AN EVALUATION OF POTENTIAL SUSTAINABLE LAND MANAGEMENT PRACTICES TO ENHANCE WATERSHED ECOSYSTEM SERVICES IN UPPER TANA CATCHMENT: A CASE STUDY OF KIRURUMWE RIVER, ENA BASIN IN EMBU COUNTY, KENYA.

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A RESEARCH PAPER SUBMITTED IN PARTIAL FULFILMENT OF REQUIREMENTS, FOR THE DEGREE OF MASTERS OF ART IN ENVIRONMENTAL PLANNING AND MANAGEMENT OF UNIVERSITY OF NAIROBI, KENYA

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Declaration

I certify that the research project work presented in this report is, to the best of my knowledge and belief, original, except as acknowledged in the text, and that the material has not been submitted, either in whole or in part, for a degree at this or any other university. I acknowledge that I have read and understood the University's rules, requirements, procedures and policy relating to my higher degree research award and to my project. I certify that I have complied with the rules, requirements, procedures and policy of the University.

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...

This research project report has been submitted for examination with our approval as University supervisors

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Signature………………….. Signature………………………

Date: __________________ Date: ____________________

Dedication

I dedicate this work to God

Acknowledgement

The compilation of this report would not have been possible without kind contribution and support from various persons in different fields. I wish to first of all recognize the World Agro forestry Centre (ICRAF) for sponsoring me to undertake data collection for this study.

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List of abbreviations and acronyms

ANOVA	Analysis of Variance
CES	Compensation for environmental services
CGIAR	Consultative Group on International Agricultural Research
CIAT:	International Centre for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CRES	Compensation and Rewards for Ecosystem Services
DMSED	Micro and Small-scale Enterprises Development
FAO:	Food and Agriculture Organization of the United Nations
ICRAF:	World Agro forestry Centre
ICRISAT:	International Crops Research Institute for the Semi-Arid Tropics
IFAD:	International Fund for Agricultural Development
IFPRI:	International Food Policy Research Institute
KARI:	Kenya Agricultural Research Institute
KEFRI:	Kenya Forestry Research Institute
MFTF	Micro Finance Trust Fund
MSEs	Micro and Small-scale Enterprises
PES	Payments for Ecosystem Services
PRA:	Participatory Rural Appraisals
PRESA	Pro-poor rewards for environmental services in Africa
RES:	Rewards for Ecosystem Services
SLM:	Sustainable Land Management
SPSS	Statistical Package for Social Science
SRA	Strategy for Revitalisation of Agriculture
SSA:	Sub-Saharan Africa
SNRT:	Soil Nutrient Replenishment Technology
UNCED	United Nations Conference on Environment and Development)
UNDP:	United Nations Development Programme
WB:	World Bank

Operational definitions of key concepts and terms

Compensation for environmental services:

Payments or other forms of restitution made to economic service beneficiaries or ecosystem stewards to offset foregone entitlements to environmental services or ecosystem stewardship benefits.

Ecosystem:

The Millennium Ecosystem Assessment (MA) defines ecosystems as dynamic complexes of plant, animal and micro-organism communities and their non-living environment interacting as functional units (2003).

Ecosystem services:

The benefits people obtain from ecosystems. These include provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services such as recreational, spiritual, religious and other nonmaterial benefit".

Environmental services:

Is a term widely used in the engineering profession to refer to the professional services that engineers provide to mitigate environmental damage.

Land degradation

is the reduction or loss of the biological or economic productivity and complexity of rain—fed cropland, irrigated cropland, or range, pasture, forest or woodlands resulting from natural processes, land uses or other human activities and habitation patterns such as land contamination, soil erosion and the destruction of the vegetation cover.

Pro-poor:

Is defined as the increase in benefits (through rewards) and/or decrease in costs (through compensation) in monetary and non-monetary forms that should lead to increased well-being of the poor and reduction of poverty

Sustainable land management)

The use of land resources such as soils, water, animals and plants for the production of goods to meet changing human needs while assuring the long-term productive potential of these resources, and the maintenance of their environmental functions

Abstract

The aim of this study was to explore and evaluate the potential of sustainable land management practices to enhance watershed ecosystem services in upper Tana catchment basin in Mt Kenya region.

The study was conducted in Nembure location of Manyatta Constituency in Embu County. The focus of the study was communities living adjacent and within Kirurumwe River, the target population was 15,833 people. Both quantitative and qualitative research strategies were used to conduct the research. Cross sectional survey design was adapted with a view of improving the promotion and adoption of sustainable land management practices in coffee ecological zone of this catchment. Probability and non-probability sampling strategies were employed during the study to determine the sample size. Data was collected using both primary and secondary sources. Findings of the study in upper Tana catchment region showed that most farmers have adopted sustainable land management practice the most common being agro-forestry, terraces, rotation system, cover crop and mulching. Based on these findings, future success in adoption of sustainable land management practices requires deliberate and pragmatic efforts from project implementers, farmers, policy makers, and extension agents. The results of this study indicate that awareness, capacity building, benefits and incentives significantly influences uptake of SLM enhancing innovations. As such, interventions by project implementers need to be targeted at increasing the benefits rewards.

This study, therefore, aims at generating empirical evidence that will inform policy and decision making processes at all levels on the importance of integrating environmental considerations into economic planning and policies with a view to influencing attitude and behavioural change, with special reference to community participation in natural resource management.

CHAPTER ONE: INTRODUCTION

1.1 Background of the study

TerrAfrica (2007) describes sustainable land management SLM as management that reverses land degradation (including desertification), maintains or enhances the supply of ecosystem goods and services, alleviates poverty, and promotes development. Sustainable land Management measures are essential to address problems of land degradation and associated poverty and food insecurity; it means the integrated process of improving land management while alleviating poverty, promoting local development, and sustaining the flow of ecosystem goods and services from the land (Hurni, 2000).There is potential to pursue several critical objectives synergistically through promotion of SLM in Sub-Saharan Africa (SSA), helping to mitigate and adapt to climate change while reducing land degradation, conserving biodiversity, and reducing poverty and food insecurity (Pender, 2008). To ensure the ecosystems withstand the current human pressure, sustainable land management must be encouraged.

According to Reij and Steeds (2003), improved land management leads to higher crop yields, farmers can achieve and reap more benefits by leaving strips of natural vegetation to terrace the slopes; the strips enrich the soils. In addition, Scherr and Sthapit (2009) opines that improved land management does not only enriches the landscapes and enhances food security but also helps to "cool" the planet by cutting greenhouse gas emissions and storing carbon in soils and vegetation.

Blaikie and Brookfield (1987) observed that land and water degradation may be unintentional and unperceived; it may result from carelessness or from the unavoidable struggle of vulnerable populations for the necessities of survival. On the other hand, in the past four decades, since 1960s, scientific advances and application of improved knowledge and technologies by some farmers have resulted in significant total and per capita food increases, reduced food prices and the sparing of new land that otherwise would have been needed to achieve the same level of production (Evenson & Gollin, 2003). Malthus' theory argues that population increase would outpace increases in the means of subsistence. Ester Boserup Danish economist offered an entirely different view on population resource debate. In her book 'The Conditions of

Agricultural Growth' published in 1965, Boserup took an empirical approach to the relationship between population growth and food production rather than Malthus's deductive approach (i.e., reasoned by calculations). Unlike Malthus, she believes that population growth is a major factor determining agricultural developments. According to Boserup, *'population growth stimulates innovation and development in agriculture* 'thus causing an increase in food production. Boserup theory argues that an increase in population provides a major incentive for ways to be found to increase food production (Boserup, 1965).

Neo-Malthusians see the rapid rates of population growth in the third world resulting in widespread poverty, economic stagnation, environmental destruction, rapid urbanization, unemployment and political instability. Like Malthus, the Neo-Malthusians, sees the problem resting with the poor who produce more children, because of their ignorance and lack of foresight. The solution, therefore, lies in persuading (or forcing if needs be) the poor to have fewer children. It is against this background that the implementation and promotion of family planning programmes by international development agencies gained popularity as an efficient and cost-effective way to tackle the problems of development. (Lahart *et al.*, 2008)

In a study done by Templeton and Scherr (1997) the relationship between population growth and resource quality on hills and mountains was influenced by rainfall (mainly by affecting crop-product choice, risks of soil degradation, and land use intensity), topography (by affecting the spatial distribution of production systems), and soil characteristics (through crop choice, cropping frequency, and input use). Land degradation results in the loss of ecosystem services which further undermines the sustainability of both managed and natural ecosystems. In another study by Stoorvogel and Smaling (1990) stated that recent trends in shrinking of smallholder communities average farm sizes, low investment in agriculture, stagnant crop productivity, and visible signs of degrading resources, is an indication that intensification is not an easy task (Böjo, 1996; Sanchez, *et al* 1997; Smaling *et al.,* 1997; Hurni 2000; Mutunga & Critchley, 2002;).

In Africa, South of the Sahara is the only remaining region of the world where per capita food production lags far behind than in other regions of the world. Depletion of soil fertility, along with the concomitant problems of weeds invasiveness, pests and diseases, is a major cause of low per capita food production in Africa (Sanchez *et al.,* 1997). Research over the past 10-15 years has raised concerns that Africa's soil capital is deteriorating at an alarming rate (World Bank, 2006).

There have been efforts by several governments in Africa to improve food production through commitments to sustainable and accelerated economic growth, poverty reduction and social development through increased productivity in all sectors and more equitable distribution of income to ensure employment creation, more accessible provision of basic needs and, faster industrialization, however, despite the country's ample resources to achieve the goals, they are also faced by a number of environmental management challenges including land degradation (ROK, 1999).

According to Shiferaw and Bantilan (2004) landscape differences and resource management challenges arise from variations in the land's use history. Mt Kenya is one of the five water towers in Kenya. It contributes close to 40% of the flow of Tana River. In turn the river supports close to 50% of the hydro power generated in Kenya, irrigated agriculture, fisheries, livestock production and biodiversity conservation in lower Tana of which are all strategic to the Kenyan economic development. Over the years there have been growing concern that these life supporting functions of the Tana River are systematically being lost due to degradation within the upper and middle sections of the river. Increasing destruction of the forest cover, inappropriate land use practice in farm lands and over grazing in the pastoral lowlands have triggered an increasing soil erosion menace that contribute a higher sediments load to the Tana and its tributaries. Consequently with increasing soil erosion land productivity has declined causing even more volatile areas to be opened for cultivation, a process that has undermined the ability of the land to hold rainwater, increasing fluctuation in the river regime- flood flows during coupled with depressed base flows in the dry season, which impair water supply (Place *et al*, 2004). Ultimately, the allocation of water resources has become a sensitive issue with potential to trigger ethnic tension and conflicts (MKEPP, 2007).

1.2 Problem statement

At the global scale, key problems threatening natural resources and the sustainability of life support systems are: soil degradation, the availability of water and the loss of biodiversity. This occurs in virtually all socio-cultural and economic contexts worldwide; however, there are great differences in the abilities of countries to cope with the problem of land degradation (Hurni, 2000).Problems of land degradation exist in many parts of the world, and are major challenge to sustainable development. The latter has been defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs". This was accepted as a common goal at the UN Conference on Environment and Development (UNCED) in 1991.Land degradation has potential to affect the following natural resources: (1) soils: about one third of the world's agricultural land has been damaged, mostly by soil loss caused by water erosion;(2) water: problems of quality and quantity, as well as spatial and temporal interdependence (highland-lowland effects); (3) natural vegetation: problems of quality, quantity and biodiversity (4) wildlife: problems of protected areas, wildlife corridors, controlled hunting and poaching. The perception of these problems, however, varies greatly between land users and other stakeholders, among these groups, and with time.

According to Tiffen *et al (*1994) in regards to strategies for sustainable land management, the East African Highlands considers strategy options for broad domains such as; areas of high agricultural potential and favourable market access, areas of high agricultural potential but less favourable market access, and areas of lower agricultural potential. Increase in farmers' production of high-value commodities and employment in non-farm activities, can contribute to higher incomes and making it possible for farmers to invest in land-improving and productivity enhancing technologies (Pandey, 2001).

In central Kenya, the practice of growing commercial products and buying food items is well entrenched, farmers also integrate a wide range of food and non-food crops on their farms. The key staple food crops in the Kenya highlands are maize, beans, potatoes, and bananas, followed by sorghum, cassava, and rice. Maize accounts for 80 per cent of all cereal value and occupies about 1.5 million hectares of land; while production of vegetable such as kale, peas, onions, carrots, and tomatoes is also common, commercial cash crops include coffee, tea, and French beans (Place *et al*., 2002).

Poverty among subsistent smallholder farmers in the Ena Catchments is characterized by food insecurity and a high dependency on food aid in the lower catchments. Food insecurity is exacerbated by poor soil fertility, soil erosion, run offs, dry spells, unreliable rainfall, poor incomes, lack of capital, and poor access to agricultural inputs (MKEPP, 2007). Farmers depend on rain fed agriculture, which is risky. The challenge is balancing the achievement of ecological functions and livelihood goals.

The study seeks an understanding of how the interactions amongst land and water resource users within the catchments could collectively design locally suited incentives to improve their livelihoods and conserve ecosystems providing critical environmental services. To what extent ecosystem services are affected is not clear and this study is aimed at unearthing the interface between technology adoption and ecosystem services. It is against this background that a research study on evaluation of potential sustainable land management practices to enhance environmental services in Mt Kenya East region will be undertaken in the Kirurmwue river of Ena river catchment basin in Manyatta Constituency of Embu County.

1.3 Research questions

1. What are the existing land management practices and potential sustainable land management practices adopted by farmers?
2. What are the potential social economic incentives influencing of the land management practices in enhancing environmental services and environmental conservation and protection within Mt. Kenya?
3. What are the motivational and constraining factors for the adoption of sustainable land management practices; can sustainable land management practices contribute significantly to farmers benefits (ecological, social and economic benefits), can it significantly contribute to food security/food self-sufficiency?
4. What are the best intervention measures for re-orientation of agricultural practices to contribute to ecosystem services for the Study site

1.4 General objective

To explore the potential of sustainable land management practices to enhance watershed ecosystem services in upper Tana catchment: a case study of Kirurumwe River, Ena basin in Embu County, Kenya.

1.5 Specific objectives

The specific objectives to;

1. To identify the existing types of sustainable land management practices by farmers along Kirurumwe and Ena River ;
2. To determine the socio economic incentives influencing the adoption of sustainable land management practice among farmers along Kirurumwe River;
3. To determine the motivational and constraining factors in the adoption of sustainable land management practices
4. Make recommendation for the re-orientation of agricultural practises so as to contribute to enhacement of ecosystem services;

1.6 Hypotheses

This study will test the following hypothesis that;

1. **H0:** there are no existing land management practices and potential sustainable land management practices adopted by farmers in Kirurumwe basin

   H1: there are existing land management practices and potential sustainable land management practices adopted by farmers in Kirurumwe basin
2. **H0:** Provision of incentives has no significant difference on farmers in adoption of sustainable land management practices on household farms.

   H1: Provision of incentives has a significant difference on farmers in adoption of sustainable land management practices on household farms.
3. **H0:** There are no constraining and motivation factors to better land management in Kirurumwe households.

   H1: There are constraining and motivational factors to better land management in Kirurumwe households.

1.7 Significance / justification of the study

In Kenya the agricultural extension officers are unable to continuously and consistently follow the progress of the sustainable land management practices adoptability. The decrease in home to home visit suggest that there has been a drop of contact between the farmer and extension personnel and thus farmers have no up to date knowledge on sustainable management practices (Mutunga & Critchley, 2002; Mugendi *et al.,* 1999). Soil fertility decline leading to household food insecurity is a problem facing farmers in Embu County. Scientists say that adoption of these technologies by farmers has been slow and often the targeted number has not been reached (Mucheru *et al*., (2002). This has necessitated this study on evaluation of sustainable land management to enhance environmental services, a case study of Kirurumwe RIVER of Upper Tana Catchment.

It is hoped that this study is hoped will yield data and information that will be useful for proper planning and decision making for the key policy makers such as the Government ministries such as the Ministry of Agriculture, Ministry of Environment and Natural Resources, Ministry of Water and Irrigation, Ministry of Energy, among other ministries and UN agencies, Donor agencies and other international organizations for the management actions for the change and development of the internally efficient farmers capacity on ways to curb land degradation, soil erosion, siltation and poor crop yields for entire Kenya.

The study is also expected to improve promotion and adoption of practices and be useful to extension of knowledge because it will highlight on suitable low cost sustainable land management practice to enhance environmental services.

