EFFECT OF CHANGE IN FARMING SYSTEMS ON SOIL RESOURCE MANAGEMENT IN SUBUKIA SUB-COUNTY, KENYA

By

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

This thesis is dedicated to my parents, Dr. Francis K. Migwi and Mrs. Loise Njambi, who taught me the value of education and hard work. To my sisters Faith and Winnie, and my brother, Lawrence, thanks for your support.

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LIST OF ACRONYMS AND ABBREVIATIONS

GDP	Gross Domestic Product
FAO	Food and Agricultural Organisation
KAPAP	Kenya Agricultural Productivity and Agribusiness Project
KAPP	Kenya Agricultural Productivity Project
ASPS	Agricultural Sector Programme Support
NALEP	National Agriculture and Livestock Extension Programme
NAAIAP	National Accelerated Agricultural Inputs Access Programme
USDA	United States Department of Agriculture
C	Organic carbon
N	Nitrogen
K	Potassium
Na	Sodium
P	Phosphorus
ADC	Agricultural Development Corporation
AFC	Agricultural Finance Corporation
ASDS	Agricultural Sector Development Strategies
UNDP	United Nations Development Program
LARMAT	Land Resource Management and Agricultural Technology
GIS	Geographic Information System
KFS	Kenya Forest Service
ESRI	Environmental Systems Research Institute
RCMRD	Regional Centre for Mapping of Resources for Development

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ABSTRACT

The Kenya Vision 2030 is a vehicle for accelerating transformation of Kenya into a rapidly industrializing middle income nation by the year 2030. It therefore recognizes the role of agriculture in ensuring that food insecurity is curbed and a reduction in the number of people receiving food relief throughout the year. An estimated 75 percent of the population depends on the agricultural sector either directly or indirectly. This therefore brings about the issue of soil resource management necessitated by a change in farming systems brought about by preference in some land uses as opposed to others. Land policies are hence important in ensuring that there is adequate implementation of laws that govern sustainable land use change. The objectives of the study were therefore to assess the changes in farming systems for the last three decades, to identify the differences in soil fertility under intensive and extensive farming systems, and to assess implementation of land policies in fostering sustainable land use and enhancing soil fertility. The study used a descriptive survey design where the population of the study was a total of 16,660 households. A sample size of 106 respondents comprising of 100 households and six key informants was used. Stratified random sampling and proportionate sampling were applied. Soil samples were collected from farmers in the three sub-locations based on the type of farming system (intensive or extensive). Surface soil (0-15cm) samples were collected from 18 farms, of which nine were from intensive and the other nine from extensive farms. To assess soil quality, samples were subjected to analysis of selected chemical properties (soil organic carbon, nitrogen, soil pH, phosphorus and potassium) in the laboratory. The data was analyzed using Genstat at five percent level of significance. Data collected using questionnaires was organised through the Statistical Package for Social Sciences (SPSS) and Chi-square statistical test was used to test all the hypotheses at $P<0.05$ significance level. This study showed that, small scale farming was the most predominant land use at 64%, and the least common was large scale farming, having reduced by over 13% in the past three decades. Other land uses which had changed significantly were; urban settlements, water resources and shrub land. More so, 97% of the farmers had adopted extensive farming as opposed to intensive farming. There were no significant differences between intensive and extensive farming systems in terms of soil pH, phosphorus and potassium. However, the two systems differed in terms of soil organic carbon and nitrogen with intensive farming system having more organic carbon and nitrogen. In light of soil fertility management practices adopted by farmers, the use of organic fertilizers was more preferred by over 60% of farmers from both intensive and extensive farming systems, as opposed to inorganic fertilizers. In addition, there are good land use related laws and policies in place, for sustainable soil resource management, but their implementation is ineffective. The study recommends that there is need to educate farmers on sustainable land use and soil fertility management practices to ensure environmental conservation for posterity. In addition, there is need to ensure that there is public sensitization on land use policies from a household level for sustainability.

CHAPTER ONE

INTRODUCTION

1.1 Background of the study

Worldwide, improving agricultural performance is the most powerful tool we have available to ensure a reduction in poverty and food insecurity (Pretty et al., 2011). In the 21^{st} century, agriculture has remained a fundamental tool for the purpose of ensuring sustainability of the environment, development of the economy and a reduction in poverty levels especially due to the fact that about 75 percent of the population in the world are from rural areas, and are mostly involved in farming (World Bank, 2008).

In Sub- Saharan Africa, it is estimated that about three quarters of the population work under the agricultural sector and one-third of the gross domestic product (GDP) is derived from agriculture. Development in the agricultural sector is about two to four times more effective in raising incomes as a main source of economic development among the very poor than growth in other sectors (Diao, et al., 2007).

Globally, almost 70 percent of fresh water is used for agriculture and 33 percent of the world's land area is agricultural land with arable land representing less than one-third of agricultural land (approximately nine percent of the world's land area). According to Kamoni and Rotich, 2013, agriculture accounts for about 24 percent of Kenya's GDP with an estimated 75 percent of the population depending on the sector either directly or indirectly. Much of the irregular strength and overall weakness in GDP and income growth in Kenya can be attributed to change in agricultural performance.

In the agriculture sector, Vision 2030 document envisages a transformation from the current practices to a more commercially oriented agriculture so as to ensure that Kenya has met its mission of being a middle income economy as a result of agricultural production. Agriculture depends largely on land which is a soil resource and is greatly affected by the farming systems in practice.

Farming systems have been broadly categorised into two major groups; intensive and extensive farming systems. According to Benton and Hemingway, 1992, intensive farming is a system of cultivation using large amounts of labour and capital relative to land area. Large amounts of labour and capital are required for the application of fertilizer, insecticides, fungicides, and herbicides to growing crops, and capital is mostly important for the acquisition and maintenance of high-efficiency machinery for planting, cultivating, and harvesting, as well as irrigation equipment where required.

On the other hand, extensive farming is a form of agriculture that will invest moderately low inputs of capital and labour in relation to the land that is being used for farming. This form of farming is best for animal rearing, however, it can also be appropriate for the growth of crops which require very little soil fertility levels. In addition, it depend on the availability of water and the elements of nature to produce the yields and does not make use of external elements such as; machinery and fertilizers (Nemecek et al., 2011).

There has been a decline in the amount of traditional organic inputs like; crop residues and animal manure, in various farming systems because of reduced yields and other uses such as; for the purpose of animal feed, fuel and fiber. Farmers are now faced with finding alternative or additional sources of nutrients from a variety of tropical agro-ecosystems and the range of organic inputs used in those systems, which include; trees, shrubs, cover crops, and composts. This thus brings about a challenge for research and extension activities in soil fertility management (Mihindo, 2008).

In Africa, there has been a steady reduction of soil nutrients which seems to be related to soil fertility management practices that are not suitable for the recent practice of constant cultivation under increasing population pressure (Haileslassie et al., 2005). Although, soil nutrient depletion does not necessary mean it is due to growing population pressure. For instance, Asia has a considerably higher population density than most African countries, but their grain yields are three times the amount found in Africa. This difference in yields has been attributed to the adoption and use of inorganic fertilizer as a soil fertility management practice, in high rates therefore translating to the continuous growth in Asia's grain productivity (Birungi and Hassan, 2007).

In addition to underutilization of chemical fertilizers, most small scale farmers in Africa adopt a subsistence-oriented output mix (Dorward et al., 2006; Jayne et al., 2002; Tegemeo Institute for Agricultural Development and Policy, 2006), which has been linked to increased cost in transportation of the yields from the farm to the market in regions with majority of smallholder farms (Onduru et al., 2010; Omamo et al., 2003). In Africa, subsistence-oriented production patterns that dominate the rural landscape have not been accounted for in relation with soil fertility depletion, however, there has been recognition that the decisions made by the farmers on soil fertility management reflect their choices of production (Marenya and Barret, 2009).

There is limited access to extension services in most parts of the country with the national extension staff to farmer ratio standing at 1:1500, inadequate research extension farmer linkages to facilitate demand driven research and increased use of improved farming systems continue to constrain efforts to increase agricultural productivity as farmers continue to adopt ineffective farming systems (Kiara, 2011).

Kenya Vision 2030, (2007); has also highlighted growth of the agricultural sector as a major challenge. However, Tittonell et al., 2008, noted that, variability in soil fertility at farm scale may be associated with topography, soil types, land degradation intensities, sharp physical discontinuities (e.g. rocky outcrops), land-use history or distance from the homestead and livestock facilities. This therefore depicts that there is a knowledge gap in terms of effects that farming systems have on the soil resource.

Land use policy is largely determined by land policy (Lambin and Geist, 2008). In Kenya, the need for a national land policy has been the main center of interest (MunkRavnborg et al., 2013) where land use policy is categorized into three distinct parts which comprise of; the control system, monitoring system and administrative system (Atisa, 2009). The failure by the existing land conservation policies and the need to have attendant laws to generate environmentally sound land use habits, has over time led to difficulties of access and utilization of land (Ogachi, 2011; Rockson et al., 2013). Land is an important resource for agriculture in Kenya and lack of access to or ownership of land has been considered one of the major causes of poverty (UNDP, 2012). The scarcity of agricultural land has made the issue of land use policy a critical one.

1.2 Statement of the problem

Over the past few years, the Kenyan Government has strived to improve agricultural productivity through government and donor supported programs such as Kenya Agricultural Productivity and Agribusiness Project 2009-2014 (Kasina and Nderitu, 2009), which is the second phase of the twelve years of the Kenya Agricultural Productivity Project 2004 (World Bank, 2004), Agricultural Sector Programme Support 2005-2010 (Webber and Labaste, 2010), National Agriculture and Livestock Extension Programme 2000 (Cuellar et al., 2006), and the National Accelerated Agricultural Inputs Access Programme 2007 (Simbowo, 2009). However, there has been an increasing decline in the trends on productivity of the agricultural sector (Kibaara et al., 2009).

Food insecurity in Kenya has grown at an alarming rate, with most of the researchers attributing it mainly to, climate change and also population growth (Maliondo et al., 2012). This is not entirely the case, other factors such as; shifting to mono-cropping for commercial purposes, limited or no addition of fertility enhancing inputs, and leaving no rest periods after each season of crop, have been noted to contribute to the low productivity of the soil (Jat et al., 2012).Soil resource has been over exploited in the past decades to ensure that agricultural productivity meets the demand for food (Johns et al., 2013).Population growth has been on the increase with an estimated 44,351,000 people in 2013, which represents an increase of 1,172,859 people compared to 2012 (KNBS, 2013). Land on the other hand, is finite in nature, and is therefore shrinking due to the need for settlement among other human needs. These therefore leaves a small fraction of land for agricultural productivity expected to produce enough food for the ever increasing population (Maletta, 2014).

The land use policies in place, have many a times been ignored and hence their ineffective implementation (Carew-Reid et al., 2013). According to Demetriou et al., (2012), the farming practices recommended in this region and in some parts of the country are not in conformity with the currently practiced farming systems, this is due to land fragmentation observed in most rural land areas in Kenya.

There is therefore a need to ensure that the land use policies in place are well implemented and appropriate farming systems are identified, and their effect on soil resource management noted in Subukia Sub-County. This forms the basis of this study.

