))
- 3) Household headship
 - a) Name of the h/h.....
 - b) Gender of the h/h Male Female
 - c) Age.....
 - d) Nature of the h/h headship (tick below)

Male headed, with wife present (No. Of wives---)	
Male headed, (Not married, Widowed, separated, divorced)	
Male headed, wife away	
Female headed, husband present	
Female (Husband away, widowed, separated, divorced, Not married)	
Female child headed M/F (specify circumstance)	
Female elderly headed M/F (specify circumstance)	

- e) Residence of the h/h
- f) Average time spent by h/h on the farm per monthday(s)

B) Labour availability

Household size Male members.....Female members.....

(NB: h/h members will be taken to mean those living on the farm or dependents away in school. Independent family members are excluded). Please fill in the individual h/h member's detail

No.	Age	Gender	Months in the h/stead /year	Hrs working in the farm/day	Main farm activities they participate in

- a) Do you hire casuals? Yes/No...
- b) If yes, how often?..... 1-Rarely. 2- sometimes, 3-Usually, 4-Always For what activities _____

- c) How many full time labourers have you hired?.....Rate..... For what activities?

- d) Do you receive unpaid assistance? Specify source..... For what activities?

- e) Do you work elsewhere as a casual /employed? Tick Yes/No. Where?.....Why?
- h) How many days in a month do you work away from the farm?.....

C) Effect of technology on labour use

Technology	Effect on labour		Effect on individual family Members working in the farm				
	Increased	Decreased	Male adults	Female adults	Male child	Female child	% increase/(decrease)

D) Farm characteristics and farming system

- a) Farm size (acres) where we are
- b) How was the land acquired (Choose ans. below) When? 19...../20
Inherited..... b) Purchased..... c) Rented in.....
- c) Size cultivated with food crops.....
- d) Size cultivated with cash crops (perennials)
- e) Do own another piece of land? Place..... size.....Area with; food crops.....cash crops.....
- f) Have you rented out land? Place..... size.....
- g) Is soil fertility a constraint in your farm?
- h) What are the main cause
a).....b).....c).....d) e)

E) Adoption of technologies

- a. Which of the technologies you know of have you tested and are still using or have abandoned?

Soil nutrient replenishment technology in use	Reason for continued use

Soil nutrient replenishment technology in abandoned	Reason for abandoning

Soil nutrient replenishment technology in not tried	Reason for not trying

- F) Indicators of farmers' acceptance and adoption of the technologies (tick on the table below)

- Are the technologies improving your soil?
- Have the technologies increased your crop yield?
- Will you continue using the technologies?
- Have you increased the size plot since you started?
- Do you have intension of increasing the size of your plots?

Technology

Question							
a)							
b)							
c)							
d)							
e)							

G) Preference ranking (Not more than 6 technologies) (criteria developed thru' FGDs)

Technology	CRITERIA							

H) Influence in the decision-making processes

How do you rate your influence on the decision-making processes High ____ Low ____.

Appendix 3: Technology by gender

	Soil nutrient replenishment Technology	Male	Female	Total
1	Calliandra as fodder	3	4	7
2	Calliandra + fertilizer	1	2	3
3	Calliandra + leucaena		1	1
4	Calliandra + leucaena + manure		1	1
5	Calliandra + manure		1	1
6	Calliandra alone	9	6	15
7	Crotalaria	1	1	2
8	Crotalaria + fertilizer		2	2
9	Control	4	2	6
10	Fertilizer alone	9	7	16
11	Fertilizer + manure	18	18	36
12	Leucaena alone	2	4	6
13	Leucaena as fodder	4	3	7
14	Leucaena + fertilizer	1	1	2
15	Manure alone	14	17	31
16	Mucuna	3	2	5
17	Mucuna + fertilizer		1	1
18	Mucuna + fertilizer + manure		2	2
19	Mulching with tithonia		2	2
20	Tithonia alone	10	7	17
21	Tithonia as manure	3	1	4
22	Tithonia + fertilizer	1	1	2
23	Tithonia + manure	2	4	6
26	Total	85	90	175