The researcher also hopes that a suitable mechanism of Payment/ Reward for Ecosystem Services Scheme will be developed for the study area. The researcher hopes that the study will form a basis for further research on rate and amount of siltation discharge from catchment as strategy to monitor on the impact of adoption of sustainable land management practices. This could lead to the generation of new ideas for the better and more efficient, sustainable land management practices to the farmers, private sectors and the rest of the world.

The findings and recommendations of the study is also envisaged to be useful in developing feasible watershed mechanism of payment or rewards for ecosystem services, environmental services agreements that yield net positive benefits to poorer groups of ecosystem stewards and beneficiaries of ecosystem services in Mt Kenya East region, managers and administrators of the private sectors like the hydroelectric power stations, irrigation and water projects, water companies, banks and farmers cooperatives. This study will improve the implementation internal efficiency and help re-invent them as centres of excellence.

1.8 Assumption of the study

1. This study assumes that the agricultural practice in question has been largely adopted as prescribed although every precaution was taken during the survey to ensure accuracy;
2. Proper natural resource management leads to the interaction contributing to an improved environment. On the other hand poor natural resource management will lead to this interaction contributing to environmental deterioration;

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter sought to introduce and explain sustainable land management (SLM) practices, study is to examine, understand, describe and explore the relationship between the existing and the potential of sustainable land management practices to enhance ecosystem services to provide insights into the processes that entail adoption of these practises, it also sought to delves into factors that influence adoption of sustainable land management practises innovations, be they socio-economic, institutional, demographic or farm characteristics. This chapter also attempted to identify gaps in knowledge and provide suggestions on how to close these gaps.

2.2 SLM adoption in Africa

Sustainable land management is the use of land resources such as soils, water, animals and plants for the production of goods to meet changing human needs while assuring the long-term productive potential of these resources, and the maintenance of their environmental functions. Sustainable land management also entails the foundation of sustainable agriculture, and a strategic component of sustainable development and poverty alleviation, and seeks to harmonize the often conflicting objectives of intensifying economic and social development, while maintaining and enhancing the ecological and global life support functions of land resources (Mwangi, 2007; Dumanski, 1997). However, there is no standard definition of sustainability, various groupings policy makers, farmers, fishermen, pastoralists' forest dwellers, scientists and even women and men within the same family may define sustainability differently, according to their own attitudes and economic, social and ecological interests, which are often contradictory and need to be harmonized (SDC, 1994).

Wealth of indigenous resource conservation practices indicates that unsustainable land management and degradation of resources is not always due to lack of awareness on the part of land users, but political, social and economic factors also limits land users' choice of options to manage land resources in a sustainable manner. Insecure land tenure also prevents the necessary investment in land care. Some symptoms of un sustainability are; soil degradation, water quality decline, loss of biodiversity and increased incidents of plant diseases, and SLM can be approached by looking at them. Land users are often aware of unsustainable land management but are not in a position to enhance SLM. In the Ethiopian highlands peasants are highly aware of soil erosion and they have a complex system of practices and a protective structure to deal with the problems. The socio-economic and geo-political framework, however, is not always supportive of farmers' efforts (Hurni, 1997).

Sustainable rural development should therefore be about the enhancement of rural livelihoods through the protection and enhancement of livelihood systems and assets, promoting and securing access to these assets, and promoting diversification on the use of these assets. SLM should address sustainable development through the protection, enhancement and use of natural assets, thus breaking the vicious cycle of land degradation and poverty (Hurni, 1997). Many case studies have shown that the rate of adoption of soil fertility, soil conservation, and water management practices is low in SSA, although substantial numbers of farmers do use particular practices (Pretty *et al.,* 2006). African soils exhibit a variety of constraints, among them soil erosion, nutrient deficiency, low organic matter, aluminium and iron toxicity, acidity, crusting and moisture stress. Some of these constraints occur naturally in tropical soils, but degradation processes related to land management exacerbate them (Henao and Baanante, 2001).

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

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

2.3 Land holdings, Land tenure and land- use change on sustainable development

Land-use and land-cover change, as one of the main driving forces of global environmental change, is central to the sustainable development debate. It has impacts on a wide range of environmental and landscape attributes, such as; the quality of water, land and air resources, ecosystem processes and function, and the climate system itself through greenhouse gas fluxes and surface albedo effects. Moreover land-use change has important implications on sustainable livelihood of local communities (Kaimowitz & Angelsen, 1998). However, knowledge of recent changes in land use, driving forces and implications of changes within the context of sustainable development is limited (Lambin *et al*., 1997).

A few years ago, most land-use and land-cover change research was focused on land-cover conversions (such as deforestation, urbanisation), researchers have increasingly realised that more subtle processes leading to a modification of land cover deserves greater attention and that land-cover modification is frequently caused by changes in the management of agricultural land use. Land-use change research would benefit from a better understanding of the complex relationships between people and their management of land resources, and that land-use intensification is a vital consideration, this implies that, to fully understand and predict human impacts on terrestrial ecosystems, there is a need for more comprehensive theories of land-use change (Lambin *et al*., 1997).

In recent years, land use in Africa has been characterized by a significant amount of land degradation and conversion; moreover, these two processes are clearly related. Overgrazing and agricultural activities are major causes of land degradation across Africa. African pastoralists and farming households respond to declining land productivity by abandoning their existing degraded pasture and cropland, and moving to new lands for grazing and cultivation. Even if rural households choose to stay on degraded land, its declining productivity will be unable to support growing rural populations. Thus, some households will be forced to abandon existing agricultural areas in search of new land. However, without additional investments in soil conservation, this process will repeat itself. Eventually, overgrazing and cultivation will lead to land degradation, and the search for new pasture and cropland will begin again (Lambin and Rounsevell, 2000).

Land-use intensity increases as farm size decreases and family size increases. Similarly, the share of land under cultivation increases as the household's amount of cultivable land per adult equivalent decreases. Studies have found that population growth is a good predictor of land use change, for example in Uganda and Malawi (Otsuka and Place, 2001). Malthusian theory argues that population increase would outpace increases in the means of subsistence. Boserup theory argues that an increase in population provides a major incentive for ways to be found to increase food production (Boserup, 1965).

The case study in Mwala, a semi-arid area of Machakos with a population density of about 100 people/km^2 in 1980 supports Malthusian Theory, farmers had larger shares of cropped areas at the expense of grazing areas and were more likely to cut and carry fodder and restrict cattle to stalls as average farm size per quartile decreased from 17.8 hectares to 1.3 hectares (Zaal, 2004). In Mwala livestock production increased per hectare as farm size decreased because either cut-and-carry fodder and crop residues or purchased animal feed more than compensated for the loss of grazing area.

2.4 Climate Change and Sustainable Land Management

The dynamic nature of climate change should be taken into account in order to ensure that land management practices indeed meet the sustainability criterion. SLM has the potential to mitigate climate change and strengthen the resilience to its impacts, while advancing broader development objectives, such as poverty alleviation and economic growth, food security and environmental health. The impacts of climate change on future land use, agriculture and food security are predicted to be negative throughout much of Africa, as a result of rising temperatures everywhere, and declining and more variable rainfall in many locations. These impacts will exacerbate and be exacerbated by widespread land degradation in SSA (Gautam, 2006).

The importance of land-cover change in altering regional climate in Africa has long been suggested. Different studies indicate that vegetation patterns help shape the climatic zones of Africa and, changes in vegetation result in alteration of surface properties and the efficiency of ecosystem exchange of water, energy and CO_2 with the atmosphere. Climate change and variability can contribute to land degradation by making current land management practices unsustainable through inducing more rapid conversion of land into unsustainable practices.

Climate change may offer new opportunities for sustainable land management by enhancing rainfall or growing periods in some places or through creating markets that might pay farmers for improved sustainable land management practices (Gautam, 2006). Sustainable land management can also reduce vulnerability to climate change and increase people's ability to adapt and in many cases can contribute to climate change mitigation through improved carbon sequestration and reduced greenhouse gas emissions (Cline, 2007; Pender, 2008).

In Kenya, farmers, especially those living in marginal environments and in areas with low agricultural productivity, depend directly on genetic, species and ecosystem diversity to support their way of life. As a result of this dependency, any impact that climate change has on natural systems will threaten their livelihoods, food intake and health. There are six situations, which make Kenya particularly vulnerable to climate change: water resources, especially in international shared basins where; there is a potential for conflict and a need for regional co-ordination in water management; food security, at risk from declines in agricultural production; natural resources productivity and biodiversity at risk; vector- and water-borne diseases, especially in areas with inadequate health infrastructure; coastal zones vulnerable to sea-level rise, particularly roads, bridges, buildings, and other infrastructure that is exposed to flooding; and lastly exacerbation of desertification by changes in rainfall and intensified land use (SRA, 2006)

2.5 Land degradation and sustainable development

Land degradation leads to a steady diminution of the natural assets and ability of the land to provide particular goods and services for human welfare. In particular the assets that get depleted include clean water, arable land, fuel wood, and timber, biodiversity for various uses including herbal medicine, fisheries and grazing resources. Decrease in ability to provide environmental services is manifested in silted lakes and rivers, drying catchments areas, polluted air, climate change leading to longer and more frequent droughts (WRI *et al*, 2007).

Land degradation is a threat to rural livelihoods. It erodes the natural capital of the local communities (and by extension to the nation) in that the natural resources available to the household are degraded and inadequate for production or support to livelihoods. It sets up a vicious cycle that affects all the other livelihood assets. It has costs to the nation at large because it depresses national capital regionally, but ripples through the whole economy because it will affect all businesses in the supply chain of the product (Chambers, 1987). Land users trigger degradation processes through inappropriate land management and land use practices relative (Smyth & Dumanski, 1993), Poor practices included inappropriate tillage methods, over-cropping and insufficient soil nutrients replacements, poor irrigation techniques, over grazing, deforestation and use of marginal lands (Huja, 1998).

Land degradation is a cumulative global phenomenon that adversely affects approximately 23% of the land under human (nearly 2 billion hectares is or has been degraded), nearly every country, including about 80 developing nations. It has been estimated that 16% of crop land and much higher percentages of all agricultural land has been significantly degraded. Water erosion has generated the most degradation, followed by wind erosion, soil nutrient depletion and salinization resulting from over grazing, deforestation and increased agricultural activities (Hurni, 1997). The important proximate causes of land degradation have been cited as; Conversion of forests, woodlands, and bush lands which are ill-suited to permanent agriculture; Overgrazing of rangelands; Excessive exploitation of natural habitats (e.g. harvesting for fuel wood in woodlands); and unsustainable agricultural practices (e.g., farming on steep slopes without sufficient use of soil and water conservation measures, excessive tillage, declining use of fallow without application of soil nutrients (Pender, 2008).

Some studies question the extent of land degradation, providing examples of particular cases where land conditions have improved in recent history or evidence that earlier land conditions (e.g., forest cover) were not as favourable as previously thought. Some studies argue that land degradation is highly context specific, acknowledging that land degradation is a problem for some farmers in some places and times but arguing that the problem is not as universal as sometimes claimed (Herweg, 1993).

2.5.1 Land degradation in Africa

Among the regions of the world, Sub-Saharan Africa has the highest rate of land degradation. Between 4-7 per cent of the land area of SSA is already so severely degraded that it is believed to be largely non-reclaimable (FAO, 1999). Erosion rates in Africa range from 5-100 tonnes per hectare per year (FAO, 2004). The issue of land degradation widely affects Africa 67 per cent of total land area with 25 per cent characterized as severe and very severely degraded and 4 to 7 per cent as non-reclaimable; at least 36 countries are affected by desertification. Some of the countries that have the worst rates of soil degradation are: Rwanda and Burundi (57 per cent), Burkina Faso (38 per cent), Lesotho (32 per cent), Madagascar (31 per cent), Togo and Nigeria (28 per cent), Niger and South Africa (27 per cent) and Ethiopia (25 per cent) (Bwalya *et al.*, 2009). Defries (2002) estimates that land cover change, such as continued deforestation expected to occur in the tropics and subtropics will have a warming effect as a result of reduced carbon assimilation.

Land degradation has manifested huge economic impacts, the estimates vary between under 1% and 9% of GDP lost from land degradation; a related estimate is that over three per cent of Africa's agricultural GDP is lost annually - equivalent to US$ 9 billion per year - as a direct result of soil and nutrient loss (Drechsel *et al*, 2001). The productivity loss in Africa from soil degradation since 1945 has been estimated at 25 per cent for cropland and 8 to 14 per cent for cropland and pasture together. In the decade 1990-2000, cereal availability per capita in SSA decreased from 136 to 118 kg/year. African cereal yields have stagnated over the last 60 years. Africa spent US$18.7 billion on food imports in the year 2000 alone. Current food imports are expected to double by 2030 (World Bank, 2007).

In terms of land conversion, 15 million hectares of forests were cleared annually in Africa during the 1980s, reducing slightly to 12 million per year in the 1990s. The rate of deforestation of 0.6% per year for the past 15 years is among the highest globally. About 26% of deforestation is estimated to pave the way for smallholder agriculture (FAO, 2001a). In Kenya, agriculture contributes about 26% of GDP and a further 27% through linkages with other sectors; it contributes about 60% of national export earnings. About 80% of Kenya's population live in the rural areas and derive their livelihoods largely from agriculture. There are many large agro-based businesses countrywide that would decline or collapse if productivity declined. Regrettably 56% of the rural populations live below the poverty line (SDC, 1994). These are positive indicators of the economic contributions to the well-being of people of Kenya.

2.5.2 Agricultural systems and land degradation in water basins

The transition to sustainable agriculture in tropical small-scale farming has been discussed intensively since Boserup published her theory on the role of population pressure as a leading factor. Boserup's work challenged the Malthusian approach to rural transformation (Boserup, 1965). There is growing evidence that agricultural intensification, though by no means equivalent to increased sustainability of small-scale agricultural systems, can occur together with and contribute to it in a context of increasing pressure on lands (Boserup, 1965; Reij *et al.*, 1996).

Agriculture land use and management present major development challenges throughout sub-Sahara Africa, land under cultivation has expanded notably, total yields are rising, and there is large- scale conversion from fallow- based cropping systems to continuous cultivation. Nevertheless, per capita food production has been declining by about 2 % per year since 1960. Constraints on growth in agricultural sectors remain prominent in most African economies and is an important factor explaining a 1% per year decline in per capita income between 1983 and 1993 (Cleaver and Schreiber, 1994: World Bank, 1994).

Yields for African countries are well below the global average, and are almost one third of the yield levels of Asia and half that of South America. Barbier (1999) most irrigation development projects in semi-arid parts of Africa end up displacing poor farmers and pastoralists from their traditional sources of water and land, thus forcing them to move to more fragile environments prone to land and resource degradation. Often this environmental entitlement loss occurs needlessly, because planners of irrigation projects fail to consider the potential impacts of upstream water diversion on downstream users of water and land (Barbier *et al.,* 2007)

An agricultural system will be considered to be sustainable if its productivity is maintained in the long run, natural resources driving agricultural production process are conserved and, profitability of production and therefore financial income of farmers are guaranteed. As agricultural production is directly linked to surrounding ecosystems, consideration of all interactions between the agricultural production system and natural ecosystems within cultivated landscapes is a critical requirement for evaluation of sustainability (Giampietro & Bukkens, 1992).

Recent evidence supports the Boserup theory as applied to Machakos District, Kenya. A debate on whether the agricultural population in dry land areas in Africa will follow a Malthusian ‘‘poverty trapped’’ or a Boserup’s ‘‘stepwise innovative’’ path has been raging for a while now. Fifty years ago, the semi-arid Machakos district in Kenya was a disaster area, characterized by overpopulation, soil erosion and poverty. Since that time the population has tripled, but so has per capita output, while soil erosion has virtually stopped. This ‘‘miracle of Machakos’’ is a massive transition from unsustainable to sustainable agriculture, based on large-scale investment in terracing (Tiffen, Mortimore, & Gichuki, 1994).

In the past 30 years agricultural land intensification has been one of the most significant forms of land-cover modification, with dramatic increases in yields being the main feature. Yields of food crops (per area of land) have outpaced global human population growth, but if current trends are extrapolated linearly into the future, intensification of agriculture will have major detrimental impacts on non-agricultural terrestrial and aquatic ecosystems. Intensification levels can also be an indicator of the ability of land-use systems to adapt to changing circumstances, e.g., because of policy or climate change. For example, many extensive land-use systems are marginal in productivity terms (e.g., uplands, semi-arid regions, high latitude areas, etc.) and these types of land uses often have little capacity to adapt (Matson *et al.*, 1997). This does not follow, however, where extensive land use is a result of deliberate policy constraints on land that is not marginal in productivity terms.