1.3 Justification of the study

To ensure food security in Kenya, there is need for adoption of appropriate and effective farming systems and implementation of the available land use policies that will in turn enhance sustainable soil productivity. It is on this basis, that the study was initiated with an aim of contributing knowledge on the potential effect of change in farming systems on soil resource management in Subukia Sub-County for sustainability. The research findings will assist farmers, government departments and other stakeholders to understand sustainable farming systems and effects associated with the change in farming systems on soil resource management. The study will be useful to policy makers in coming up with appropriate methodologies to ensure that there is effective implementation of the land use policies in place. Therefore, sustainable land use practices will be adopted by the residents in Subukia Sub-County which in turn will result into proper utilization of agricultural land for posterity.

1.4 Objectives

1.4.1 Broad objective

To investigate effects of change in farming systems on soil resource management in Subukia Sub-County for sustainability.

1.4.2 Specific objectives

1. To assess the change in farming systems for the last three decades in Subukia Sub-County, Kenya.
2. To identify the difference in soil fertility under intensive and extensive farming systems in Subukia Sub-County, Kenya.
3. To assess implementation of land policies in fostering sustainable land use and enhancing soil fertility in Subukia Sub-County, Kenya.

1.5 Research hypotheses

1. There is no significant change in farming systems over the past three decades in Subukia Sub-County, Kenya.
2. There is no significant difference in soil fertility levels under intensive and extensive farming systems in Subukia Sub-County, Kenya.
3. There is no significant indication of implementation of land policies in fostering sustainable land use and enhancing soil fertility in Subukia Sub-County, Kenya.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The concept of farming systems research is seen as a new and different approach to organizing agricultural research in developing countries. As such, it has received significant attention by researchers in agricultural development activities and substantial support by organizations financing agricultural development projects (Dillon and Anderson, 2012).

According to Carr et al., 2013, depending on management practices of soil, its dynamic quality varies. Management choices might alter the amount of soil organic matter, soil structure, soil depth, water and nutrient holding capacity (Larney and Angers, 2012). In addition, Ramachandra, 2006, documents that, the overuse of fertilizer and pesticides can limit the ability of soil organisms to process wastes, which in turn make the soil less productive or even poisonous. This hence necessitates assessment of soil quality to minimize soil resource degradation and to implement mitigation measures (Ramachandra, 2006).

2.2 Farming Systems

A farming system is defined as a population of individual farms that have broadly similar resource bases, enterprise patterns, household livelihoods and constraints and for which similar development strategies and interventions would be appropriate (Darnhofer et al., 2011).

Globally, farming systems have varied and evolved along numerous ways. Population growth joint with current technology selections and market prospects have induced farmers to diversify and intensify systems (Dixon et al., 2001). Over reliance on the natural resource base and management systems, can either sustain and improve productivity over time, or degrade the natural resource base and therefore lower production potential over time (Darnhofer et al., 2011). On the other hand, increased population in the absence of technological or market opportunities can lead to: deepening poverty, degradation of the resource base and long-term agricultural involution (Dixon et al., 2001).

In Sub-Saharan Africa's humid and sub-humid areas, maize mixed farming system, located in East, Central and Southern Africa and cereal-root crop mixed farming system, located in West and Central Africa, are the predominant systems of agriculture which occupy 10 percent and 13 percent respectively, of the total land area (Waha et al., 2013). However, less than 11 percent of the agricultural population in Sub-Saharan Africa have adopted; root and tuber crop system, located in West and Central Africa; agro-pastoral millet/sorghum system located in West, East and Southern Africa; highland perennial system, located in East Africa; highland temperate mixed system, located in East and Southern Africa; forest-based system, located in humid lowland heavily forested areas in Central Africa; pastoral farming system, located in West, East and Southern Africa; tree crop based system and rice/tree crop mixed system, located in West and Central Africa (Waha et al., 2013) .

In addition, less than five percent of land area in Sub-Saharan Africa is occupied by; fish-based system, predominantly along the coast and around major lakes; commercial large holder and small holder system, irrigated farming system, predominantly located in low rainfall areas, and urban and peri-urban based system, located in all parts of Africa (Vanlauwe et al., 2014).

In Middle East and North Africa, 30 percent of agricultural population practice; highland mixed system, 18 percent, rain fed mixed system, 14 percent, dry land mixed system, and five percent sparse (arid) system, located in West, North-east and Southern Africa (Dixon et al., 2001).

Therefore, this study will focus on intensive and extensive farming systems which are the predominant systems in the study area.

2.2.1 Intensive Farming System

Intensive farming is a system of farming that aims to increase crop yield by artificially maximizing plant growth and by using synthetic chemicals to provide fertility and control pests and diseases that threaten crops (Hough et al., 2006; Benton 2012). According to Karp et al., 2012, intensive farming or intensive agriculture is a kind of agriculture where a lot of capital and labour is used in addition to large amounts of pesticides for crops and medication for animal stocks being common. The size of land in this type of system varies from place to place. For example; in Trans Nzoia County, land that is less than 100 hectares is referred to as intensive while in areas such a Nakuru County such a piece of land falls in the category of extensive farm land (District Agricultural Officer, 2013).

2.2.2 Extensive Farming System

Extensive farming is defined as the use of more land with lower yield to produce the same amount of food (Kremen et al., 2012). Extensive farming could also be defined as the agricultural production system that uses small inputs of labor, fertilizer and capital relative to the area being farmed (FAO et al., 2012; Tuomisto et al., 2012).

2.3 Changes in Farming Systems

The mixed farming system was once the backbone of all agricultural production systems. The twentieth century saw a gradual separation and specialization of production systems in the western world (Arthur et al., 2012). Almost all arable land through North America and Europe is now intensively and exclusively cropped and livestock production separated and intensified

(Clay, 2013). The move to separation has two prime motivations; firstly, the economic efficiency of specialization and secondly, the advent of cheap synthetic nitrogen fertilizer. No longer is cropping reliant on animals as a source of fertility (Groot et al., 2012).

In general the complex key farming system practiced for centuries has been replaced by specialized and efficient cropping operations (Robinson, 2008). These operations not only produce food products cheaply, but also support livestock units that are similarly specialized but spatially removed from the crop production unit (Entz et al., 2005). Mechanization and improvement in scale and efficiency of farm machinery has also added to the move towards intensive cropping (Sassenrath et al., 2008).

The ability of agriculture to sustainably maintain its growth in the long-term has faced many concerns brought about by, increased pressure on population growth resulting to a decrease in size of land holdings and thus, reduced fallow periods (Akpan et al., 2012). Farmers have been limited to the option of increased soil fertility inputs due to limited ability to restore soil fertility through the use of traditional soil fertility management practices, like, fallow periods and rotational farming (Martey et al., 2013).

Historical patterns of land use change can be used to more firmly establish relationships between land quality and land use (Aumtong et al., 2009). Lands that have recently shifted into or out of cultivated cropland from other, less intensive uses are at the extensive margin of cultivated land, with land use evidently susceptible to economic or other forces (Bucholtz et al., 2006). A conclusion on economic forces driving land use change and whether transitioning lands are of lower quality can be derived from a comparison within land attributes such as; the location of the land, productivity potential and the gradient of land which is transitioning with lands that have not shifted into diverse forms of land uses (Bucholtz et al., 2006).

By comparison, over 24 percent of cultivated cropland transitioned to conservation reserve program (CRP), and other land uses such as; grassland, rangeland, and forest cover, with about nine percent of cultivated cropland being registered as the lands that shifted from less intensive uses into crop cultivation during the period 1982 to 1997 (Sampson and De costa, 2000; Walker et al., 2006).

2.4 Soil quality

The term soil quality has many definitions suggesting that soil quality concept continues to evolve (Singer and Ewing, 2002). Arshad and Coen 1992, defined soil quality as "the sustaining capability of a soil to accept, store and recycle water, minerals and energy for production of crops at optimum levels while preserving a healthy environment." Karlen et al., 1997; stated that soil quality is the ability of the soil to serve as a natural medium for the growth of plants that sustain human and animal life.

Soil quality is a composite measure of both a soil's ability to function and how well it functions, relative to a specific use (Gregorich et al., 1994). It also refers to the capacity of a soil to function within ecosystem and land use boundaries, to sustain biological productivity, maintain environmental quality, and promote plant and animal health, (Doran et al., 1998).

Quality can be viewed in two ways:

i) As inherent soil quality, which is defined by the soil's inherent properties as determined by the five factors of soil formation.

ii) As dynamic soil quality, which is the change in soil function as influenced by human use and management of the soil (Arshad and Coen, 1992).

Soil quality is an account of the soil's ability to provide ecosystem and social services through its capacities to perform its functions under changing conditions (Johnson et al., 1997). Arshad and Martin, 2002, define soil quality as the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation.

Soil quality is a measure of the condition of soil relative to the requirements of one or more biotic species and or to any human need or purpose (Toth et al., 2007). It reflects how well a soil performs the functions of maintaining biodiversity and productivity, partitioning water and solute flow, filtering and buffering, nutrient cycling, and providing support for plants and other structures. According to Onduru et al., 2010, soil quality is the foundation of successful crop production, therefore, a decline in soil physical, chemical and biological properties are an indicator of poor soil quality.

Assessments of soil quality are used to evaluate the effects of management on the health of the soil (USDA, 2001). Soil management has a major impact on soil quality; hence, maintenance of soil quality is important to reduce the amount of water and fertilizer used. There are a number of practices that help maintain or improve the soil quality such as addition of manure and compost, covering the soil with crop residues and crop rotation (Arshad and Martin, 2002).

2.4.1 Soil Fertility

The differences between intensive and extensive farming are to an extent explained in the effect they have on the environment specifically the soil. According to Power and Prasad, 2010, extensive farming maintains the correct pH of the soil since it does not utilize artificial fertilizers. On the other hand, intensive farming affects the soil fertility due to its use of artificial fertilizers.

According to Jordan, 2012, converting natural land, such as grassland to intensively managed agriculture affects the soil. The soil structure is disturbed, soil organic matter is lost and bacteria increase at the expense of fungal communities. These impacts degrade the soil and affect the ecosystem services, hence reducing the ability of the soil to take up more nitrogen.

Large use of machineries, chemical fertilizers and pesticides can often cause, in time, a substantial decline in soil fertility by affecting soil physical and chemical properties and in turn soil microbial community (Scotti et al., 2009). Alteration in soil structure, nutrient loss and in particular changes in quality and quantity of soil organic matter are some of the principal soil degradation processes deriving from an intensive agricultural system (Scotti, 2010).

According to Government of Kenya, 2010; land remains under-exploited for agricultural production. In the high and medium rainfall areas, only 31 percent of the land is under crop production which is approximately five percent of the total land in the country. Much of the available cropland remains under-utilized. For instance, about 60 percent of small scale farmers use their crop land for agricultural purposes (Government of Kenya, 2010). In rural areas, land-use practices are largely incongruent with the specific ecological zones. Uneconomic land subdivisions coupled with poor land-use practices are responsible for accelerated land degradation and declining land productivity (Government of Kenya, 2010).

Most agricultural production occurs in the medium to high potential highlands, in the context of small (1-5 ha) mixed farms growing maize and beans, tea or coffee (Gruhn et al., 2001). Soil fertility is one of the primary constraints to agricultural production in Sub-Saharan Africa. This is particularly true where population densities are high (Cakmak, 2005).