Globally, increase in agricultural production has led to higher nutrient inputs and higher nutrient outputs. In East and Southern Africa, however, production is not keeping pace with population growth, and sustainability of soil fertility seems to be at stake. In this early agriculture soil fertility levels remained rather equilibrated, mimicking the natural ecosystems. The food gathering era gave way to shifting cultivation based on long fallow periods after the site had been cropped for three or more seasons. In this era, therefore, nutrient removal could occur only at the plot level during these short cropping seasons. The productivity and sustainability of the shifting cultivation system is dependent on adequate restoration of fertility during the fallow phase to replace and build stocks lost during the cropping phase (Stoorvogel & Smaling, 1990). Between 1961 and 1999, agricultural expansion accounted for two-thirds of crop production increase in sub-Saharan Africa, compared to only 29% globally (MEA 2003). In the absence of growth in employment opportunities in urban areas, rural population continues to grow rapidly in sub-Saharan Africa (at about 2.3%), fuelling the quest for new agricultural land.

With respect to rangelands, WRI (1994) estimated that between 1945 and 1992, almost 500 million hectares of African rangelands became degraded. Overgrazing was estimated to have accounted for half of the degradation. However there is much unsettled debate about how much of the observed degradation (e.g. vegetation loss) is due to management and how much to climate changes. Both are clearly related, as climate change shocks, like a prolonged drought, will lead to reduced vegetation to which herd size cannot be easily adjusted in the short term. In his book, Hiernaux (1993) indicate that unanticipated changes in climate have had a more important impact on rangeland vegetation than rangeland management, arguing therefore that rangeland degradation is not irreversible in most cases. Instead, studies often point towards the dependence of rural populations on the resources found in natural habitats. In Zambia, for example, more than half the country's fuel wood is converted to charcoal, requiring the clearance of some 430 km^2 of woodland every year to produce more than 100,000 tonnes of charcoal. In 2000, over 175 million m^3 of wood were used in Western Africa for fuel wood and charcoal production (Broadhead *et al.,* 2001).

Environmental problems associated with agricultural production have also become a major concern. With market expansion and intensification of farming, total forested area in Africa declined by 50 million hectares during 1980s (Dembner,1991), reducing the availability of wood products for fuel and construction, degrading range resources and exposing vulnerable soils to degradation. In many areas, particularly in densely populated highlands and in dry lands, soil degradation due to inappropriate agricultural practices and nutrients depletion threatens long term productive potential (Scherr & Yadav, 1995; Smaling *et al., 1997*). Agro forestry systems are most extensive in developing countries where approximately 1.2 billion poor people depend directly on a variety of agro forestry products and services (Leakey & Sanchez, 1997). In the five sub-Sahara African case studies in, agro forestry is shown to have potential to increase farm incomes and solve difficult environmental problems. It is financially more profitable to local farmers in comparison with traditional cultivation, beside its other economic and social benefits. Thus, it can be a potential alternative cultivation practice that helps to enhance poverty reduction and transition to permanent cultivation.

2.6 Factors Influencing Adoption of Sustainable Land Management Practices

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

2.5 Concept of Household Headship

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

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

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

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

2.6.1 Socio-economic Factors Influencing Adoption of SLM

Thangata and Alavalapati (2003) in a study conducted in Malawi identifies socio-economic factors influencing adoption of SLM technologies as farmers' perception of soil fertility, land productivity, increase in ecosystem services as a problem, off-farm income, level of education, ability to hire labour, security of tenure and participation in agricultural training activities.

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

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

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

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

In East Africa, Kruseman *et al* (2006) show that fewer than 5% of farmers in Tigray practice long fallows, improved fallows, mulch, or apply green manures and only 7% ploughed crop residues back into the soil. Benin (2006) finds similarly low percentages of plots having been improved by farmers in the Amhara region of Ethiopia. Pender *et al*. (2004) found in Uganda that fewer than 20% of plots had received inorganic fertilizer, manure, compost, or mulch and only one quarter incorporated crop residues. In the Sahel, some technologies, such as contour ridging and *zai* pits are becoming widespread. But still, many practices, especially in terms of adding nutrients to soils, remains low. In a study in central Malawi, Place *et al* (2002) found that just 21% of farmers invested in water management. Further, he found terracing investment in the past five years on just 33% of plots, despite the hilly terrain. On the other hand, there have been a few land management practices where adoption rates have expanded noticeably. Stone terracing was found to be practiced by almost half of farmers in Tigray (Kruseman *et al.,* 2006 and Deininger *et al.,* 2003) estimated that 47% of all Ethiopian farmers had built or maintained terraces between 1999 and 2001.

Rainwater harvesting methods is another that has been found to be widely used, e.g. in semi-arid Tanzania, various other conservation techniques, like bunding (e.g. Kenya), minimal tillage (e.g. Zambia), agro forestry (e.g. Tanzania), or terracing (e.g. Madagascar), are often practiced by at least 20% of farmers across a range of African sites, putting total adoption in the millions. Despite these bright spots, what is considered to be a good adoption rate for recently introduced technologies is tens of thousands of farmers and for mature technologies, upwards of 50% of plots/farmers. UNEP-UNCTAD (2008), estimated that at least 6 million smallholder farmers in SSA are using low-cost, productivity-enhancing land management practices on at least 5 million. There is a need to identify existing types of sustainable land management practices by farmers in the study and potential benefits of best practices in sustainable land management to enhance environmental services. As such, there is a need to further investigate the impact of inceptives on adoption patterns.

2.6.2 Demographic Factors Influencing Adoption of Sustainable Land Management Practices

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

2.6.3 Farm Characteristics

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

Similarly, the area of land under food and cash crops in hectares has been found to positively influence adoption decisions as cash crops and food crops can be sold to generate income that may be used to hire labour or purchase fertilizers (Muriu, 2005). The larger the area of land under food crops, the higher the likelihood that a farmer would adopt sustainable land management technologies, with the expectation that he would increase his food stocks and probably generate income from the sale of surplus produce (Adesina and Chianu, 2002).

2.6.4 Institutional Factors Influencing Adoption of SLM practices

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

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

Furthermore, Tenge et al. (2004) reported that membership in farmer groups was found to be positively influencing the adoption of Sustainable Land Management. In West Africa, it was noted that sustainable land management practises innovation had higher success rates in adoption when soil fertility management projects worked through farmers' groups (Adesina and Chianu, 2002). There is thus a need to investigate motivational and constraining factors in the adoption of sustainable land management practices in the study.

2.7 Identifying and Closing Gaps in Knowledge

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

However, socio-economic studies conducted to evaluate adoption of these sustainable land management technologies have showed low adoption rates (, Muriu, 2005). The reasons given for this trend have been varied but have mainly revolved around socio economic factors such as gender, benefits of a technology, farmers' resource endowments and biophysical aspects of farming such as slope of land and farm/plot size. There have been studies that have tried to link gender to adoption, albeit by way of mention. Studies conducted in Ethiopia, Tanzania and

Zimbabwe (Chinangwa, 2006 and Tiruneh et al., 2001) revealed that gender plays a critical role in adoption of sustainable land management practices and as such cannot be ignored. The importance of equal participation of both men and women in soil fertility related projects has also been emphasized though regrettably, women have been found to participate in lesser numbers than men, a factor that has greatly contributed to the unsuccessful implementation of projects.

It was against this background that this study was undertaken to investigate how the interactions amongst land and water resource users within the catchments could collectively design locally suited incentives to improve their livelihoods and conserve ecosystems providing critical environmental services, finally to examine and analyse factors, be they socio-economic, institutional, farm characteristics and demographic factors that influenced adoption decisions. As such, the findings of this study are intended to fill in gaps in the body of knowledge and provide useful recommendations to future researchers, policy makers, extension agents and project implementers that could inform future actions geared towards increasing adoption of sustainable land management

2.8 Conceptual Framework

Land degradation is a central challenge to sustainable development. Sustainable land management has been defined as "a system of technologies and/or planning that aims to integrate ecological with socio-economic and political principles in the management of land for agricultural and other purposes to achieve intra- and intergenerational equity" (Hurni, 1997).

SLM is thus composed of the three development components technology, policy and land use planning. Figure I represent a "multi-level stakeholder approach to sustainable land management" for finding feasible, acceptable, viable and ecologically sound solutions at local scales. A stakeholder impact and responsibility analysis has to be integrated in establishing sustainable land use practices in order to understand the interplay of factors, levels of interaction and the responses for addressing issues within the watershed. The main drivers within the integration of sustainable land use practices include local community, national and international organizations among others. The legislative and policy framework that yield to the adoption of the integrated management at watershed level, encourage the settlers within the river basin to adopt agricultural practices that increase agricultural output. Moreover, they embrace conservation practices such as soil moisture conservation, soil erosion management as well use of organic manure and integrated pest management. This agricultural practice that are inculcated in farmers by agricultural extension education increases a unit output per acre for farmers for improved socio-economic standing as well as achieving ecological benefits of the individual parcels of land they hold in the catchment.

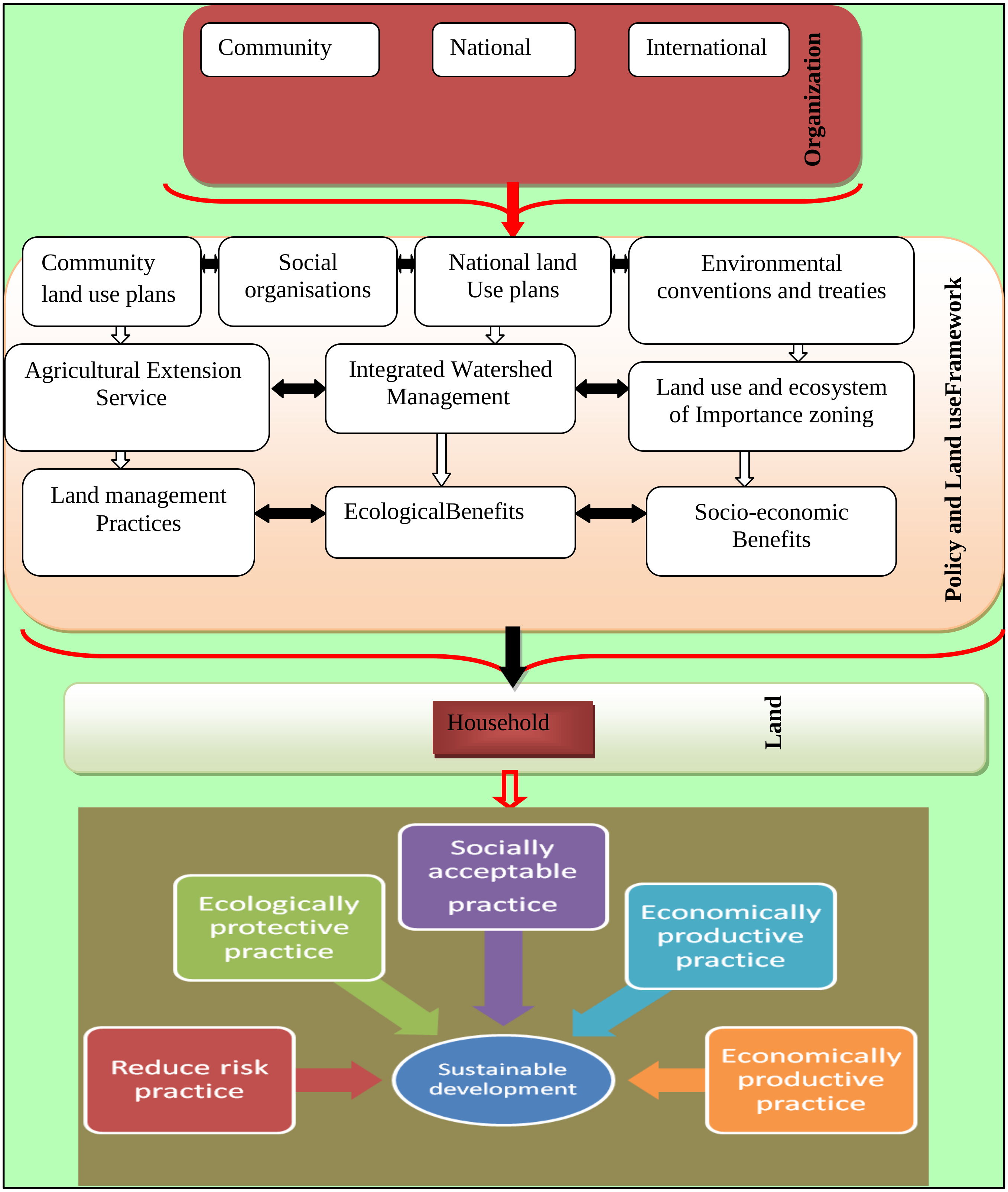

Figure 1: Adopted and modified from a multilevel stakeholder approach from (Hurni, 1997)

The land use within the river basin has impacts on the environment emerging from a household holding a parcel of land whose impacts can be realized through understanding the agricultural land use practices and livestock systems within the watershed. It is the activities of the farmers that cause catchment degradation that should be addressed. For example, the methods used to control pests, weeds and cropping systems i.e. of season irrigation of crops have different effects on the sustainable use of water catchments.

To achieve sustainable use of a water catchment the agricultural activities and practices of the farmers individual parcels at household level how they influence land productivity; water quantity and quality; and genetic resources which include forest or vegetation cover and rain water runoff. The community agricultural practices could result in livestock overstocking and harvesting of fodder and pastures within the riparian areas thereby exposing the river banks to incidences of soil erosion and deposition of soil particles in water raising water turbidity.

In water catchment areas, the soil at and near the surface has the highest organic matter and nutrient content, soil erosion increases, the potential for loss of soil surface organic matter increases, resulting in further degradation of soil structure. Best practices such as contour plantings, vegetative strips, terraces and Intensive land management by households can effectively check watershed degradation.

CHAPTER THREE: THREE: DESCRIPTION OF STUDY AREA

3.1 Introduction

This chapter provides a description of the study area, a map of the study area, geographic location and biophysical characteristics, climatic and hydrological characteristics dynamics, and demographic and socio-economic aspects

3.2 Location

The study was carried out in Nembure sub location of Gaturi South Ward in Manyatta constituency of Embu County. The study locations is within and along the Kirurumue river catchment, which is a major tributary to Ena River which stretches along Kevote and Makengi sub- locations in Manyatta Constituency. Ena River is part of the upper Tana catchment Basin.

Manyatta constituency lies between 1,000-1,500 m above sea level and it covers an area of 288.1 km^2. Nembure has three administrative locations: Gaturi South, Kithimu, and Makengi. The estimated population is 154,632. The average land size is 2.1 hectares per household. Embu County is in the Eastern Province of Kenya. It has a total population of 516,212, 131,683 households and covers an area of 2,818 square kilometre. The Population density is 183 persons per square kilometre and 40.8% of the population live below the poverty line. The county is divided into four constituencies: Siakago, Gachoka, Runyenjes, and Manyatta

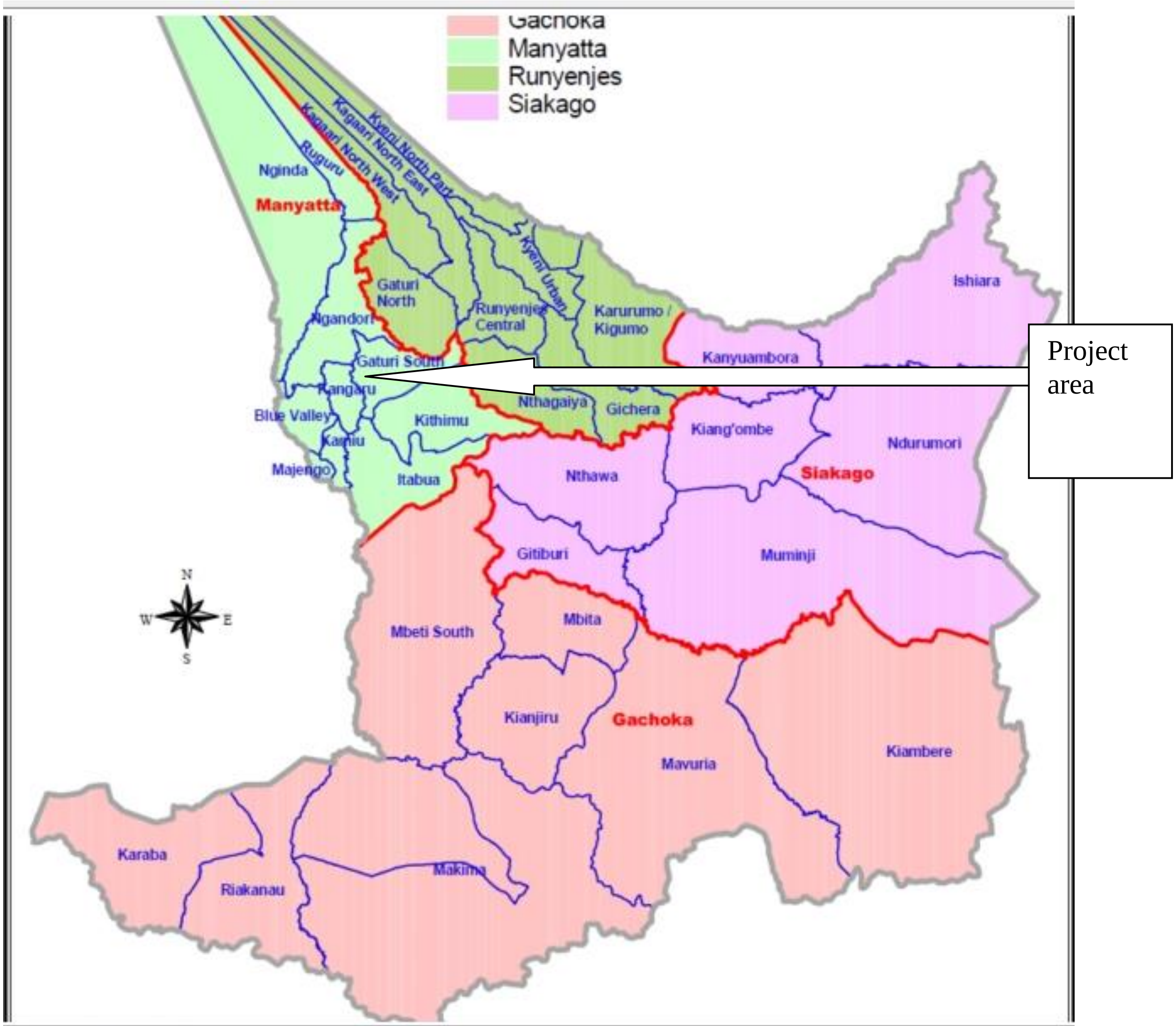

Figure 2: Map of Embu County (source: worldwide web)

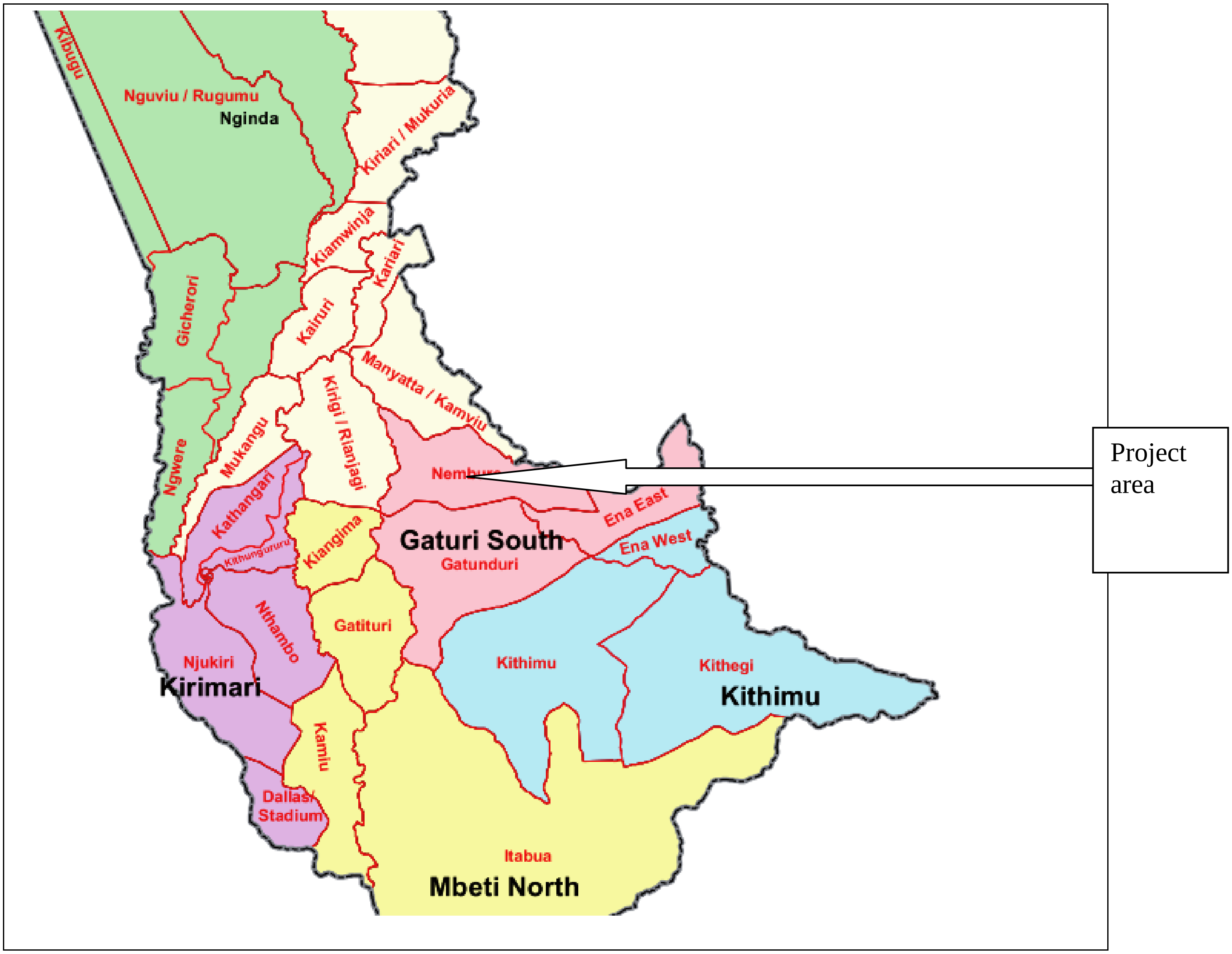

Figure 3: Map of Manyatta constituency (source: worldwide web)

3.3 Topography, climate and Hydrology

Embu is characterized by typical highlands, midlands and other features which include hills and valleys. Altitude for these highlands range between 1500 m and 4500 m at the foot of Mt Kenya and cover parts of Manyatta, Siakago, Gachoka and Runyenjes constituencies, the midland range between 1200 m to about 1600 m above sea level and covers most of Nembure and Central divisions. The study area is located in a predominantly maize growing area, which is also referred to as a coffee agro-ecological zone. The annual mean temperature in the county is 20^0 C and ranges from 12^0 C in July to a maximum of 27^0C in March. The average annual rainfall ranges from 1,200 to 1,500 mm. The rainfall is bimodal and is distributed in March/April (long rains) and October/November (short rains) (Mucheru *et al.,* 2002).

The main channels of drainage are permanent rivers Ena and Rupingazi which drain to the South and South East respectively and subsequently drain into the Tana River. Kirurumwe River is perennial and a tributary to Ena River which has varied water flow throughout the year due to the watershed characteristics and the rainfall distribution. The Kirurumwe watershed covers approximately 45 km^2 (Figure 4). It is owned by smallholder farmers who undertake intensive cultivation and carry out mixed farming. As a result, the river experiences wide water flow variations between dry spell and wet seasons.

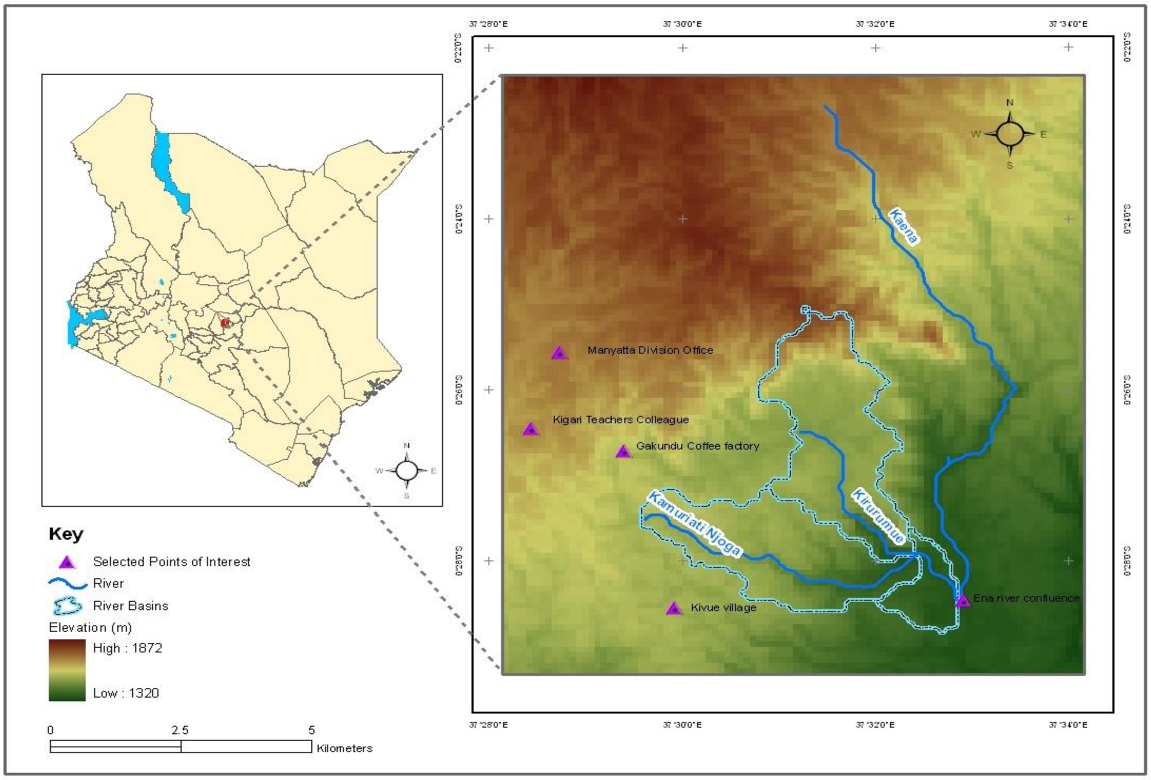

Figure 4: River Kirurumwe drainage system (Source: Miika 2009)

3.4 General soil characteristic and farming systems of the County

Embu County has five major soil types, *nitosols, andosols, vertisols, ferrosols, and cambisols*. The soils and agro ecology of the area are greatly influenced by Mount Kenya and Nyandarua ranges. Soils are fertile and well drained. Deep, well weathered with moderate inherent fertility (Jaetzold & Schmidt, 1983). Agriculture is the mainstay of the economy of Embu County. The farming system in the area is characterized by integration of both crops and animals. A wide variety of species and breeds of livestock, which include cattle, goats, sheep and poultry are found in the area. The physical features, soils and climate create a very favourable environment for growing high value crops like tea (*Cameliasinensis*), coffee (*coffee arabica*) and macadamia. The food crops include maize (*Zea mays*) is the main staple food, which is cultivated form season to season, Beans (*Phaseolus spp*), potatoes (*Solanum spp)*, sweet potatoes (*Ipomea spp*), cassava (*Manihot esculanta*), bananas (*Musa spp*.), various fruits and vegetables . All land is demarcated and owned individually under the freehold system of land tenure. The area is densely populated with a population of about 700 persons per km^2 (ROK, 2001).

CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

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

4.2 Study design

This research study used the quantitative and qualitative research strategies. The research was conducted through a cross-sectional survey design and was concerned with examining, understanding, describing and exploring the relationship between the existing and the potential of sustainable land management practices to enhance ecosystem services in Ena river catchment Basin. The design enabled the researcher to consider issues such as economy of the design, rapid data collection and ability to understand population distributions and resource use. The research design generally entails presenting oriented methodology, investigating populations by selecting samples to analyse and discover occurrences. For the purpose of this study use of cross-sectional survey design was adapted with a view of improving the promotion and adoption of sustainable land management practices in coffee ecological zone of the Ena catchment.

4.3 Sampling strategy

The study employed two main sampling strategies; probability and non- probability sampling techniques. In probability sampling techniques, stratified and simple random were used, and for non-probability sampling techniques convenience and purposive sampling were applied.

4.3.1 Sampling techniques

The area of study was purposively selected based on the location of the river of study; Simple random sampling was used to select a random representative sample. This ensured that each member of the target population had an equal and independent chance of being selected for the study.

The researcher was convinced that the target population was not uniform since all the farmers would not necessary have had similar characteristics in terms of land use, population distribution and land characteristics. As such the target and accessible population cannot be regarded as homogeneous. Purposive sampling was also done to select the various farmers which comprised of 173 households whose farm bordered the river, spring sources, or beneficiaries from the water or irrigation project. Stratified random sampling was therefore used to ensure that the target population is divided into different homogeneous strata and that each sub group (strata) is represented in the sample in a proportion equivalent to its size in the accessible population. This ensured that each subgroup characteristic is represented in the sample thus raising the external validity of the study. The strata included households cultivating in the upstream and downstream, households, benefiting from irrigation and water projects.

4.3.2 Population of study

This study was conducted in Nembure division of Manyatta constituency in Embu County. The target population consists of 15,833 people. (Source- MKEPP 2007)

4.3.3 Sample size

The target population consisted of 15,833 people. The sample size consisted of 173 households whose farm bordered the river, spring sources, or beneficiaries from the water or irrigation project.

$$Ss = \frac{Z^2 * (p) * (1-p)}{c^2}$$

Where:

Z = Z value (e.g. 1.96 for 95% confidence level)
p = percentage picking a choice, expressed as decimal (48% = 0.48)
c = confidence interval, expressed as decimal (7.4%= 0.074)

4.4 Data collection

This study relies on both primary and secondary sources of data. A pre-test on a sample of 10 farmers from a site different from the study site was done, and necessary changes to the research instruments was made, after which they were administered to the study site's sample. Key informant interviews, and focus group discussions was also conducted to augment information generated through semi structured interview schedules.

4.4.1 Secondary Data Sources

Secondary data was synthesized from books, periodicals, journals, newsletters, electronic media (internet) and reports from the government ministries and the District Development Plans. Sustainable land management related publications and articles were also reviewed with a view of gathering information on potential sustainable land management practices.

4.4.2 Primary Data Sources

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

4.4.2.1 Semi-Structured Interview Schedules

Semi-structured interview schedules were administered to 173 respondents. 70 households in the up Stream of Kirurumwe River, 13 households benefiting from irrigation and water project, 90 households cultivating on the down Stream of Kirurumwe River. The semi-structured interview schedules generated both qualitative and quantitative data that was collected through self-administration for 2 weeks by the researcher.

Table 1: Respondents across the village

Village	Frequency
Kagondi	23
Nthamari	20
Ngai Ndiethia	20
Makengi	19
Ngoire	18
Total	173

4.4.2.2 Key Informant Interviews

The key informants interviewed were 18 in number, this represented 10% the of sample size (N=173). The key informants were selected purposely with an intention to elicit an incisive and enlightening opinion of potential sustainable land management practice to enhance environmental services. They included; 1 project nursery group leader, 1 area extension officer, 2 upstream households, 2 downstream households, the chairman of the Ena water river user association, chairman of an irrigation scheme, 2 the chairmen of water project, 4 Mt Kenya East Pilot Project Component managers, 1 WRMA official, 1 Local Administration official, 1Ministry of Water and Irrigation official and 1 Ministry of Agriculture official. The key informants were engag33ed in personal interviews using an open-ended interview guide to obtain information on sustainable land management practice and challenges.

4.4.2.3 Focus Group Discussions

For proper facilitation of the discourse, focus group discussions were organized. The focus group comprised of 5-10 members to be manageable. An open-ended question guide was used to generate information within the groups. Seven focused groups were conducted.

4.5 Data Analysis

Quantitative and qualitative techniques were used for data analysis. Data analysis begun by ensuring that the interview schedules are correctly filled in and a coding sheet is developed by the Statistical Package for Social Scientists (SPSS) to ease entry and coding of the interview schedules. Summary tables were then prepared on all the responses. The second stage of the analysis involved descriptive analysis, where cross tabulation, chi-square, Spearman's Rank Correlation Coefficient, and percentages.

4.5.1 Measures of difference

4.5.1.1 Chi-square

Chi-square statistic was performed to test the validity of the observed difference in gender on factors constraining the adoption of sustainable land management practices in household in Kirurumwe River, Ena river basin in Embu District. This was used to test the Null hypothesis that was stated as;

H0: There are no constraining and motivation factors to better land management along gender line in Kirurumwe households.

H1: There are constraining and motivational factors to better land management along gender line in Kirurumwe households.