By measuring soil texture, bulk density, water content, water holding capacity, pH, cation exchange capacity, organic carbon (C), total nitrogen (N), potassium (K), sodium (Na) and lime across three soil sample under controlled conditions, indicated that the soils not subjected to intensive farming always showed better values of chemical properties and higher values of enzymatic activity and microbial biomass to indicate a negative effect of intensive agriculture practices (Diacono and Montemurro, 2010).

Von Westarp et al., 2004, investigated the level to which soil fertility had been compromised through intensification of agriculture by developing nutrient budgets for nitrogen (N), phosphorous (P) and potassium (K), to examine if inputs of these nutrients were sufficient to meet crop uptake. She discovered that phosphorous inputs to irrigated sites under intensive agriculture were considerably greater than crop uptake requirements, whereas inputs of nitrogen and potassium were insufficient leading to negative nutrient budgets. The imbalance had caused a significant increase in the level of available phosphorous in the soil and a significant decline in the amount of exchangeable potassium in the soil (Von Westarp, 2002). In addition, intensification was accompanied by decline in the levels of base cations in the soil indicating soil acidification (Von Westarp et al., 2004).

With the fertilization efforts under intensive farming comes the danger of nutrient saturation of soil. However, the effects to the soil are mostly limited to reversible inhibition of soil biota (Thiele-Bruhn, 2003; Schauss et al., 2009). This high input farming model has created a fertility problem as natural sources of soil fertility are destroyed and the more the fertilizer used, the more the fertilizer needed each year to maintain production levels for crop growth (Oerke et al., 2012).

Sustainable soil management implies using the soil in a manner that does not compromise production capacity for future generations and does not lead to environmental problems downstream (Liniger et al., 1998a). The rising population density has contributed to the subdivision of land to uneconomically small units. In addition, the reductions of fallow periods and continuous cultivation have led to rapid depletion of soil nutrients, declining yields and environmental degradation (Government of Kenya, 2010).

2.5 Land use

Land is an important factor of production because it provides the foundation for all other activities such as agriculture, water, settlement, tourism, wildlife, forestry and infrastructure. Land is an area of the earth's surface, including all attributes of the biosphere, vertically above and below this area with those of the atmosphere, the soil, the geology, the hydrology, the plant and animal populations and the results of past and present human activity (Cieszewska 2014). Land issues are important to the social, economic and political development of Kenya. Secure land tenure, sustainable land-use planning and equitable distribution of land contribute to food security and social-economic development of a country. The physical quality, relative location and form of ownership of a certain piece of land will make it more or less suited for certain activities (Eriksen and Lind, 2009).

2.5.1 Challenges in Land use

Lack of a comprehensive National Land Policy over the years, and existence of many land laws, some of which are unrelated, has brought about challenges in the administration and management of land (Republic of Kenya, 2014). This has led to fragmentation of land, breakdown in land administration, and disparities in land ownership, with other challenges including; deterioration in land quality, squatting, landlessness, under-utilization and abandonment of agricultural land, tenure insecurity and conflict. In some parts of the country, high population densities and cultural practices of dividing land for inheritance have resulted in highly fragmented and uneconomical plots. Increased damage and vulnerability of the environment due to the issues of growth in the number of people and inadequate availability of land therefore resulting into shifting marginal lands such as; mountain slopes and flood plains, into agricultural land (Republic of Kenya, 2014).

Consequently, In some of the areas in the country, where the number of people are less, some factors such as traditional practices have resulted to idle or under-utilized land, thus, the affected rural population are hardly able to meet their subsistence needs (Republic of Kenya, 2014).

The availability of surface water has been consistently affected by increased run-off, flash flooding, reduced infiltration, erosion and siltation, hence, causing the rivers and reservoirs to dry up and a decline in limited sustainable water resource base in the country (Kiteme et al, 1998). The main causes of degradation are poor farming methods, population pressure and cutting down forests for agricultural land and fuel wood. Flash floods and turbidity are brought about by; over-abstraction of surface water in some parts of the country, inappropriate land use practices, soil erosion in catchments and deterioration of riparian lands. Thus, siltation of water courses and storage facilities has led to serious degradation of the capacity and value of water resources (Government of Kenya, 2010).

Massive wetland loss and degradation has been brought about by lack of a single agency in charge of wetland conservation and management, thus, lack of a holistic institutional framework has affected overall coordination and management of wetland resources in Kenya (Republic of Kenya, 2013). The Government of Kenya, has undertaken reforms intended for conservation of environmental resources including wetlands. The Constitution confirms the government commitment on sustainable exploitation, utilization, management and conservation of the environment and natural resources, and ensures fair distribution of the ensuing benefits. This includes enactment of legislations related to conservation and management of wetlands in the country. The relevant laws include the Environment Management and Coordination Act (section 42), the Merchant shipping Act of 2009, the Wildlife policy and Bills and the Water Act (2002) which deals with management, conservation and control of water sources. Even with the various sections of law, sustainable management of wetlands in Kenya has not been realized (Republic of Kenya, 2013).

Land use and land tenure changes in Subukia Sub-County were witnessed over the last century and characterized by vivid changes (Government of Kenya, 1965). Three distinct periods: pre-colonial; colonial; and post-colonial are important to consider in order to analyse these changes.

In pre-colonial times, most of Subukia Sub-County formed part of the Maasai community territory. The Maasai community practiced traditional pastoralism and land was owned communally (Government of Kenya, 1965). The expansive Maasai country provided virtually unlimited space, allowing for movement from one region to the other, following the rains in search of pastures and water for their large herd of cattle (Kohler, 1987).

The beginning of the 20th century was marked by the coming of Europeans and subsequent colonisation of Kenyan territory, which signified the beginning of the colonial period in Kenya (Government of Kenya, 1965). The process of colonisation saw the balkanisation of Kenyan land, which was divided into two major blocks: The ‘White Highlands’ or the ‘Scheduled Areas’ and the ‘Native Reserves’ (Government of Kenya, 1965). The Maasai in Subukia, being victims of this balkanisation, were forced out and pushed to the southern parts of Laikipia District (Ayiemba, 1989). The area was subdivided into large scale farms and ranches exclusively owned by white settlers. Africans were only allowed to stay in the scheduled areas if they found work on one of the European farms (Kiteme et al., 1998). Large dairy cattle ranches, wheat, pyrethrum, and coffee production were introduced on what was formerly pastoral land. Similarly, different land and resource management systems were put in place (Huber and Opondo, 1995).

The events that followed soon after Kenya's independence were largely responsible for giving land use systems in Subukia Sub-County their present form (Government of Kenya, 1965). When Kenya became independent in 1963, the 'Scheduled Areas' were abolished and the White Highlands became an open frontier for African immigration and settlement (Government of Kenya, 1965). Some of the white settlers decided to withdraw from ranches in Subukia, thereby allowing for the acquisition of the same by either the Government, the Land Buying Companies and Co-operatives, or individuals (Kohler, 1987). Some of these land buying companies and co-operatives were; Kirengero, Tetu, Kianoe, and Kabazi. However, a good number of the white settlers decided to remain in Kenya and continue their ranching and farming activities (Wiesmann, 1998).

The wave of land subdivision that started immediately after independence has continued unchanged to the present time. Land buying companies continued to acquire more and more land, into the most fringe areas, subdividing it into small parcels to be sold to landless peasant farmers from the high-potential neighbouring areas (Wiesmann, 1992). Similarly, the Government has continued to open formerly large scale ranches for subdivision and subsequent settlement by communities (Huber and Opondo, 1995).

According to Wiesmann 1998, looking critically at the events of land subdivision and the trends that have emerged since independence, we can clearly see two distinct features: the first wave of land subdivision that took place within one and one-half decades after independence, necessitated by the genuine desire of the government to settle the people who had been rendered landless by the events of the struggle for independence, and the desire of the land buying companies to provide the landless poor from the high-potential area of central Kenya with a relatively cheap means of acquiring their own land (Wiesmann, 1998). This explains why land for subdivision was acquired following strict assessment of the ecological capability of the given areas to support certain agricultural activities (Wiesmann, 1992). Consequently, land subdivided under the government settlement schemes was limited to the wetter, high-potential areas in the West and North-Western parts of the Sub-County, with plot sizes ranging between 15 and 30 acres (Huber and Opondo, 1995). Similar settlement schemes in the East were characterised by plots that averaged 5 acres. Areas subdivided under land buying companies averaged 9 acres and 5 acres in the same region (Huber and Opondo, 1995).

The second feature that emerges is that subsequent conversion of large scale farms and ranches into smallholdings, either originating with the government or private land buying companies, seemed to be driven more by economic and political considerations than the noble objective of creating land for the landless (Wiesmann, 1992). Taking advantage of the landlessness affecting people in central Kenya, directors of the many land buying companies that mushroomed shortly after independence bought land in Nakuru on a speculative basis and recruited members in order to maximise profits and build political bases for their future political advancement (Kohler, 1987).

Consequently, subdivision motivated by political and economic greed ignored the need to assess the ecological capacity of these areas to support the resulting land use activities (Wiesmann, 1992). Land subdivision was based exclusively on absolute numbers of shareholders and not on the carrying capacities of the areas affected. Based on these considerations, many of the subdivided farms averaged 10 acres (Government of Kenya, 1965).

Another important aspect relating to land subdivision in the Sub-County is secondary subdivision, which was first experienced a decade or so after the initial subdivision (Huber and Opondo, 1995). Secondary subdivision is usually caused by sociocultural and socioeconomic factors and is rather difficult to control (Wiesmann, 1992). Over time, as the families of the first generation settlements matured, more land was required to fulfil inheritance and other important domestic obligations such as education costs, subjecting the already subdivided land to further subdivision (Kohler, 1987). As a result, the original acreage dropped, sometimes to extremely small parcels (as small as 1 acre) depending on the size of the family, with the initial effects of population pressure manifesting themselves clearly in the affected areas (Ayiemba, 1989). Another glaring effect is the degradation of the sloppy areas forming the walls of the Great Rift Valley due to tree cutting and seasonal burning of the vegetation just before the rains by the communities. This has affected the water sources and resulted to extensive erosion of the soil resource (Liniger et al, 1998).

According to Katila, 2008; until recently, the debate on the interface between land tenure and land use was restricted to enhance agricultural production. However, land tenure, since it determines access to land is a critical variable in the management of natural and environmental resources, soil conservation as well as wildlife management. Kenya having an agricultural based economy has majority of its people deriving their livelihood from various forms of agriculture (Waiganjo and Ngugi, 2001).

According to Chauveau, 2007; land tenure provides the legal framework within which all agricultural as well as other economic activities are conducted. Tenure insecurity, customary or statutory tenure regimes, undermines the effectiveness of these activities. When tenure rights are certain, they provide incentives to use land in a sustainable manner or invest resource conservation whether for individuals or group of individuals (Chauveau, 2007).

2.6 Land use policy

Policy refers to general principles and proceedings formulated or adopted by an organization to reach its long term goals and typically published in a booklet or any other form that is widely accessible (Post and Preston, 2012). Webster's dictionary defines a policy as such a specific decision or set of decisions together with the related actions designed to implement them. Although a policy is like a decision, it is not a one off independent decision. It is a set of coherent decisions with a common long term purpose(s) and are supported by special legislation (Aregheore, 2009).