The following chi-statistic values were obtained. χ^2_{Cal} = 17.018, df= 11, χ^2 cri 0.05, 11= 11.07 α 0.05.

The χ^2 calculated was found to be greater than critical χ^2 hence the null hypothesis was rejected. And the alternative was accepted at the stated significance level that, There are constraining and motivational factors to better land management along gender line in Kirurumwe households.

4.5.2 Measures of linear relationship

4.5.2.1 Spearman's Rank Correlation Coefficient

The study performed a Spearman's rho statistic to determine the degree of linear relationship among factors that affect the adoption sustainable land management practices among men and women in the study area. There existed a significant Spearman's rho statistic 0.766 among women and land ownership at the (α =0.05). The study established that women are impacted negatively with land ownership regimes in Kirurumwe water catchment area thereby impacting on their adoption of sustainable land management practices on their farms. The study established a negative and significant Spearman's rho statistic among men on access to credit for sustainable land management practices at (-0.719) when compared to land ownership which was not significant for Men (α =0.05). This implies that men consider accessing to credit facility a factor affecting them negatively on the adoption of land management practices

CHAPTER FIVE: RESULTS AND DISCUSSION

5.1 Introduction

This chapter presents the results and discussions, specifically; the findings of the study have been presented using tables and graphs for easier interpretation. This chapter highlights the household demographic and agricultural practices as well as the environmental state that is affected by household farming practices.

5.2 Respondent characteristics

5.2.1 Villages

Majority of the respondent (38%) were from Kagondi village followed by Nthamari, Ngai Ndiethia, Makengi and Ngoire at 35%, 35%, 34% and 31% respectively (Table 2). Given this distributions of the samples, the results are generally applicable to the five villages.

Table 2: Villages sampled

Village	Frequency	Percentage
Kagondi	23	38
Nthamari	20	35
Ngai Ndiethia	20	35
Makengi	19	34
Ngoire	18	31
Total	173	100

5.3 Household Demographic characteristics of the sampled population

5.3.1 5.3.1 Household Headship

Table 3, highlights that majority of households in the area are male-headed at 78% compared to the female headed households at 22% where the women were either widows, divorced or single women.

Table 3: Household headship in line with gender

Head	Frequency	Percentage (%)
Male	135	78
Female	38	22
Total	**173**	**100**

In male headed household, the man is the final decision maker on what activity to practice, income use and extension activities to attend and what inputs to use on the farm. Women farmers often face particular cultural constraint; these findings underscore the fact that when households headed by women are taken into account, total female participation in agriculture is fully integrated into the research arena unlike when only male headed households are considered (Gladwin *et al.*, 2002).

Women in Kenya are not entitled to inherit land, according to a National Report of Kenya (2001), and in many circumstances the matrimonial properties including land is registered in the man's name. In case of death, separation or divorce, the sons remain the legal heirs to the property. The widow only enjoys occupancy rights, which cease the time she remarries. Discrimination against women in the area of land ownership presents itself in customs and traditions of most ethnic groups. The gender imbalance exhibits itself as it is believed that women are not supposed to own land and have no right to make decisions on the use of land. This discrimination occurs even though women work on land more than any category of people in the society, providing 80%-90% of labour in subsistence production and over 70% of labour in cash crop production in Kenya.

5.3.2 Gender and farm management

On the farm management, the results indicated that men were the farm managers at 78% while 19% were women managers, 3% of the households hired managers to manage their farms (Figure 5). This indicates that the management of farms was based on the headship of the household, and a few female headed household delegated the management role to male relatives or hired labourers.

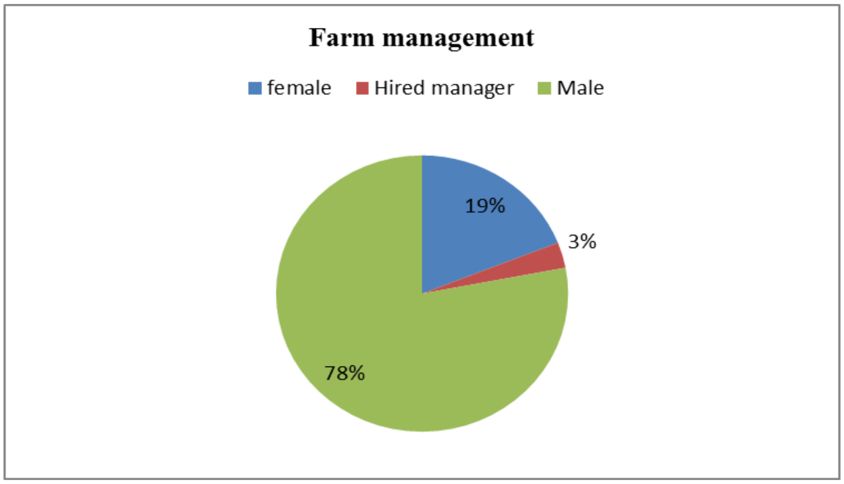

Figure 5: Farm management

Women in Kenya are not entitled to inherit land, according to a National Report of Kenya (2001), and in many circumstances the matrimonial properties including land is registered in the man's name. In case of death, separation or divorce, the sons remain the legal heirs to the property. The widow only enjoys occupancy rights, which cease the time she remarries. Discrimination against women in the area of land ownership presents itself in customs and traditions of most ethnic groups. The gender imbalance exhibits itself as it is believed that women are not supposed to own land and have no right to make decisions on the use of land. This discrimination occurs even though women work on land more than any category of people in the society, providing 80%-90% of labour in subsistence production and over 70% of labour in cash crop production in Kenya.

5.4 Popularity of land management practices

Objective one sought to establish the existing SLM practises. (Figure 6) Agro-forestry is more popular with 40%, terraces 24%, Crop rotation system 15%, cover cropping 10% and mulching 10% were relatively popular, and land resting did not get a vote Because of the small land sizes there is no more room for expansion. The study area is a coffee zone area and still has colonial terraces which have been abandoned and neglected, while all household practised agroforestry.

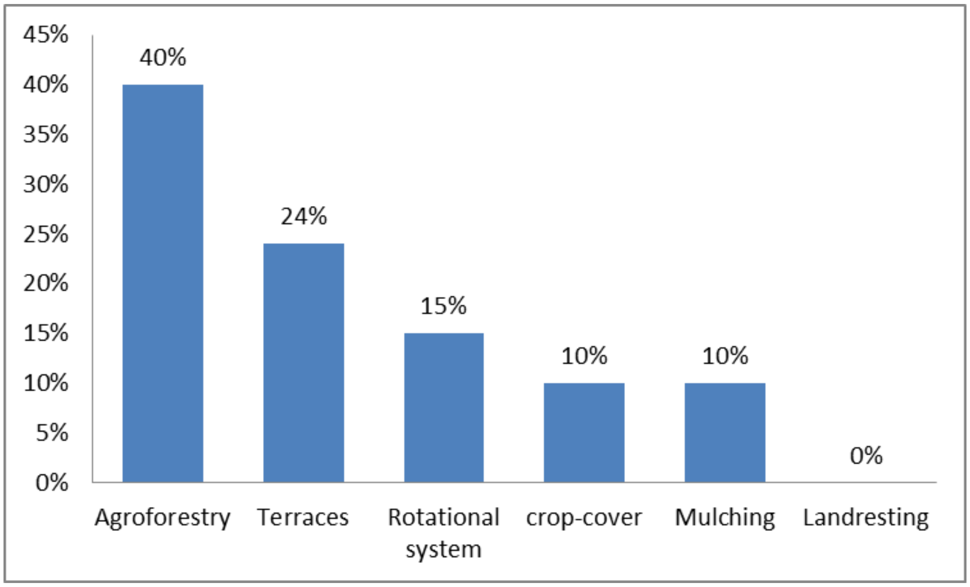

Figure 6: Existing land management practices

Most farmers are aware of the technologies that raise production levels but are reluctant to invest in them unless they are assured that the resultant crop surpluses can be readily marketed. In central Kenya, the dominant tree on the landscape is *Grevillea robusta*, which was found to be grown by 86 to 94 per cent of households on their boundaries (indeed, it is used to demarcate boundaries) (Njuki and Verdeaux, 2001).

5.5 Cropping practices and decision making

5.5.1 5.4.1 Cash crop control

Results indicate that male made decisions on the utilization of cash crops (such as coffee and Macadamia nuts) at 68%. In 22% of the households, female made decisions on cash crop usage (Table 4).

Table 4: Cash crops control

Cash crops	Frequency	Percentage (%)
Male	118	68
Female	38	22
Both	17	10
	173	100

5.5.2 Food crop control

On food crop control, majority of the respondents indicated that household decision on usage of food crops such as maize potatoes, vegetables, is made by both gender heads of the family at 63%, followed by 22 % female members, male members have no much decision of food crop as illustrated on (Figure 7).

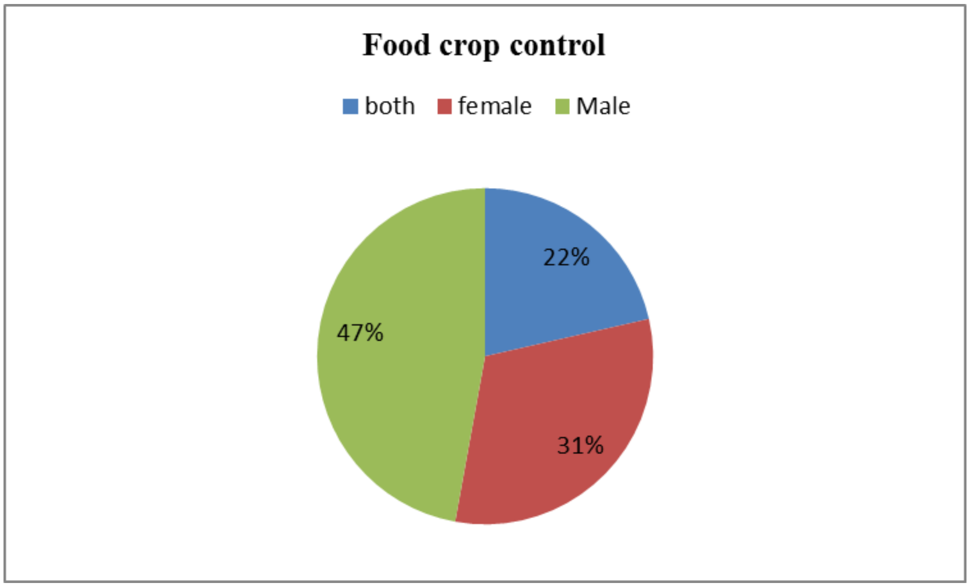

Figure 7: Food crops control

Making of the choice for crops grown on a farm is a key decision which guides crop production practices hence the choice of sustainable farming practices. The choice of crops to be grown among households in the locations was made by different persons or jointly between men, women. Njuki and Verdeaux (2001) found that though women are main agricultural producers, they rarely participate in decisions that affect their participation in agriculture and food production.

Farm Characteristics and Land Ownership

5.5.3 Land size

Majority (48%) of the respondents land sizes ranging from 1.1 to 3.1 hectares, followed closely by respondents whose farm size range between 0.25 – 1 hectares (Table 5). This indicates that most farms were of relatively small size because of increased land sub division and population pressure. The average small holder farms measures 1.1 hectares in the high potential zones such as tea zone and neighbouring coffee zones and experiences increasing trend but failing productivity capacity on descending towards the dry lands where it averages 2-3 hectares at the lower end, the average land size is 1.2 hectares in coffee zone (MKEPP, 2007).

Table 5: Land Size

Land size(hectares **)**	**Frequency**	**Percentage (%)**
0.1 - 1	76	44
1.1 – 3	84	48
3.1 - 5	13	8
5.1 – 7	0	0
Above 7.1	0	0
Total	173	100

The average farm size near the slopes of Mt. Kenya is between 1.0 and 2.0 hectares. Ouma et *al* (1998) found a mean of 1.9 hectares in the coffee zone. In nearby districts, a mean of 1.3 hectares was reported by (Argwings-Kodhek *et al*., 1999). In most areas of the western Kenya highlands average farm size is somewhat lower, at between 0.6 and 1.0 hectares (Argwings-Kodhek *et al.,* 1999; de Wolf and Rommelse, 2000). As in most places in Africa, there is a noticeable variation in holding size, but there are very few large farms. For example, in the western Kenya sites, the range in farm sizes within a village is generally from 0.2 to 5 hectares.

5.5.4 Land Ownership

The majority of the respondents indicated that the pieces of land were individually owned and that ownership at location level within the study area is an important aspect as it determines the property rights and land use. The study established that seventy three per cent (73%) of the respondents in the entire study area owned land as individuals or private, twenty seven per cent (27%) of the respondents in the study area owned land communally (Table 6). In group ownership, the farms either belonged to churches or societies who sublet to farmers. Since the most of the land is individually owned the households have the influence to determine the adoption of sustainable land management practices. The study established that households in the study area do not use state owned or state gazetted land.

Table 6: Land ownership

Ownership	Frequency	Percentage (%)
Group	47	27
Individual	126	73
Total	173	100

Access to land is a key component of the technical package needed to achieve productivity to crop lands to sustain yield increases (Pender *et al.*, 2008. The theorized effect of secure and titled land tenure is through its effects on land transactions: secure land tenure may facilitate the emergence of efficient land markets, where land is employed for its best use (Feder *et al*,. 1988; Carter & Olinto, 2003; Pinckney & Kimuyu, 1994; Gavian & Fafchamps, 1996)

5.5.5 Land acquisition

The study established that respondents acquired land through different ways. Land acquisition of by inheritance from parents was highest with 90%. Respondents who acquired land by purchasing were at 8%. It is also notable that there are respondents who were allocated land by the government, though this category was the least among the methods used to acquire land (Table 7).

Table 7 : Land acquisition

Ownership	Frequency	Percentage (%)
Inherited from parents	156	90
Bought	14	8
Allocated by Government	3	2
Total	173	100

Land is acquired mainly through inheritance, but land purchases also occur, and tenure is considered to be secure, one difference is that in central Kenya most farmers hold titles to land, but in western Kenya, many farmers do not bother to update titles that are often in the name of their father (Migot-Adholla *et al.*, 1991).

5.5.6 Method of land cultivation

Majority of the respondents cultivate their farms manually at 68%. Drought power was done by a few respondents whose land was on a fairly flat place and near the road access. Due to the sloppy terrain topography of the study area and the small average land sizes mechanization and animal traction was being used in decimal percentage in the area as reflected on (Table 8).

Table 8: Methods of land cultivation

Method of cultivation	**Frequency**	**Percentage (%)**
Manual	118	68
Animal traction	35	20
Mechanized	20	12
Total	**173**	**100%**

Huja (1998) Africa is the only region in the world where agricultural productivity is largely stagnant. Farm power in African agriculture, relies to an overwhelming extent on human muscle power, based on operations that depend on the hoe and other hand tools. Such tools have implicit limitations in terms of energy and operational output in a tropical environment.

5.5.7 Funding sustainable land management practices

Majority of the respondents obtained their funds from sales of farm produce at (49%) and loan from cooperatives societies (37%) (Table 9). The farmers derived income from selling farm outputs such as milk, macadamia, coffee berries, firewood and fruits. Other crops such as maize, potatoes and beans are used mainly for domestic consumption in most household. Lack of credit facilities is often mentioned in relation to low-adoption rates. When money is available it may be invested in innovations, but money is not borrowed for this purpose (Tiffen *et al.*, 1994) thus, people may want to invest in the education of their children, the establishment of businesses, or livestock.

Table 9: Sources of funds

Sources of funds	**Frequency**	**Percentage (%)**
Cooperative societies	64	37
Personal savings	17	10
Bank loans	8	5
Sales farm produce	84	49
Total	**173**	**100**

5.5.8 Household expenditure and income

Majority of the respondents incur higher expenditures than income. The main expenditures mentioned were purchase of food stuff estimated at Ksh.6000 per month, paraffin estimated as Ksh.300 per month, electricity bills an average of Ksh.400 per month, firewood cost average of Ksh.500 per month per donkey cart monthly contribution of Ksh.50 to the water projects. Moreover, expenditure on education averaged at Ksh 10,000 per term per household and medical costs average of ksh.100 per month. Lastly, farm inputs such as fertilizers average of ksh.6000 per growing season, a bag of 50kg fertilizer cost about ksh.3000. An average farmer requires an average of 2bags for a growing season and fertilizer was mainly applied on coffee plants (Figure 8).

The sources of income were sales of farm inputs, such as coffee, milk banana, macadamia, mangoes, avocado, surplus beans and maize (rarely). Other income sources included farm labour; remittances from relatives; formal employment such as teachers and government officials; and loans from banks or cooperatives societies.

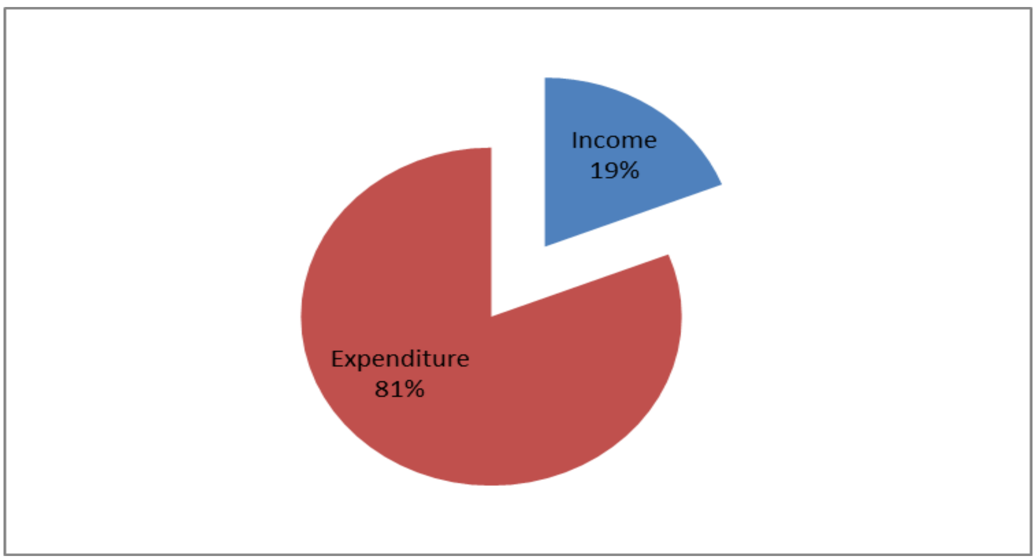

Figure 8: Household expenditure and income

Defined income strategies are the set of activities that households pursue to produce or acquire income and consumption goods, such as subsistence production of food crops, production of perishable cash crops, livestock production, forestry, and nonfarm activities. These have important direct implications for the outcomes of interest, and also affect them indirectly by influencing technology adoption and sustainable land management decisions. Production of high-value horticultural crops or other cash crops may lead to higher household incomes than production of food crops (Tiffen *et al.,* 1994).

5.6 Motivation and constraining factors affecting the adoption of sustainable land management practices

5.6.1 Access to Credit

The results indicate that majority of the farmers had not obtained credit in the recent past (68%) (Table 10) In addition, the respondent's access credit was easier from cooperatives 37% as compared to the banks 9% (Table 9). This is because the cooperatives societies were nearer and accessible as compared to banks. The loans received from the societies is inform of advances payments of their coffee produce, and the monetary loan is mainly spend on school fees, the other form of loan they get from the societies in farm inputs subsidized. However, in the recent past because of the poor economic status in the country, the farm inputs are expensive. The high cost of farm inputs interest rates hinder farmers from accessing loan which they would probably invest in sustainable land management. Low access to credit affects adoption to SLM.

Table 10: Access to credit

Access to credit	Frequency	Percentage
Yes	56	32%
No	117	68%
	173	100%

Majority of the respondents indicated that they use the credit facilities in paying school fees 57%, followed by purchasing farm inputs such as fertilizers 26% (Table 11).

Table 11: Use of credit

Use of credit	**Frequency**	**Percentage (%)**
Farm supplies	46	26
School fees	98	57
Domestic supplies	27	16
Entertainment	2	1
Total	**173**	**100**

Credit is an important input into the sustainable land management practises adoption and it contributes to increased food productivity. Limited access to financial services is a major constraint inhibiting growth of Micro and Small-scale Enterprises (MSEs) (ROK national report, 2001). Studies of multiple African countries suggest that although access to credit is increased for those with title, this access does not increase the overall supply of credit but rather a redirecting of the credit (Besley, 1995). Programmes and activities require financing; of particular concern is the ability of rural people to adapt promising technologies that can improve production in the context of severe and widespread poverty in rural areas.

Land tenure security may increase demand for credit: increased land security may result in the desire of families to invest more in their land, resulting in a greater demand for capital. The effect on the credit supply is an increase in the willingness of lenders to provide credit if borrowers have the ability to use secured land as collateral. With secure and titled land as collateral for credit, creditors can lawfully repossess land if necessary in the event of a default. In addition, the threat of repossessing collateral acts as an incentive to the borrower to repay the loan on time (Pender, *et al* 2004).

5.7 Factors constraining the adoption of sustainable land management practices at households

Table 12: Constraining factors to adopt SLM along gender lines

Location	**Gender**	**Ranking of factors constraining the adoption of Sustainable Land management practices**						**Total**
		Land ownership	Access to credit	Social groupings	Level of education	Access to Extension service	Access to Technology	
Kagondi	Men	9%	34%	9%	20%	15%	13%	100%
	Women	27%	18%	14%	10%	14%	17%	100%
Nthamari	Men	6%	31%	8%	19%	16%	20%	100%
	Women	31%	20%	13%	12%	11%	13%	100%
Ngai Ndiethia	Men	5%	33%	5%	22%	13%	22%	100%
	Women	26%	19%	16%	14%	12%	13%	100%
Makengi	Men	10%	30%	5%	18%	19%	18%	100%
	Women	29%	22%	15%	12%	11%	11%	100%
Ngoire	Men	7%	29%	9%	21%	19%	15%	100%
	Women	30%	21%	16%	12%	11%	10%	100%

The study investigated the factors constraining the adoption of sustainable land management practices at households along gender lines. The factors varied among the respondents in different village. Land ownership ranked highest among women as a factor constraining the adoption of sustainable land management practices with 31% of women in Nathamari being the highest followed by Ngoire women at 30% and Makengi 29%. Men ranked land ownership as a least factor constraining the adoption of sustainable land management practices with only 9% of men in Kagondi followed by Ngoire at 7% this ranked is low when compared to women from the respective villages.

Access to credit for financing sustainable land management practices such as technology and extension training was ranked high among men as a factor constraining the adoption of sustainable land management practices with 34% of men in Kagondi followed by 33% of men in Ngai Ndeithia. When compared with women access to credit was not a major factor constraining the adoption of sustainable land management practices The study investigated how this factors constrained the adoption of sustainable land management practices where only 21% of women Makengi considered it a constrain (table 12).

Table 13: factors constraining the adoption of SLM and perceived causes of land degradation and soil fertility among the farming community

		Factors constraining the adoption of sustainable land management practices												Total	
		Land ownership		Access to credit		Social groupings		Level of education		Access to extension services		Access to technolog y			
		*Co	%	Co	%	Co	%	Co	%	Co	%	Co	%	Cou nt	%
Perceived Causes of land degradation and soil infertility	Poor soil management	15	46.9	14	32.6	7	35.0	6	19.4	9	36	9	40.	60	34.7
	Poor use of farm inputs	10	31.3	16	37.2	4	20.0	13	41.9	8	32.	4	18	55	31.8
	Low soil vegetation cover	6	18.8	7	16.3	6	30.0	8	25.8	7	28.	6	27	40	23.1
	Poor irrigation methods	1	3.1	6	14.0	3	15.0	4	12.9	1	4.	3	13.6	18	10.4
Total		32	100	43	100	20	100	31	100	25	100	22	100	173	100

From Table 13, it is clear that access to credit largely (43%) influenced SLM and hence poor credit facilities impacted negatively on SLM. The least was access to technology at 22%, this was low due to the availability of extension services from the ministry of agriculture and thus did not hamper much the adoption of SLM as the practices are known but the capacity to implement is lacking.

Table 14: linear relationship among factors that affect the adoption sustainable land management practices and gender

Correlation statistic	Variable	Correlation Coefficient	Number of Women	Number of Men
Spearman's rho statistic	Number of Women	Correlation Coefficient	1.000	-.528(**)
		Sig. (2-tailed)	.	.
		N	173	173
	Number of Men	Correlation Coefficient	-.528(**)	1.000
		Sig. (2-tailed)	.	.
		N	173	173
	Land ownership	Correlation Coefficient	-.766(**)	.021
		Sig. (2-tailed)	.000	.000
		N	173	173
	Access to credit	Correlation Coefficient	-.066	-.719(**)
		Sig. (2-tailed)	.	.
		N	173	173
	Social grouping	Correlation Coefficient	.567(**)	.472
		Sig. (2-tailed)	.000	.000
		N	173	173
	Level of education	Correlation Coefficient	.567(**)	.582(**)
		Sig. (2-tailed)	.	.
		N	173	173
	Access to Extension service	Correlation Coefficient	-.617(**)	-.529(**)
		Sig. (2-tailed)	.000	.000
		N	173	173
	Access to Technology	Correlation Coefficient	-.315(**)	-.571(**)
		Sig. (2-tailed)	.	.
		N	173	173

** Correlation is significant at the 0.05 level (2-tailed).

The study performed a Spearman's rho statistic to determine the degree of linear relationship among factors that affect the adoption sustainable land management practices among men and women in the study area. There existed a significant Spearman's rho statistic 0.766 among women and land ownership at the (α =0.05). The study established that women are impacted negatively with land ownership regimes in Kirurumwe water catchment area thereby impacting on their adoption of sustainable land management practices on their farms. The study established a negative and significant Spearman's rho statistic among men on access to credit for sustainable land management practices at (-0.719) when compared to land ownership which was not significant for Men (α =0.05). This implies that men consider accessing to credit facility a factor affecting them negatively on the adoption of land management practices (table 14).

Therefore a chi-square statistic was performed to test the validity of the observed difference in gender on factors constraining the adoption of sustainable land management practices in household in Kirurumwe River, Ena river basin in Embu District. This was used to test the Null hypothesis that was stated as;

H0: There are no constraining and motivation factors to better land management along gender line in Kirurumwe households.

H1: There are constraining and motivational factors to better land management along gender line in Kirurumwe households.

The following chi-statistic values were obtained. χ^2_{Cal} = 17.018, df= 11, χ^2 cri 0.05, 11= 11.07 α 0.05.

The χ^2 calculated was found to be greater than critical χ^2 hence the null hypothesis was rejected. And the alternative was accepted at the stated significance level that, There are constraining and motivational factors to better land management along gender line in Kirurumwe households.

All programmes and activities require financing; of particular concern is the ability of rural people to adapt promising technologies that can improve production in the context of severe and widespread poverty in rural areas. Access to financial resources is one of the quickest ways of empowering disadvantaged communities. Rural finance and credit is provided by commercial banks, cooperative societies, state agencies and non-governmental organizations. Agriculture gets between 10-12% of total credit disbursed although the target is 17% Limited access to financial services is a major constraint inhibiting growth of Micro and Small-scale Enterprises (MSEs) (World Bank, 2005)

Although both land and labour are limiting in certain cases, most farmers mention lack of cash as the most critical constraint. This stems from lack or irregularity of income, weaknesses in credit markets, and high demands for expenditures, both anticipated and unexpected. Expenditure needs are relatively high in Kenya because of the need to contribute to education and health services through cost sharing. In addition, unexpected expenditures related to increased numbers of funerals have stretched capacities of many households. Significant amounts of credit are available only through membership in coffee or tea cooperatives. Other sources are informal, for example, through small community-based groups that generally provide modest resources. The net result of all these factors is that cash flow is often the main focus of management of households. Cash flow management leads to the foregoing of purchase of inputs, the hiring out of one's labour rather than working on one's land, and the searching for water and firewood over long distances rather than buying the resources on the market (Pender and Hazell, 2000).

Access to land at a household determines the income strategies and land management decisions are affected by many different factors operating at different scales. These include factors that influence the relative profitability and hence comparative advantage of different income strategies and land management practices in a particular location, such as biophysical factors determining agricultural potential, population density, and access to markets and infrastructure (Pender et al., 2004). These factors may have generalized effects at the village or higher level on income strategies and land management, such as through their influence on soil conservation strategies, cropping systems, technologies adopted for production of commodities or inputs used, or they may affect household-level factors such as average farm size (Pender et al., 2004)

Land tenure security may increase demand for credit: increased land security may result in the desire of families to invest more in their land, resulting in a greater demand for capital. The effect on the credit supply is an increase in the willingness of lenders to provide credit if borrowers have the ability to use secured land as collateral (Feder et al., 1988). With secure and titled land as collateral for credit, creditors can lawfully repossess land if necessary in the event of a default. In addition, the threat of repossessing collateral acts as an incentive to the borrower to repay the loan on time. The theorized effect of secure and titled land tenure is through its effects on land transactions: secure land tenure may facilitate the emergence of efficient land markets, where land is employed for its best use (Carter and Olinto, 2003; Besley, 1995; Pinckney and Kimuyu, 1994; Gavian and Fafchamps, 1996).

Studies of multiple African countries suggest that although access to credit is increased for those with title, this access does not increase the overall supply of credit but rather a redirecting of the credit (Barrows and Roth 1990). Data from Ghana, Kenya, and Rwanda showed no significant relationship between tenure rights and investment in the land (Place and Hazell 1993). Additionally, a comparative study of Uganda's neighbors Tanzania and Kenya found similar results. Pinckney and Kimuyu (1994) found that neither of the countries' tenure systems increased access to land-secured loans, increased security through titling, or increased investment as a result.

Credit is an important input into the production system and it contributes to increased food productivity. Access to credit increases the farmer's working capital enabling the farmers to buy productivity enhancing inputs such as good quality seeds, fertilizers and chemicals. The challenge for agricultural financial institutions is to develop low cost ways of reaching farmers, especially smallholders (World Bank, 2005). Access to bank credit by farmers is still a major challenge despite the fact that Kenya has a relatively well-developed banking system. Risks associated with agribusiness coupled with complicated land laws and tenure systems that limit the use of land as collateral make financing agriculture unattractive to the formal banking industry. In addition, corruption, political interference in the operations particularly of State-owned banks, and a dysfunctional court system in the past, gave rise to a culture of defaulting that led to high numbers of non-performing loans. This development forced many banks to charge their customers, who included farmers, prohibitively high interest rates to remain afloat (Pender and Hazell, 2000)

5.7.1 Group Membership

88% the respondents belonged to at least a community self-help group (figure 10). Some member said that, by belonging to a community group they had acquired more knowledge and skill including saving skills among others. Women participated more in the groups; indeed, the number of women in a group was higher in the mixed sex group. There were also women exclusive groups, no men group was found. The group may be the solution to certain cultural constraints, which hinder women's participation. (Munyua, 2000)

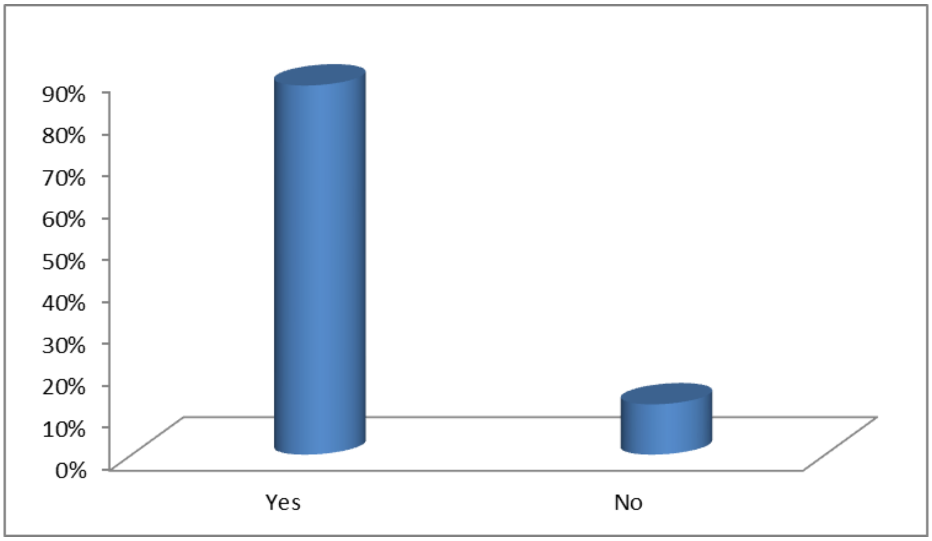

Figure 9: Group membership

5.7.2 Group membership influence to sustainable land management adoption

Most of the respondent indicated that the group membership benefits them by sharing of knowledge (68%) and training on conservation methods (18%) as indicated in (Table 15). Most groups took the initiative to invite as agricultural extension officer to teach them on soil and water conservation measures, for facilitation they contributed to pay the extension officer travel expenses. Further, the group member ship facilitated the ease of demonstration of SLM practises there by increasing their adoption rate. The invitation of agricultural officer is an illustration of willingness to learn and adopt the sustainable land management.