The need for a national land policy has been the main center of interest in Kenya. In December 2009, the Government of Kenya approved a new national land policy to ensure sustainable and equitable land use. The new framework classifies land ownership in Kenya as private (leasehold and freehold), public and community land, managed and used by councils for the benefit of a community (Sifuna, 2009).

Land use policy can be subdivided into three parts, every part having a different nature of its own. The control system consists of different plan documents, conservation decisions and other plans that concern a specific area, region and space (MunkRavnborg et al., 2013). The issue of whether these plans of land use are realized or not is handled within the monitoring system, in which also environmental impacts are assessed. The administrative system (either public or private) is responsible for producing and also partly for executing land use plans (Atisa, 2009). Land use policy is largely determined by land policy (Lambin and Geist, 2008).

An important pillar of land use policy is land use planning. Planning refers to decision making process that is fundamental in policy making. Planning is problem driven, information dependent and never an absolute or perfect answer (Lein, 2008). Land use planning is a process of examining different land use options, choosing them and marking off a land use plan to make the chosen priorities come true. Land use planning realizes the outcomes of land use policy (Thompson, 2010).

The failure by the existing land conservation policy and the need to have attendant laws to generate environmentally sound land use habits, has over time led to difficulties of access and utilization of land (Ogachi, 2011; Rockson et al., 2013). Land is an important resource for agriculture in Kenya and lack of access to or ownership of land has been considered one of the major causes of poverty (UNDP, 2012). The scarcity of agricultural land made the issue of land use policy a critical one.

2.6.1 Policy statements related to land use

According to the policy document on land use (Republic of Kenya, 2014), to attain sustainable land use management, both the national and county governments should ensure the following:-

> That they identify, map and regulate zones for agricultural practices in terms of type of resource, systems, climatic and ecological diversities. Legislate appropriate land sizes suitable for various agricultural enterprises based on ecological zones and economic potential. Provide for rural land use strategies to assist communities achieve optimum productivity and make rural land use planning an integral part of land adjudication process (Republic of Kenya, 2014).

Develop and enforce the legal frameworks for implementation of agriculture, livestock, fisheries and related policies. More so; they should develop, manage and sustainably use agriculture, livestock and fisheries resources while conserving water catchments and riparian zones to ensure regular supply of water for development of agriculture, livestock and fisheries resources. In addition, there should be improved access to affordable inputs in agriculture, livestock and fisheries, and lastly, promoting the use of modern technologies to increase food and feed production (Republic of Kenya, 2014).

In the densely populated rural rain-fed counties, the two levels of government, must prescribe the minimum units that may not be subdivided any further. This will vary from county to county but the guiding principle must be units that can economically support agricultural production including aquaculture (Republic of Kenya, 2014).Where feasible, and this applies to many rain-fed regions with private land ownership, a carefully considered policy of reconsolidating land for agricultural production should be implemented (Republic of Kenya, 2014).

It was envisaged that, consolidation will allow for better agronomic practices including application of machinery that ease farming and increase its attractiveness particularly to the youth (Republic of Kenya, 2014). Moreover, it will equally curtail further subdivision of agricultural land, increase efficiency in provision of social amenities and minimize degradation of rural agricultural land (Republic of Kenya, 2014).

While much has been achieved in the last five years, an outdated and fragmented legal and regulatory framework still remains a challenge to development in the agricultural sector (Government of Kenya, 2010). An all-inclusive land policy involved in taking care of, the usage, administration, tenure, security, and delivery systems of land is not available (Government of

Kenya, 2010). This has brought about low investment in land improvement, underutilization of productive land and lack of right to use land (Government of Kenya, 2010).

2.7 Theoretical Framework

This study is based on the von Thunen's general theory of land use (Thunen, 2002). The distinctive aspects of this theory are; land value, land use intensity and transportation cost. This theory has been used since it helps to explain the locational aspect of the agricultural land use pattern.

The study is also based on participatory program planning model (Lefevre et al., 2000). The model is a planning paradigm that emphasizes involving the entire community in the strategic and management processes of planning or community-level planning processes that is often considered as part of community development (Lefevre et al., 2000). With regard to rural development, participation includes people‘s involvement in decision making process, implementing programs, sharing in the benefits of development programs, and their involvement in efforts to evaluate such programs (Lefevre et al., 2000).

2.8 Conceptual Framework

The dependent variable in this study was soil resource management which was measured by soil fertility management practices such as; organic and inorganic fertilizer used by the farmers, crop rotation, agroforestry, irrigation and fallowing of croplands. The independent variable was the farming systems which included intensive and extensive farming systems.

The intervening variables, which according to Kothari (2004) are independent variables that are not related to the purpose of the study but can have an effect on the dependent variable. In this study the intervening variable included land use policies such as the; Water Act 2002, Agriculture Act 2012, National Land policy 2009 and Forest Act 2005.

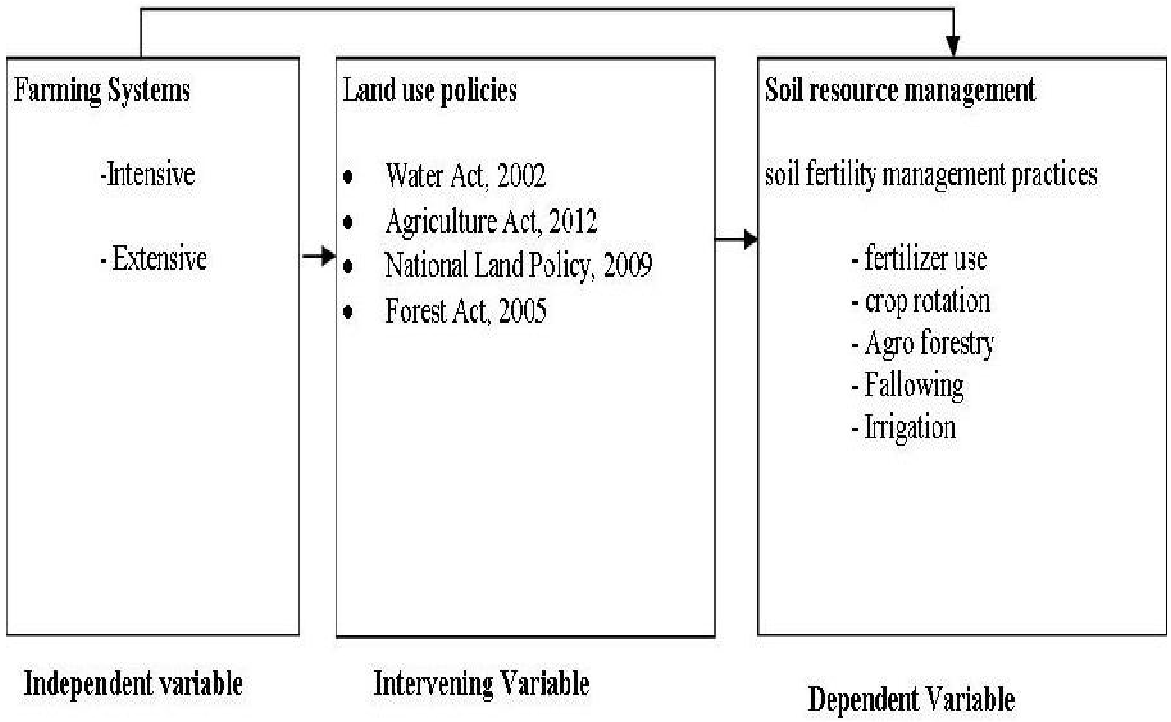

Figure 1: Conceptual Framework

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study Area

Subukia Sub-County is located in the Rift Valley region, Nakuru County and lies between Latitude 0° 0' 6.7705" S and Longitude 36° 13' 40.1682" E. It has an average elevation of 2012 meters above the sea level and is approximately 43 kilometers from Nakuru town (District Agricultural Officer, 2013).

The Sub-County experiences bimodal rainfall pattern characterized by long rains from mid-March to August; and the short rains being received in the months of September to December. The average annual rainfall ranges from 700mm to 1400mm with a mean of 900mm and temperatures ranging between 10°C during the cold months (July and August) and 20°C during the hot months (January to March) (Jaetzold et al., 2006). The soils found in Subukia Sub-County are Phaeozems. They are well drained, less weathered clayey soils with high contents of organic or humic substances in the topsoil as well as a high CEC and plant-available soil water (Jaetzold et al., 2006).

The Sub-County covers an area of 42,420 hectares and has two wards namely Subukia East and Subukia West (Figure 1) which comprise of Subukia, Kabazi, and Weseges sub-locations with a projected population of about 85,000 persons, with 19,600 households and 16,660 farm families (KNBS, 2010). The Sub-County has a total of 34,000 hectares classified as agricultural land with 60 percent of it being cultivated. The most important livelihood in the Sub-County is farming which is practiced by about 85 percent of the households (District Agricultural Officer, 2013).

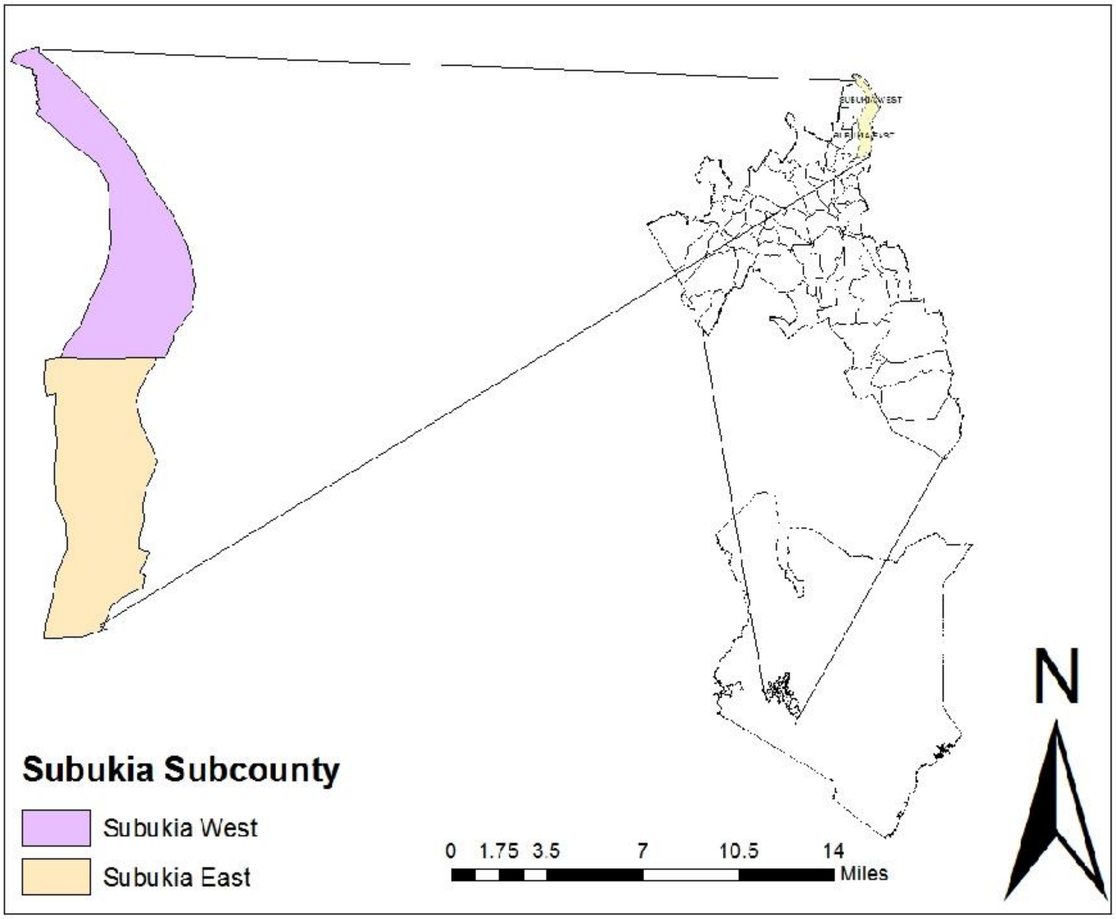

Figure 2: Map of the study area showing the two wards (District Agricultural Officer, 2013)

3.2 Land cover change

Landsat imageries obtained from Regional Centre for Mapping of Resources for Development (RCMRD), Kenya; were used to assess land cover changes in the study area. The selected years of the images were purposively chosen considering temporal sensitivity. ENVI 4.7 software (ESRI, 2009) was used to process the Landsat imagery for the years 1985, 1995, 2005, and 2015. False colour composite using different reflective indexes were used for the visual examination and interpretation of the images.