Table 15: Group membership influence to SLM adoption

Assistance	**Frequency**	**Percentage**
Demonstration	27	16%
Knowledge sharing	114	68%
Training	32	18%
Total	173	100%

Access to land at a household determines the income strategies and land management decisions are affected by many different factors operating at different scales. These include factors that influence the relative profitability and hence comparative advantage of different income strategies and land management practices in a particular location, such as biophysical factors determining agricultural potential, population density, and access to markets and infrastructure (Pender *et al.,* 2004).These factors may have generalized effects at the village or higher level on income strategies and land management, such as through their influence on soil conservation strategies, cropping systems, technologies adopted for production of commodities or inputs used, or they may affect household-level factors such as average farm size (Pender *et al*., 2004).

5.7.3 Loss of soil fertility

58% of the respondents indicated that loss of soil fertility was a constraint; this may be because additional costs are incurred to maintain the soil fertility levels (figure 11).

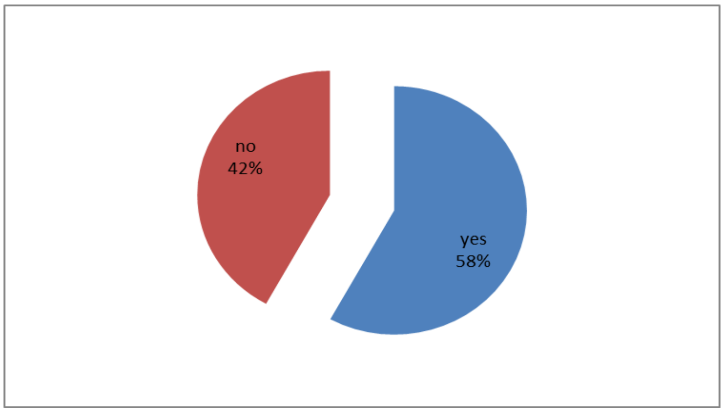

Figure 10: Loss of soil fertility

5.7.1 Accessibility of extension services providers

Majority of the respondents indicated that they do not receive any advice from the extension services at 82%; the remaining 18% receive advices from the extension service. Technical assistance can be useful in identifying and promoting profitable technologies.

A general consensus exists that extension services, if properly designed and implemented, improve agricultural productivity (Evenson & Mwabu, 1998). The performance of the public agricultural extension service in Kenya has been a very controversial subject. The system has been perceived as top-down, uniform (one-size-fits-all) and inflexible and considered a major contributor of the poor performing agricultural sector. Agricultural extension in Kenya has evolved through improvements, development and adoption of more participatory systems such as Focal Area Approach (FAA), Farmers Field Schools (FFS) and Promoting Farmer Innovations (PFI). Kenyan women do over 70% of agricultural activities, and the ministry is enhancing their role in agricultural production, processing and marketing by mainstreaming gender issues in all programs (FAO, 2001b).

5.8 Social economic incentive factors influencing adoption of sustainable land management practices

Table 16: Adoption of SLM practises with incentives

Location	Gender	Adoption level of Sustainable land management practices with incentives						Total
		Land rights entitlement	Credit from Microfinance	Cooperative formation	Level of education	Availability of Extension service	Training on new Technology	
Kagondi	Men	8%	32%	11%	21%	14%	14%	100%
	women	24%	17%	17%	9%	12%	21%	100%
Nthamari	Men	9%	30%	11%	14%	13%	23%	100%
	women	35%	18%	14%	11%	12%	10%	100%
Ngai Ndiethia	Men	7%	31%	5%	21%	12%	24%	100%
	women	29%	22%	13%	14%	11%	11%	100%
Makengi	Men	12%	32%	7%	13%	15%	21%	100%
	women	30%	19%	18%	11%	12%	10%	100%
Ngoire	Men	9%	34%	6%	22%	16%	13%	100%
	women	31%	20%	14%	15%	9%	11%	100%

The established farmers who adopted sustainable land management varied in response to the incentives as they exist in the village. Women who had land rights entitlement defined readily adopted sustainable land management technologies with 35% of women in Nthamari followed by 30% of women in Makengi as compared to only 9% and 7% of men in Ngoire and Ngai Ndeithia adopting sustainable land management practices respectively. Access to micro finance credit to farmers had men adopt sustainable land management in percentages higher than women. For instance, 34% of men respondents adopted sustainable land management followed by Makengi and Ngai Ndiethia men at 32% and 31% respectively (table 16).

This implies that accessing to credit facility is an incentive to men in the adoption of land management practices. Institutional factors such as land ownership, membership in farmers' organizations, and technical assistance have been found in some studies to influence on-farm adoption of conservation practices, insecurity of tenure reduces farmers' incentives to invest in land conserving practices while membership in local groups has a positive and significant effect on the adoption of such technologies (Besley, 1995; Meredith *et al.*, 2000).

Table 17: linear relationship among incentive that influence the adoption sustainable land management practices

Correlation statistic	Variable	Correlation Coefficient	Number of Women	Number of Men
Spearman's rho statistic	Number of Women	Correlation Coefficient	1.000	.021
		Sig. (2-tailed)	.	.
		N	173	173
	Number of Men	Correlation Coefficient	.021	1.000
		Sig. (2-tailed)	.	.
		N	173	173
	Land rights entitlement	Correlation Coefficient	.736(**)	.021
		Sig. (2-tailed)	.000	.000
		N	173	173
	Credit from Microfinance	Correlation Coefficient	.032	.629(**)
		Sig. (2-tailed)	.	.
		N	173	173
	Cooperative formation	Correlation Coefficient	.237(**)	.422
		Sig. (2-tailed)	.000	.000
		N	173	173
	Level of education	Correlation Coefficient	.653(**)	.638(**)
		Sig. (2-tailed)	.	.
		N	173	173
	Availability of Extension service	Correlation Coefficient	.429(**)	.629(**)
		Sig. (2-tailed)	.000	.000
		N	173	173
	Training on new Technology	Correlation Coefficient	.511(**)	.607(**)
		Sig. (2-tailed)	.	.
		N	173	173

** Correlation is significant at the 0.05 level (2-tailed).

The study established that land tenure entitlement (rho=0. 736), Cooperative formation (rho=0.237), Level of education (rho=0.653) Availability of Extension service (rho=0.429), and Training on new Technology (rho=0.511) were positive and significant at the significance level (α =0.05). With the level of adoption of sustainable land management practices among women in the study area

As to men the study established that land tenure entitlement (rho=0.021), Cooperative formation (rho=0.629), Level of education (rho=0. 638) Availability of Extension service (rho=0.629), and Training on new Technology (rho=0. 607) were positive and significant at the significance level (α =0.05) with the level of adoption of sustainable land management practices.

The study determined that there exists a linear correlation relationship among factors that motivate farmers to adoption sustainable land management practices and adoption level among men and women in the study area. There existed a significant Spearman's rho statistic 0. 736 among women and land ownership at the (α =0.05). The study established that land rights entitlement in Kirurumwe water catchment area is an incentive for them to adopt sustainable land management practices on their farms. Further, the study established a significant Spearman's rho statistic among men on access to credit from Microfinance for sustainable land management practices at (0. 638) when compared to land ownership which was not significant for Men (α =0.05). This implies that accessing to credit facility is an incentive to men in the adoption of land management practices (table 17).

The validity of the above findings was performed by a chi-square statistic on the observed difference in gender on incentives for the adoption of sustainable land management practices in household in Kirurumwe River, Ena river basin in Embu District. This was used to test the Null hypothesis that was stated as;

H0: Provision of incentives has no significant difference on farmers in adoption of sustainable land management practices on household farms.

H1: Provision of incentives has a significant difference on farmers in adoption of sustainable land management practices on household farms.

The following chi-statistic values were obtained. χ^2_{Cal} = 28.018, df= 11, χ^2 cri 0.05, 11= 11.07 α 0.05.

The χ^2 calculated was found to be greater than critical χ^2 hence the null hypothesis was rejected. And the alternative was accepted at the stated significance level that, Provision of rewards and incentives has a significant difference on farmers in adoption of sustainable land management practices on household farms.

This finding is an important on when perception in adoption of sustainable land management practices as depicted by Ethiopian farmers, it was realized that perception about land rights entitlement had a significant effect on adoption sustainable land use management (Negatu & Parikh, 1999). Adesina and Baidu-Forson (1995) in their analysis reasoned that varieties that farmers judge accessing agricultural extension service and training on new technology resulted in better yield performance over local varieties tend to be those that are adopted.

Institutional factors such as land ownership, membership in farmers' organizations, and technical assistance have been found in some studies to influence on-farm adoption of conservation practices (Amin, 1999). Insecurity of tenure reduces farmers' incentives to invest in land conserving practices (Lee and Stewart 1983) while membership in local groups has a positive and significant effect on the adoption of such technologies (Burton et al. 1999). Finally, perceptions of erosion problem are found to be positively associated with the adoption of conservation practices (Santos et al., 2000)

5.8.1 Perception of potential of SLM on to enhance ecosystem services

Most respondents indicated that adoption of sustainable land management practices can improve the soil fertility and crop yield, increase in water quality and quantity (98%) (Table 18)

Table 18: Perception of impacts of SLM on environmental services

Response	Frequency	Percentage (%)
Yes	170	98
No	3	2
Total	**173**	**100**

5.8.2 Production and social economic benefits

32% of the respondents indicated that they have achieved increased crop yield and increased fodder production from improved soil and water conservation technology (Figure 12). Economic and financial factors, such as farm and off-farm income and risk aversion, are found to influence adoption decisions (Bett, 2004). Farm income positively influences adoption of technologies while off-farm jobs inhibit this decision.

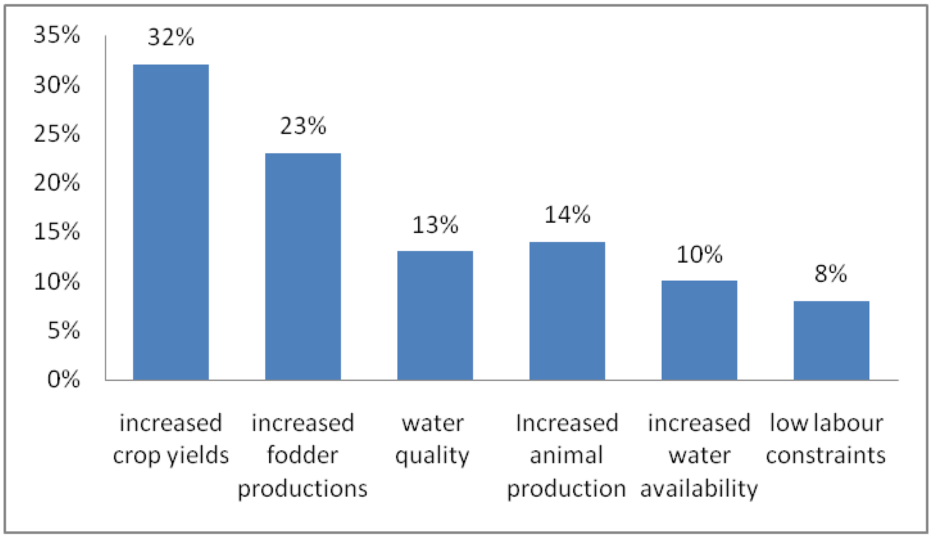

Figure 11: Production and socio-economic benefits

5.8.3 Socio Cultural Benefits

Most of the respondents indicated that adopting SLM practices has some socio cultural benefits and that it has led to improved conservation, improved food security and knowledge improvement (Table 19). Some studies indicate various factors that influence on-farm adoption of soil conservation practices, including socio-demographic characteristics of farm operators and physical features of the farm. Physical and environmental characteristics such as farm size, slope length, degree of slope, and soil erodibility also affect the adoption of conservation practices (Feder *et al.*, 1985)

Table 19: Socio- Cultural benefits

Socio-cultural benefits	**Frequency**	**Percentage (%)**
Improved conservation	75	20
Improved food security	34	43
Knowledge	15	9
Improved cultural opportunities	13	8
National institution strengthening	10	6
Increased recreational opportunities	9	5
Conflict management	9	5
Institution strengthening	8	5
Total	**173**	**100**

5.8.4 Perceived benefits for sustainable land management practices

Table 20: Farmers Perceived benefits for SLM practices

Improved farm earning	23%
Improved food security	59%
Increased crop diversity	18%
Total	100%

The study sought to establish the farmers perceived benefits from adoption of SLM practices. The study established that, improved food security was the main benefit farmers perceived to have achieved (59%). 30% of the respondents attributed sustainable land management practices to increased crop diversity in their household (Table 20).

Improved land management led to higher crop yields, often derived from improved fallow management, rotations with leguminous food and cover crop species, the targeted use of rock phosphate to enhance biological, nitrogen fixation, conservation (minimum tillage) farming, and innovative livelihood diversification approaches involving agriculture and community-based wildlife management (Gabre-Madhin & Haggblade, 2004). In a study focusing on African dry lands, SLM successes were found to include reforestation of degraded lands, harnessing of indigenous knowledge about soil and water conservation, and area development via the rehabilitation of degraded lands (Reij & Steeds, 2003).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The results of this study affirm the need for creating awareness and providing incentive to farmers to enhance adoption of sustainable land management practices.

The first objective sought to identify the existing types of sustainable land management practices by farmers, to establish the popularity of SLM practiced by farmers in the study area. From the results, Agroforestry was most popular SLM practices, Mulching was the least practiced. Even though sustainable land management faces many challenges in lower Tana area, it is possible to achieve sustainability. Policy makers, land owners and government agencies need to improve capacity of settlers to fully utilize settled plots while enhancing natural resource conservation.

Secondly, the study sought to determine the social economic incentives influencing adoption of sustainable land management among farmers. Factors significantly influencing adoption in households were found to be access to credit, membership in a farmer's group, land ownership, access to extension services, access to technology. The implication of this is that if these household specific factors encouraging adoption were promoted and proper support systems availed to farmers, the likelihood of adoption of sustainable land management practices would increase. In efforts to enhance sustainable land management practises, it is important to realize that many strategies involve trade-offs among these objectives and that their impacts are often context-specific. For example, improved education leads to higher incomes and better soil nutrient balances, but it may also reduce crop production and increase soil erosion, as a result of reduced labour intensity in farming. Agricultural extension and training increases productivity but also contributes to increased soil erosion and soil nutrient depletion, by promoting increased production of annual crops without sufficient promotion of soil fertility improvements or soil and water conservation measures. Similarly, improvements in market access can help to increase fertilizer adoption and reduce use of slash and burn, but they also contribute to soil nutrient depletion. In general, these results imply that there are few "win-win-win" opportunities to simultaneously increase production and household income reduce land degradation and achieve sustainable farming. Different instruments are needed to achieve different objectives, and trade-offs among these objective must be expected. Just as no single solution exists to improve all outcomes simultaneously, different approaches are needed in different locations. There is no "one-size-fits-all" solution the complex problems of small farmers in the diverse circumstances of lower Tana.

The third objective sought to investigate the factors constraining the adoption of sustainable land management practices at households along gender lines. Land ownership ranked highest among women as a factor constraining the adoption of sustainable land management practices. Access to credit for financing sustainable land management practices such as technology and extension training was ranked high among men as a factor constraining the adoption of sustainable land management practice. Farmers who had access to credit were said to have more options to acquire costly new technologies such as improved seeds or fertilizer. There is a need to ensure that farmers are educated on how to access credit. These results demonstrate the need to ensure the equal participation of women and men in project activities in order to increase the likelihood of adoption. These results demonstrate the need to ensure the equal participation of women and men in project activities in order to increase the likelihood of adoption.

6.2 Recommendation

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

As well, owing to the fact that this study has designed a predictive understanding of factors influencing adoption of sustainable land management; this can be applied to predict adoption patterns in the study area and Central Kenya in general, where almost similar household, demographic, climatic and farm conditions exist. Efforts geared towards strengthening these factors with a view to increasing adoption would be a plus for successful project implementation.

Scientists also need to consider gender-targeted design of technologies so as to meet the needs of both male and female farmers and design technologies that would not unnecessarily overburden women. This may be done through the active involvement of both gender groups in the design and development of these technologies. More importantly is the adoption of sustainable land management practices that are deemed ecologically compatible. Water users association, education and awareness programs to farmers at local level would enhance water harvesting techniques during rainfall abundance would reduce reliance on rain fed agriculture by farmers and also help cope with adverse weather changes. Human settlements are indeed complex entities and any strategy for sustainability needs to work with different disciplines and sectors, and just as every practitioner needs to understand those working around her or him, governments too need to ensure that plans for sustainable development are integrated across the sectors, and will genuinely meet international targets while also meeting the needs of the poorest. A primary concern is the protection and conservation of water catchment areas and restoration of those that had been degraded and destroyed. Deforestation and degradation of water catchment areas has been going on without adequate checks. The ecosystem approach should be integrated into water resource management policies at all levels.