The images were then classified into different land cover types using supervised classification. Seven main land cover types were classified according to Anderson, 1998; guidelines and selected to carry out statistical analysis. The types of land cover were forest land, urban areas, water bodies, small scale farm lands, large scale farm lands, grass land, and shrub land. Thematic change detection was established using ENVI EX Software (ESRI, 2009) by comparing two images of different times (1985-1995 and 2005-2015 image changes). The software identified differences between the images with a resultant classification image and statistics. The statistics on image changes were examined and analysed for land cover change and their percentage changes subjected to Chi-square test to establish significance levels.

3.3 Soil sampling and analysis

A total of 18 soil samples (six for each ward) were collected from the farm households which undertook the questionnaires. Three of the soil samples for each ward were collected from the intensive farms while the other three from the extensive farms. This ensured that there was an equal collection of the soil samples from both intensive and extensive farms. From each selected farm, distributed soil samples were taken from six spots. The soil sampling approach used was the zigzag pattern (Okalebo et al., 2007).

Soil samples were collected to a depth of 0-15 cm at each of the six auger points as indicated above. Samples from each of the auger points were transferred into a clean bucket and thoroughly mixed to make a composite sample. From this, about two kilograms of soil was scoped and placed in a sampling bag. The bags were labeled indicating the depth of sampling and field designation number.

The samples were transported to the Soil Science Laboratories in the Department of Land Resource Management and Technology (LARMAT), University of Nairobi for analysis. They were air-dried, crushed and passed through the 2 mm sieve. A further soil sample was passed through the 0.5 mm sieve for organic carbon and nitrogen analysis. The soil samples were analysed based on the recommended standards of soil analysis by Okalebo et al., 2007, in the determination of soil organic carbon, nitrogen, soil pH, phosphorus and potassium.

3.3.1 Sampling size and technique

A questionnaire with both open and closed ended questions was administered to obtain information from 100 respondents. Stratified random sampling procedure was used to select the respondents. This is because the technique produces estimates of overall population parameters with great precision (Shuttleworth and Cowie, 2014). The population of 16,660 households was grouped into three strata i.e. Subukia, Weseges, and Kabazi sub-locations (Table 1) based on population of farming households and using simple random sampling for each stratum, proportionate selection of households was done giving a total sample size of 100 households. Proportionate sampling was used because each ward was allocated a sample of households depending on its proportion to the total number of households.

Table 1: Sampled households from Subukia Sub-County

Stratum (sub-location)	Target population	Sample size (±10%)
Subukia	6048	**36**
Weseges	5657	**34**
Kabazi	4955	**30**
Key informants		**6**
TOTAL	**16660**	**106**

In addition, six key informants were sampled from the relevant line ministries which included the Ministry of Agriculture, Livestock and Fisheries and the Ministry of Environment, Water and Natural Resources in the Sub-County. They were selected using purposive sampling technique (Denscombe, 2008) and interviewed to get in-depth information on some key issues as indicated in Appendix II.

Primary data collected was as indicated in Appendix 1, while, secondary data on land use policies and their implementation in Subukia Sub-County was collected from the Ministry of Environment, Water and Natural resources, and the Ministry of Agriculture, Livestock and Fisheries in the Sub-County.

3.4 Data Analysis

The data collected using questionnaires was organized through the Statistical Package for Social Sciences (SPSS) and analyzed using Chi- square to determine their significance levels. To assess the effect of farming systems on soil quality, soil data was analyzed using GenStat, 13th Edition at five percent level of significance. To assess land cover change obtained by GIS maps, statistics on image changes were examined and their percentage change subjected to Chi-square test to establish significance levels.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Changes in farming systems for the last three decades

4.1.1 Land-use change in Subukia Sub-County

The year 2005 recorded approximately 11 percent of forest cover in Subukia Sub-County as compared to 8 percent in 1985 (Figure 2 and 3). This significant ($P<0.05$) increase was attributed to the continued increase in forest plantations over the years in the Rift valley region. However, the years 1985-1995 and 2005-2015 ($P=0.63$) registered an insignificant decrease in forest cover of approximately 1 and 5 percent respectively (Table 2).

There was a significant effect of urbanization ($P=0.00$) and the area occupied by water bodies ($P=0.01$) on the available agricultural land for the past three decades in Subukia Sub-County (Table 2). More so, large scale farm lands have reduced by about 14 percent from the year 1985 to 2015 (Table 2). On the other hand, the area occupied by small scale farms in the years 1985-2015 have significantly increased by 24 percent ($P=0.01$) (Table 2). This was as a result of land fragmentation and changes in land tenure and ownership system.

Grassland and shrub land had also changed with a significant decrease (Table 2) of 10 percent in the area covered by grassland from the years 2005-2015 ($P=0.25$) and a corresponding increase in shrub land ($P=0.00$) of 12 percent (Table 2). A drastic reduction in shrub land from the year 1995 to 2005 was also recorded (Figure 3 and 4). All these changes have occurred in a period of about 30 years, and could be attributed to the various human activities and prioritization on some land uses as opposed to others. The decrease in shrub land cover was as a result of encroachment into the ecosystems by human activities especially agricultural land use and settlement.

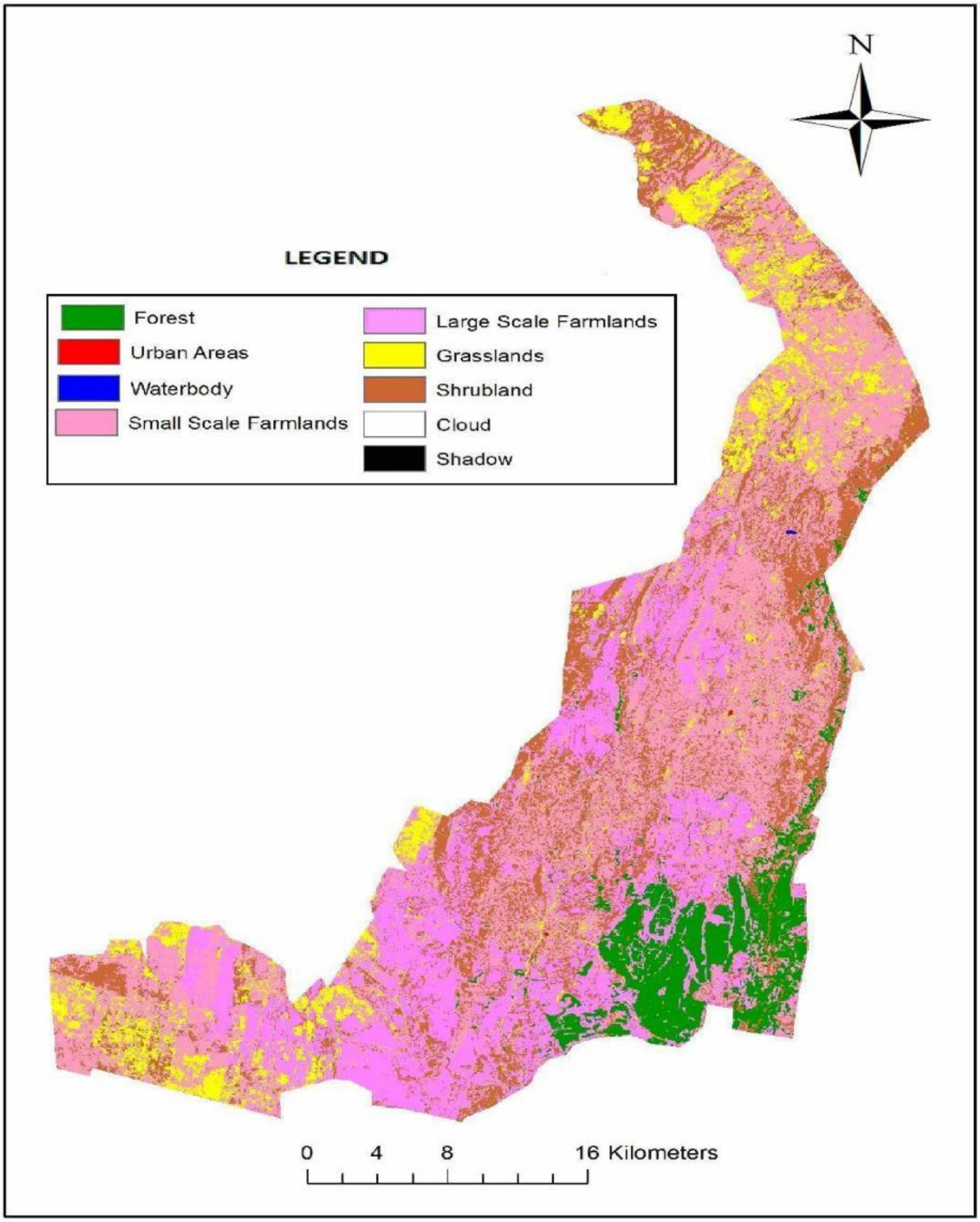

Figure 3: Land cover in Subukia Sub-County for 1985 (Landsat)