Population increase has been identified as a major cause of environmental degradation especially in dry lands. Settlement schemes have been established without due consideration of the carrying capacity or the population a given parcel of land can support. This is necessary for development planning and provision of other services such as family planning and infrastructure.
These are strategies that will help to increase the value of crop production include establishment of agricultural extension and training programs, specialization in cash crops and increased non-farm activities. Accessibility to credit was cited by farmers as the most significant influence in the adoption of SLM practices. However, the income to households can be enhanced through increased market access for their products to reduce over-reliance on credit especially at the current high interest rates. The adoption of SLM practices is influenced by a horde of incentives including technical assistance and opportunities that contribute to increased household incomes.

Accordingly, requisite management policies are required to entrench principals of sustainable agricultural production that integrate SLM practices and facilitate the reversal of land degradation. Further, to promote SLM practices, it is crucial to start national extension programs or integrate their ideals in the pre-existing agricultural and natural resource management initiatives. Interestingly, farmers actively experiment and innovate SLM practices but their break through are under-exploited since they are not shared with other farmers. As such, better management of SLM strategies will capitalize on farmers' experiences and facilitate dispensation of knowledge on a wider variety and unique SLM practices. To benefit from farmers innovations, the implementation of extension programs will require efficient feedback systems to capture these innovations. In addition, the establishment of regional satellite centres to document information on best SLM approaches and success stories will improve the adoption of SLM practices

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

Sustainable land management can be enhanced through access to more research information and assessments of land use and land capability to prioritize on SLM practices. Besides, it is essential for policy makers to establish the role of the private and public sectors in execution of SLM programs and provision of requisite technical and financial support for their implementation. Accordingly, it is necessary for policies to be established that provides farmers and other SLM stakeholders with abounding advice tailored to fit their agro-ecological zones. In addition, policy frameworks that address how incentives, subsidies, taxation and licensing fees can be utilized to align the structures of Kenyan environmental and social ideals with regards to sustainable land management.

6.3 Suggestions for future research

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

A study to evaluate challenges facing rural youths in agriculture enterprises will shed more light to the policy makers, investors on priority areas for development for increase employment opportunity and enhanced food security. Scaling up of to ensure that its technologies reached farmers, KARI embarked on the Agricultural Technology and Information Response Initiative (ATIRI) to empower farmers to make technology and information demands on agricultural service providers

Finally, policy makers, extension personnel, researchers and project implementers require sensitization on the need to be gender literate in order to ensure that gender considerations are taken into account in policy making, design and dissemination of sustainable land management practices and in the formulation and implementation of soil and agriculture related projects.

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APPENDICES

Annex 1: Photos

<table>
<tr><th colspan="2">Existing sustainable land management practices</th></tr>
<tr><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><th colspan="2">Focused group discussions</th></tr>
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ANNEX 2: FARM INTERVIEW SCHEDULE

Way point:________________Interview schedule no________

GENERAL INFORMATION

1) **Date of Interview______________________ Name of interviewee_____________**
2) **Sub location ____________ village__________**
3) **District---------------------- Division-------------------- Location _____________,**

4Agro-ecological zone

□ **Coffee** □ **transition (coffee, tea)**

HOUSEHOLD DETAILS

1) **Is the household head ship:**

□Male Adult headed □ Female adult headed □ male child headed

□ Female child headed □ elderly male headed □ elderly female headed

2) **Who is the farm manager?**

□ Male headed manager □ female headed manager □ both

□ hired manager □ other specify

3) **Who makes its decisions on SWC technologies to be adopted?**

□ Male HH head □ Female HH head □ Male HH member □ Female HH member

4) **Who controls use of cash crops**? □ Man □ woman □ both

5) **Who controls use of food crops**? □ Man □ woman □ both

Relation to head of Household	**Marital status(single, married, divorced/separated, window)**	**Age**	**Sex**	**No of children level of education**	**Occupation**	**income**		
						Per month	**Per year**	

A. FARM CHARACTERISTICS AND LAND OWNERSHIP

1) **Farms size (**hectares):

□ 0.25-1hectares □ 1.1-3 hectares □ 3.1-5hectares □ 5.1-7hectares □ above 7.1

2) **Size of homestead ________________**

3) **Land ownership**: □ communal □ state □ group □ individual

4) **When did you acquire the land ________________**

5) **How did you acquire it**? □ Bought □ Inherited □ Allocated by the government

6) **If you bought it how much did you pay for it/ per acre for the whole parcel/ksh**---------------?

7) **When** did you come to this area? (Year)………………………

8) **Where** did you come from (Name District?)…………………….

9) **Why** did you come to this area………………………………….

10) **Is your land registered**? □ YES □ NO

11) Under who is the land registered?

□ Husband □ wife □ both □ other specify □ His own father

12) How is land cultivation performed?

□ Manual labour □ animal traction □ mechanized

13) Water supply

□ Rain fed □ post-flooding □ mixed rain fed - irrigated □ full irrigation

14) Livestock

Is livestock grazing on crop residues: □ No □ little □ yes

15) Number of growing seasons per year

Crop	**Month of Start**	**Month of End**	**Average annual rainfall**

16) What is your source of income?

Source of income	**How much**	**The period (per year, per day)**

17) <u>Household expenditure</u>

No.	Item	Cost per day	Cost per month	Per year
1.	food			
2.	Water			
3.	Fuel			
4.	Medical			
5.	Transport			
6.	Education			
7.	Housing			
	fertilizer			

18) Out puts (list them down)

Type of activity	type of variety
1. coffee farming	
2. cotton farming	
3. tea farming	
4. fruit tree	
5. live stock	
6. vegetables	
7. pulses	
8. fodder	
9. trees	
10. firewood	
11. medicine	
12. timber	

B. ACCESS TO CREDIT

1) Do you get access to money lending facilities? □ YES □ NO

2) If yes, which credit lending institution?

□ banks □ cooperatives □ microfinance □ farmers groups

3) What do you use the credit for?

□ Domestic supplies □ farm supplies □ school fees □ entertainment

4) **Does the money support your adoption of SNRTS** □ YES □ NO

5) **If you do not receive credit, what are the reasons**____

6) **Does you lack of credit affect your ability to adopt SWCs**? □ YES □ NO

7) If yes, how?

□ Not able to buy land □ not able to buy farm inputs □ unable to hire labour

□ unable to participate to project activities

C. FARMER'S GROUP

1) **Do you belong to any project group**? □ YES □ NO

2) **Which one?** Name:____

3) If yes how does your group membership improved your understanding of SWCs

□ Demonstration of use □ sharing knowledge □ training by project staff □ other specify

4) **If you do not belong to any group what are the reasons**?

□ Lack of interest □ lack of time □ lack of info □ group problems □ lack of money

□ lack of labour on farm □ lack of permission from spouse

5) **How does your lack of membership to a farmers' group affect your understanding a**

D. CONSERVATION TYPES

1) **Which of the listed conservation groups are available in your farms: Mark in the blank boxes what applies**

CA	**Conservation agriculture/(mulching)**	**RH**	**Gully control/ rehabilitation**	**SD**	**Sand dune stabilization:**
NM	**Manuring/ composting/ nutrient management**	TR	**Terraces**	CB	**Coastal bank protection**
RO	**Rotational system/ shifting cultivation/ fallow/slash and burn**	**GR**	**Grazing land management**	**PR**	**Protection against natural hazards**
VS	**Vegetative strips / cover** (mainly vegetative measures	**WH**	**Water harvesting**	**SC**	**Storm water control, road runoff:**
AF	**Agro-forestry**	**SA**	**Groundwater / salinity regulation /water use efficiency**	**QT**	**Other:** (specify)
AP	**Afforestation and forest protection**	**WQ**	**Water quality improvements**		

E. Acceptance or adoption trend of soil nutrient and water conservation technologies (SNWRT)

1) **Have you adopted any swc technologies?** YES NO

2) If yes please Mark types of and layout of agronomic measures s you have tested, adopted, abandoned or not tried as listed below. **Use T for tested, A for adopted, B for abandoned N for not tried**

A: Agronomic/soil management

A1	**Vegetation / soil cover**	**A2**	**Organic matter/soil fertility**	**A3**	**Soil surface / subsurface:**

	better crop cover by vegetation		green manure cropland		breaking crust / sealed surface
	early planting (cropland)		legume inter-planting		breaking compacted topsoil
	relay cropping		Applying manure / compost / residues		Conservation tillage
	mixed cropping / intercropping		Applying mineral (inorganic) fertilizers		Contour tillage
	contour planting / strip cropping		Applying soil conditioners (lime, gypsum)		contour ridging
	cover cropping		rotations / fallows		furrows (drainage, irrigation)
	retaining more vegetation cover(removing less vegetation cover)		other (specify)		
	mulching (actively adding vegetative or non-vegetative material or leaving it on surface)			**A4**	**Surface treatment**
	Temporary trash lines				Breaking compacted soils
	Others specify				deep tillage / double digging

V: Vegetative

V1	**Tree and shrub cover**	**V2**	**Grasses and perennial herbaceous plants**	**V3**	**Clearing of vegetation**
	- dispersed in annual crops : eg Faidherbia, Grevillea, Sesbania-perennial fodder and browse species		- dispersed		clearing / reducing of undergrowth eg prescribed fires, grazing, cutting back

	aligned (in annual crops : eg live fences, hedges, barrier hedgerows, alley cropping:		- **aligned (grass strips)**		- fire breaks cutting of aisles / strips through vegetative cover
	Sub-categories: graded; on contour; - along boundary; - linear, - against wind		Sub-categories: graded; on contour; woodlots; - along boundary; - linear; - against wind		
				V4	others
	In blocks: subcategories ; - woodlots, -perennial crops (tea, sugar cane coffee, banana; - Perennial fodder and browse species		in blocks **Further subcategories for dispersed, aligned and in blocks; - natural reseeding- re-seeding; - planting**		
	Further categories of dispersed, aligned and in blocks; - natural reseeding; - re-seeding; planting				

M: Management:

M	**Management**				
M1	**Change of land use type:**	**M2**	**Change of land use practices / intensity level:**	**M3**	**Layout according to natural and human environment**

	land resting;		From grazing to cutting (for stall feeding)		exclusion of natural waterways and hazardous areas
	protection		from mono-cropping to rotational cropping		separation of grazing types
	change from crop to grazing land, from forest to agro-forestry, from grazing land to cropland, etc.		farm enterprise selection: degree of mechanization inputs, commercialization from continuous cropping to managed fallow from herding to fencing adjusting stocking rates		distribution of water points, salt-licks, livestock pens, dips (grazing land
M4	**Major change in timing of activities**		from grazing to cutting (for stall feeding		reduction of invasive species
	planting		from random (open access) to controlled access (grazing land forest land eg access to firewood),		selective clearing
	cutting of vegetation		staged use to minimize exposure (eg staged excavation		encouragement of desired species
M6	Others				- controlled burning / residue burning

3) How has the Practice been developed (its origin)?

□ through land user's initiative (innovation, traditional)

□ Through experiments / research □ Externally / introduced through project

□ other (specify): ………………………………..

Comments (e.g. Precise year) …………………………………..

F. ON-SITE BENEFITS

1) **Have the technologies improved your soil** □ YES □ NO

2) Has the technology increased your crop yields? □ YES □ NO

3) **If yes how?** *Mark with* **+** sign if it is an advantages and **–** sign if it is a disadvantage

Production and socio-economic benefits

X		X		X	
PA	Increased crop yield	**PF**	increased drinking / household water availability / quality	**PJ**	reduced risk of production failure
PB	increased fodder production	**PF**	increased water availability / quality	**PK**	increased animal production
PB	Increased fodder quality	**PG**	increased irrigation water availability/ quality	**PL**	reduced expenses on agricultural inputs
PD	Increased wood production	**PH**	reduced demand for irrigation water	**PM**	increased farm income
PD	increased wood production	**PI**	increased production area (new land under cultivation / use)	**PM**	diversification of income sources
PE	decreased labour constraints			**PN**	simplified farm operations
				PM	increased product diversification
	Others specify:				

Socio-cultural benefits

X		X		X	
SE	improved cultural opportunities (e.g. spiritual, aesthetic, others)	**SE**	increased recreational opportunities	**SH**	community institution strengthening
SB	national institution strengthening	**SF**	improved conservation / erosion	**SI**	knowledge
SC	improved situation of socially and economically	**SG**	conflict mitigation	**SJ**	improved health

	disadvantaged groups (gender, age, status, ethnicity etc.				
SD	improved food security / self-sufficiency (reduced dependence on ext. support)				
	Others specify				

Ecological benefits

X		**X**		**X**	
EA	Increased water quality	**EJ**	improved excess water drainage	**ER**	increased animal diversity
EA **EC**	increased water quantity improved harvesting / collection of surface runoff	**EK** **EL**	recharge of groundwater table/aquifer reduced wind velocity	**ET** **EU**	reduced hazard towards adverse events (drought, floods, storms,) increased biomass / above ground C
ED	increased soil moisture	**EM**	improved soil cover	**EU**	increased soil organic matter / below ground C
ED **EC**	reduced evaporation reduced surface runoff	**EN** **EO**	increased nutrient cycling / recharge reduced soil crusting/sealing	**ER** **EX**	increased / maintained habitat diversity reduced fire risk
EG	reduced emission of carbon and greenhouse gases	**EP**	reduced soil loss	**EY**	reduced soil compaction
EH	increased biological pest / disease control	**EQ**	reduced salinity	**EZ**	reduced invasive alien species

EI	increased beneficial species (predators, earthworms, pollinators)	**EP**	increased plant diversity	**EV**	Energy generation (e.g. hydro, bio)
	Others specify:				

Indicate Off-Site benefits

Off-site: *concerns the adjacent area or areas further away from the area where the SLM Practice is applied.*

X		**X**		**X**	
OA	Downstream siltation	**OE**	reduced groundwater / river	**OI**	pollution
OB **OC**	increased water availability (groundwater, springs) □ reduced downstream flooding capacity (by soil, vegetation, wetlands)	**OF** **OG**	increased stream flow in dry season / reliable and stable low flows reduced reduced damage on neighbours' fields	**OJ** **OK**	improved buffering / filtering reduced wind transported sediments
OG	reduced damage on public/ private	**OH**	infrastructure		
	Others specify:				

4) **Have you made any modification to the soil and water conservation technologies (SWCs) contrarily to what was taught**

□ yes □No

5) **Which ones**, list…………………….

6) What do you do with the extra harvest

□ Domestic supplies □ farm supplies □ school fees

□ Social commitment □ entertainment

7) **Have you increase your farm size to accommodate the technologies:**

□ YES □ NO

8) If no, why?

□ limited land □ lack of money □ lack of labour □ lack of benefits □

□ lack of benefits from technology □ spouse decision other specify

9) Has the adoption improved your living standards? □ yes □ No

If yes how?

□ Able to pay school fees □ domestic supplies □ farm supplies

□ Social commitments □ entertainment

10) Are there any technologies you plan to abandon: □ YES □ NO

If yes why?

Technology	**Reason for abandoning**

G. NON ADOPTION FOR SOIL & WATER TECHNOLOGIES

1) Do you attend project meetings? □ YES □ NO

2) If you don't attend project meetings what are the reasons:

□ Lack of time □ not interested □ lack of money □ communication barrier

□ unsuitable venue □ lack of information

3) Why haven't you adopted any of the technologies?

Technology not adopted	**reason**

4) Do you intend to adopt them in future? □ Yes □ No

5) If yes why?

□ high yields □ soil fertility □ more income □ labour availability □ increased land

6) What recommendation would you give in order to increase the adoption of rejected technologies-

____

H. EXTENSION SERVICES

1) **Do you receive any extension advices: □ Yes □ No**

2) **If yes how often? □ Never occasionally □ S/times □ always □ everyday**

3) **Do the extension officers have preferences for whom to give information?**

□ YES □ NO

4) **If yes who do they prefer giving advice to □ Man □ Woman □ Both**

5) **What is mainly the gender of the extension officers? □ Men □ Women**

6) **What areas of knowledge do they emphasize on**

□ SWC uses □ soil erosion control □ pest and diseases management □ crop varieties

□ Soil fertility management