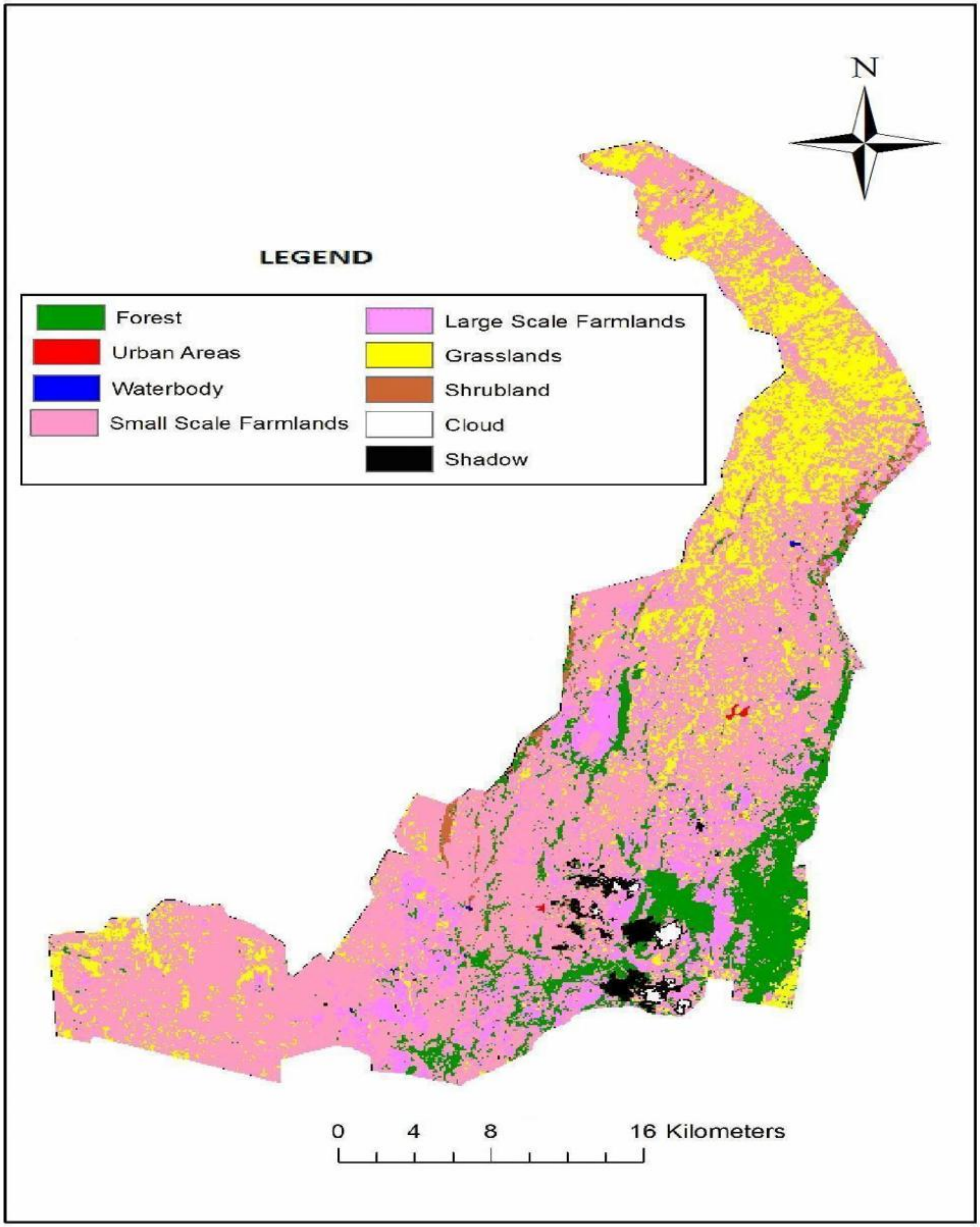

Figure 4: Land cover in Subukia Sub-County for 2005 (Landsat)

Table 2: Land cover change in Subukia Sub-County

	Coverage (%)				Change in Coverage (%)				Chi-square test		
Land cover	**1985**	**1995**	**2005**	**2015**	**1985-1995**	**1995-2005**	**2005-2015**	**1985-2015**	x^2	df	p
Forest	8.07	7.11	11.02	6.30	-0.96	+3.91	-4.72	-1.77	1.75	3	0.63
Urban area	0.01	0.02	0.07	0.16	+0.01	+0.05	+0.09	+0.15	21.69	3	0.00
Water-bodies	0.02	0.01	0.03	0.10	-0.01	+0.02	+0.07	+0.08	12.50	3	0.01
Small scale farmlands	40.22	36.66	59.99	64.55	-3.56	+23.33	+4.56	+24.33	11.74	3	0.01
Large scale farmlands	21.32	6.02	10.42	7.71	-15.30	+4.40	-2.71	-13.61	11.98	3	0.01
Grassland	9.88	10.16	17.28	7.89	+0.28	+7.12	-9.96	-1.99	4.16	3	0.25
Shrub land	20.47	23.25	1.20	13.28	+2.78	-22.05	+12.08	-7.19	18.49	3	0.00

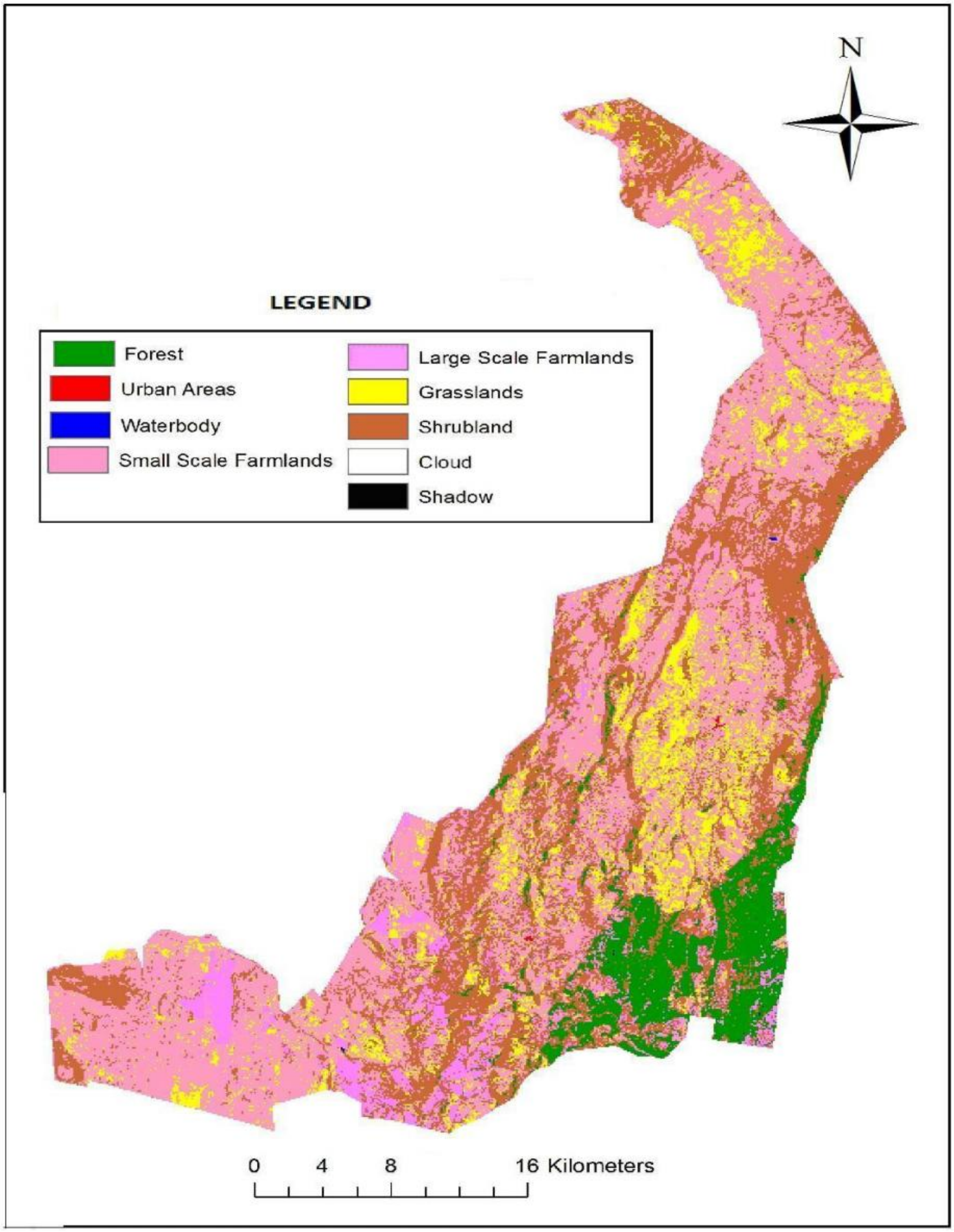

Figure 5: Land cover in Subukia Sub-County for 1995 (Landsat)

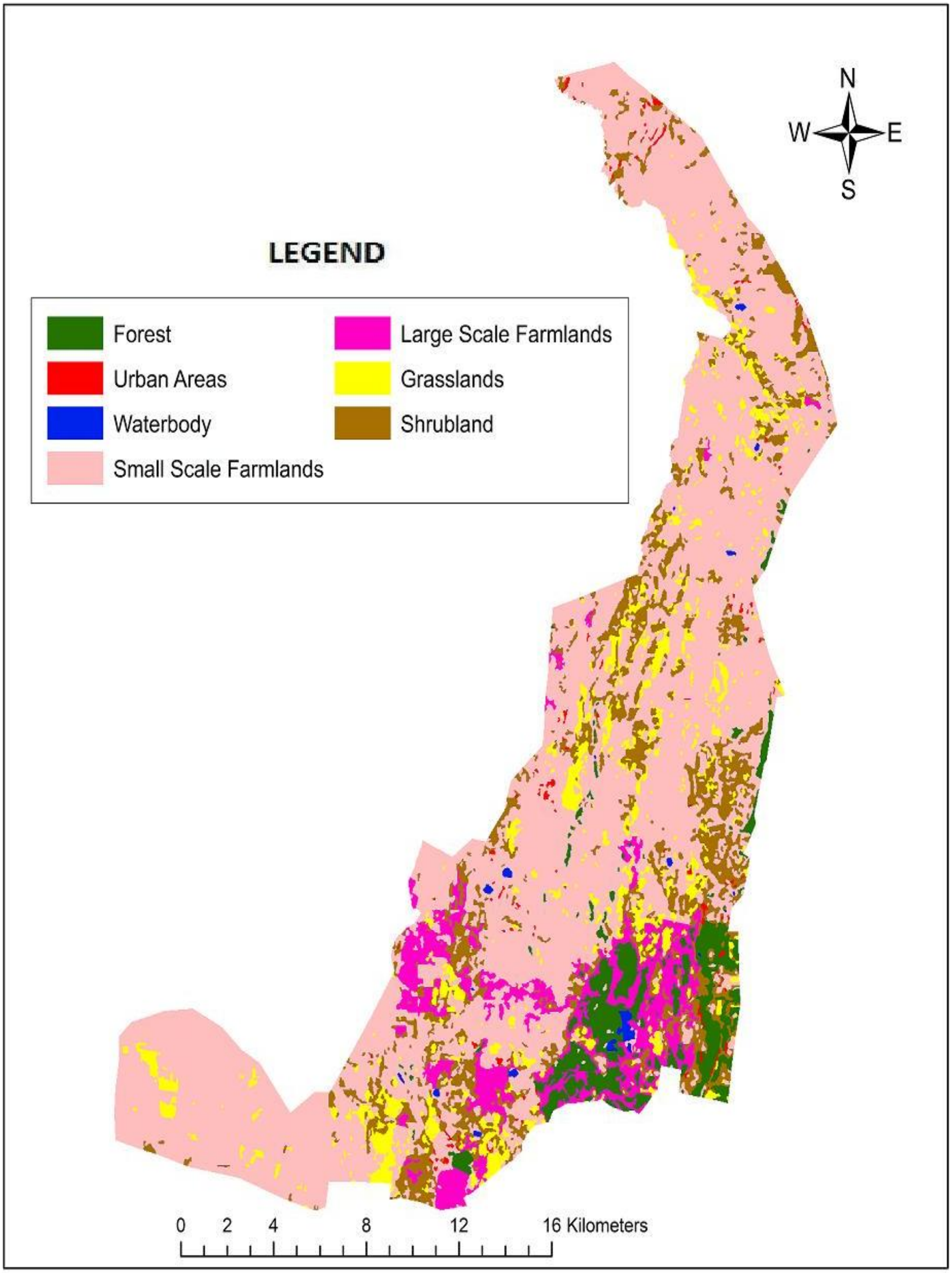

Figure 6: Land cover in Subukia Sub-County for 2015 (Landsat)

These results are supported by the indication that spatial patterns of land use have occurred across East Africa over the past 50 years characterized by increased intensively managed landscape outside protected areas of extremely marginal environments (Olson et al., 2004). Land use and land cover change are so pervasive that, when aggregated globally, they significantly affect key aspects of Earth Systems Functioning (Sala et al., 2000). However, increase in forest cover seems to be an exception as most studies on tropical forests point toward reduction in forest cover and do not account for areas where forest cover is increasing except in areas with a low population density (Kukkonen, 2013). This study attributes such increase to the increase in commercial tree farming and conservation efforts spearheaded by Non-State Actors who have been active in the study area.

4.1.2 Land size and farming area

The total land area of Subukia Sub-County was 44,373 hectares with Subukia sub-location covering 22 percent, Kabazi sub-location 32 percent and Weseges sub-location 46 percent (Table 3).

Table 3: Land size of three sub-locations in Subukia Sub-County

Sub location	**Subukia**	**Weseges**	**Kabazi**
Acreage (ha)	9,663	20,320	14,390
Percentage (%)	21.8	45.8	32.4

Out of the total area in Subukia Sub-County, 88.5 percent was described as arable land while 1.7 percent was defined as water catchment while the remaining 9.8 percent was land under infrastructure, including urban and rural settlements, roads, health facilities, religious institutions, and educational institutions among other social amenities (Figure 6).

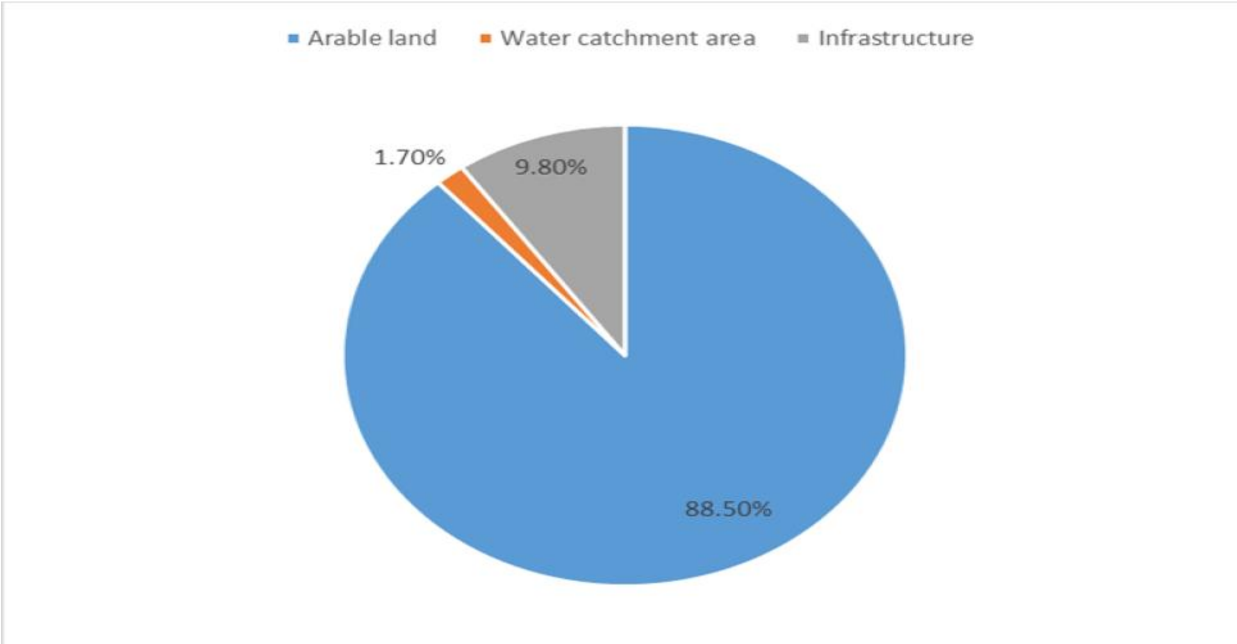

Figure 7: Land use in Subukia Sub-County

The results indicated that for arable land, 88 percent was rain fed while 12 percent was irrigable, with only 18 percent of the irrigable land being currently under irrigation (Figure 7). Besides, 9.8 percent of land described as water catchment area, was already encroached and was either under cultivation or used as grazing land (Figure 7).

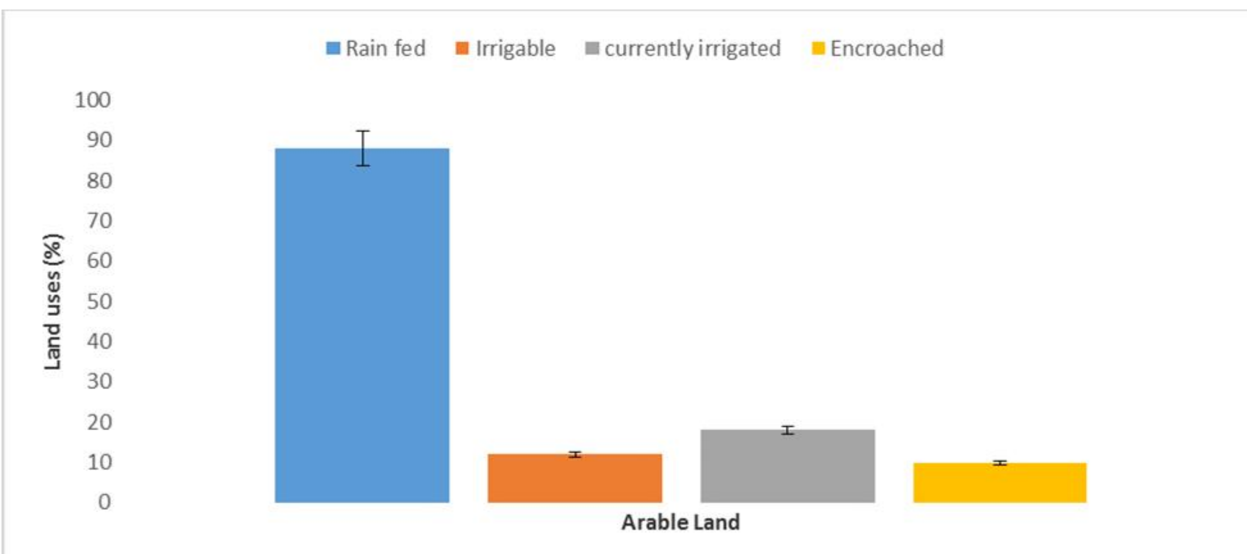

Figure 8: Arable land use in Subukia Sub-County

When the three sub-locations in Subukia Sub-County were compared, the results indicated that 48 percent of the total area in Subukia sub-location was rain fed, 52 percent in Kabazi sub-location and 36 percent in Weseges sub-location. While for irrigable land 3.7 percent was currently under irrigation in Subukia and only 0.3 percent in both Kabazi and Weseges (Figure 8). The distribution of land under infrastructure among the three sub-locations was 28 percent in Subukia, 47 percent in Kabazi and 62 percent in Weseges (Figure 8).

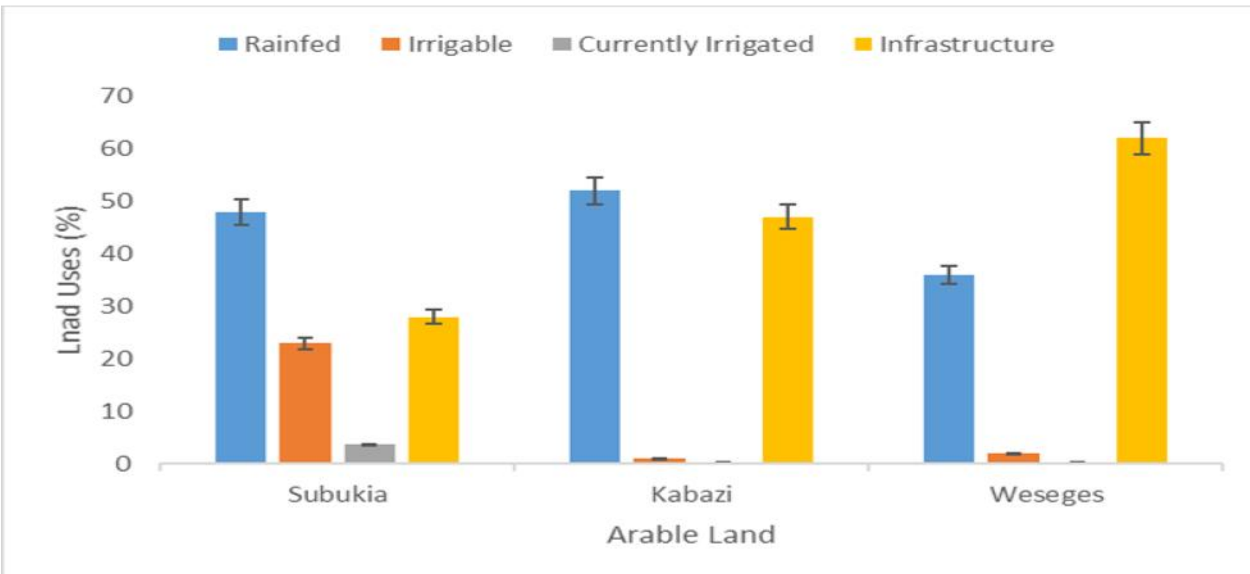

Figure 9: Arable land use in the three sub-locations of Subukia Sub-County

The study area has Phaeozem soils which are highly arable and are used for growing wheat, soybeans, and pasture for cattle, as well as for wood and fuel production (FAO, 2012). This accounts for 88 percent of land in the study area which is arable. However, the climate of the study area varies slightly across the sub-locations with Kabazi registering higher average rainfall compared to Subukia and Weseges. This explains why a higher land area in Kabazi supports rain fed agriculture compared to Subukia and Weseges. The low uptake of irrigation especially in Weseges which receives the least rainfall of the three sub-locations is due to the challenges such as lack of financing, poor maintenance, absence of functioning farmer support services and low income levels (Blank et al., 2002). FAO 2012, also adds to the discussion by citing financing of irrigation equipment as a major constraint.

According to the Water Resource Management Authority of Kenya (WRMA), the main causes of catchment degradation have been deforestation, encroachment of water sources and population pressure. In addition, cultivation of riparian reserve along major rivers and wetlands has led to siltation which in turn causes reduction in water body mass (District Agricultural Officer, 2013). The sub-division of land is also a major factor contributing to encroachment of water catchment areas (Musuva, 2010) while infrastructure to support the increasing population is also a factor in increased encroachment. The level of urban development has increased in the study area indicated by infrastructure. With all these in mind, shortcomings in the implementation of policies that govern land use have been experienced especially with regard to the agricultural productivity in this area.

4.1.3 Farming systems

There were two major farming systems in Subukia Sub-County namely; intensive and extensive farming, with 97 percent of the farmers practicing extensive farming. More so, the types of farming had changed over the last three decades, where 93 percent of the farmers practiced subsistence farming in mixed cropping of maize, beans, potatoes, vegetables and tomatoes while the remaining 7 percent practiced commercial farming in coffee, tea, pyrethrum and wheat.

In addition, following the sub-division of large scale ranches into small scale farms in the last decades, Rift Valley region low mountain slopes and the plateau have undergone very rapid human population growth, with an annual growth rate of up to 7-8 percent (Wiesmann 1998). According to the Nakuru County Integrated Development Plan 2013-2017, the County has few large scale land owners holding approximately 263 hectares of land on average. On the other hand the county is dotted with many small scale land owners with mean landholding size of 0.77 hectares. The bulk of the land holdings in the County are small-scale and are found mainly in the high potential agricultural areas. There has been over-subdivision of land into uneconomic units particularly in Nakuru North, Subukia and Molo Sub-County a sentiment echoed by the African Development Bank report of 2010 (Salami et al., 2010). This has led the area to experience a dramatic change in land use especially the land occupied for agricultural activities (Gichuki et al., 1998) and this could be the main reason for the changes recorded in this study. However, the policies that govern sustainable land use have not been effectively implemented as shown by the various unsustainable land use cover changes seen in the study area.

4.2 Difference in soil fertility under intensive and extensive farming

4.2.1 Soil analysis

The predominant soil type in the area is Phaeozem. These are well drained, less weathered clayey soils with high contents of organic or humic substances in the topsoil as well as a high CEC and plant-available soil water (Jaetzold et al., 2006). When the soil from the two farming systems were compared in each sub-location, the results indicated that, soil pH (H_2O) was 6.4 in Weseges sub-location under intensive farm system and 5.9 under extensive farm system while in Kabazi sub-location under extensive farm system the soil pH (H_2O) was 5.6 and under intensive farm system was 5.9. In Subukia sub-location the soil pH (H_2O) was 5.7 and 5.9 in intensive and extensive farm systems respectively (Table 4). With the exception of Subukia, intensive farming system registered a higher value of soil pH (H_2O) than the extensive farming system. For organic carbon, in Weseges sub-location the percentage in the soil was 3.1 and 2.9 for intensive and extensive farming systems respectively, while for Kabazi was 4.4 and 3.2 for intensive and extensive farming systems respectively and for Subukia was 4.3 and 3.1 for intensive and extensive farming systems respectively (Table 4). The organic carbon level under the intensive farming system was higher than in extensive farming system across all the sub-locations.

Table 4: Soil laboratory analysis results from each sub-location

Soil elements for each sub-location															
	Subukia					**Kabazi**					**Weseges**				
	pH	***OC***	***N***	***P***	***K***	***pH***	***OC***	***N***	***P***	***K***	***pH***	***OC***	***N***	***P***	***K***
Intensive	5.7	4.3	0.5	50.1	2.3	5.9	4.4	0.4	9.7	2.6	6.4	3.1	0.4	15.5	1.8
Extensive	6.3	3.1	0.3	45.1	2.1	5.6	3.2	0.4	11.6	1.9	5.9	2.9	0.3	9.5	4.5

In addition, nitrogen and phosphorus contents were 0.5 percent and 50.1ppm respectively for Subukia sub-location and 0.4 percent and 9.7ppm respectively for Kabazi sub-location under the intensive farm system (Table 4). Potassium content was lowest at 1.8 cmol/Kg under intensive farm system and at 4.5cmol/Kg under extensive farm system both in Weseges sub-location (Table 4).

When the results of the three sub-locations were put together, the study indicated that soil pH levels were 6 and 5.9 for intensive and extensive systems respectively (Table 5). These levels of pH were thus found to be suitable for most crops because they were neither too acidic nor too alkaline. Organic carbon in intensive farms was found to be 3.9 which was slightly higher than 3.1 registered from extensive farms (Table 5).

Table 5: Soil elements compared between the two farm systems in Subukia Sub-County

Soil Properties	**Summary Statistics**				
	Intensive	**Extensive**	**Mean Difference**	**t-test (0.05%)**	**P-Value**
Organic Carbon (% OC)	3.89	3.05	-0.85	-2.87	0.02
pH (%)	6.01	5.93	-0.08	-0.41	0.69
Nitrogen (N %)	0.44	0.34	-0.10	-3.95	0.00
Phosphorous (P)	25.11	22.07	-3.04	-0.36	0.72
Potassium (K)	2.23	2.81	0.58	0.59	0.57

More so, the levels of nitrogen in the soil for the two systems of farming were; 0.4 for intensive farms and 0.3 for extensive farms (Table 5). Both systems were hence found to contain moderate levels of nitrogen. On the other hand, Phosphorus (P) and Potassium (K) levels were found to be 25.1 units P and 2.2 units K in intensive system and 22.1 units P and 2.8 units K in extensive system (Table 5). Based on the recommended levels for crop production, both systems recorded high levels of phosphorus and potassium. However, statistically, there was a significant ($P<0.05$) difference in soil organic carbon (0.00) and nitrogen (0.01) levels for both systems (Table 5), while no significant difference was recorded by soil pH (0.69), phosphorus (0.72) and potassium (0.57) (Table 5).

The heavy use of fertilizer in intensive farming system has increased the high level of nitrogen in the soil. Global total nitrogen input from fertilizers and animal manure in intensive agricultural systems had doubled between 1970 and 1995, and is expected to continue to do so over the next three decades (Bouwman et al., 2005). Combined application of Nitrogen and Carbon (e.g. in manure) has a positive effect on soil organic matter content in agricultural soils (Sutton et al., 2011). This explains the significant increase in the soil nitrogen and organic carbon level in intensive farming systems. A high number of farmers in the study area practiced mixed farming and therefore complemented manure from livestock with nitrogen rich fertilizers so as to maximize productivity. However, the level of organic carbon and nitrogen should be watched carefully as they are used as indices of soil quality assessment and land use management (Ge et al., 2013). The soil in the study area was found to be fertile for both systems indicating that despite the higher levels of nitrogen and organic carbon in intensive farming systems, they are still within the recommended levels.

4.2.2 Fertilizer use

The farm inputs applied in the area were; organic and inorganic fertilizers (Table 6). There were no differences among the farmers that used either organic or inorganic fertilizers across all the sub-locations. The majority of farmers in all the sub-locations used organic fertilizers with 60, 61 and 64 percent in Weseges, Kabazi and Subukia respectively using farm yard manure and 25, 29 and 30 percent in Weseges, Kabazi and Subukia respectively using inorganic fertilizers (Table 6).

Table 6: Inputs used for soil fertility management in Subukia Sub-County

Inputs	**Farmers applying the inputs for each sub-location (%)**		
	Subukia	**Kabazi**	**Weseges**
Inorganic	30	29	25
Organic: Farm yard	64	61	60
Compost	4	5	10
Ash	2	5	5

The main source of the organic fertilizer was acquired from cows, goats, sheep and chicken droppings. Most of the farmers adopted organic fertilizer because it was deemed cheap and easily available as compared to inorganic fertilizer which was seen as expensive and only available to the few who had the money to buy. The use of compost manure was the second most preferred organic fertilizer after farm yard manure. The need for more processing of compost manure was a challenge to majority of the farmers since they did not know how to process the manure. This could thus be the cause of low nutrients in the soil properties obtained from the area.

However, many of the small scale farmers use inorganic fertilizer, and put on approximately 22.5 kg of nitrogen per hectare which is equivalent to 125 kg of DAP per hectare, and remove most of the crop residues as animal feed leading to depletion in soil fertility (Murungu et al., 2011). According to VandenBygaart and Angers, 2006, extensive use of inorganic fertilizer, especially nitrogen based, may increase soil organic carbon through increased crop residues. More so, Kihanda et al., 2005, found that inorganic fertilizer usage improved Olsen phosphorus and not soil organic carbon, while 5 tonnes of goat manure resulted to a rise in soil organic carbon but not phosphorus. This therefore helps to explain that, the higher extractable phosphorus in Subukia sub-location is due to usage of inorganic fertilizer.

On the other hand, soil organic carbon has increased in the short term due to the use of organic inputs (Mucheru-Muna et al., 2007) also when observed in long term trials (Zhangliu et al., 2009). The outcome of organic inputs on other soil nutrients like phosphorus, calcium and magnesium is determined by the kind (Ayoola and Makinde, 2009), quantity and period of use of the organic input. More so, other features like soil type and climate also controls the role of managing soil properties (Ayoola and Makinde, 2009). Sanginga and Woomer, (2009), indicate that, the little inorganic fertilizer available is often not the correct type required for various crops and farmers are unfamiliar with its correct usage. Moreover, fertilizer adulteration is not uncommon in several of the African countries, and discourages fertilizer investment by farmers (Shiferaw et al., 2009). Increasing pressure on agricultural land over the last few decades have resulted in much higher nutrient outflows and the subsequent breakdown of many traditional soil fertility maintenance strategies, such as; fallowing land, intercropping cereals with legume crops, mixed crop-livestock farming and encroachment on new lands (Kimigo, 2008). These has resulted to the change in farming systems with more than 60 percent of farmers adopting small scale farming as opposed to large scale farming. Therefore, there has been more pressure on the soil and its productivity hence the need for proper governance of the land use resources through adequate implementation of land use policies to ensure sustainable soil productivity.

4.3 Effectiveness of land policies in fostering sustainable land use

The results of the study indicate that in Kenya, broad legislation or policy that address the governance of land use have been in existence but their implementation has been inadequate mainly because of the fact that most of these issues link several sectors stretching from water resources to land and forests. For instance, the Forest Act enacted in 2005 was to ensure sustainable management of forest and related products, whether on land owned by the public (state and local authority) or private entities and provides authority to the Minister in charge of forests to give a declaration that, any land under the jurisdiction of any local authority should be stated as a local authority forest where such land is an important catchment area, a source of water springs, or a fragile environment.

However, even with these policies in place, their full implementation has not been felt especially in Subukia Sub-County. This is because, most of the residents in the study area are not well vast with the knowledge of the Act that allows them to participate in the management of the forests through the formation of Community Forest Associations (District Agricultural Officer, 2013). In addition, there is little knowledge on the fact that, the Forest Act governs all forests including the ones on privately owned land (District Agricultural Officer, 2013). This has resulted to unauthorized felling of trees on privately owned land and charcoal burning in publicly owned land which has reduced the forest cover to 6.3 percent in 2015 from 11 percent in 2005 in the study area (Table 2).

Further, the study findings indicate that although land forms the center of means to livelihoods for the most of the people of Kenya especially in rural areas at 70 percent (World Bank, 2008), until 2009, Kenya did not have an all-inclusive and plainly distinct National Land Policy which necessitated the Draft National Land Policy of 2009 (Republic of Kenya, 2009). This has resulted into: extreme land pressure and division of landholdings into improvident units; decline in land value due to poor land-use practices; unproductive and hypothetical land hoarding; underutilization and desertion of agricultural land; severe tenure uncertainty due to overlying rights; failure to receive inheritance by the women and vulnerable members of society and biased verdicts by land management and dispute resolution establishments; landlessness and the squatter occurrence; uncontrolled development, urban dirt and environmental pollution; excessive destruction of forests, catchment areas and areas of unique biodiversity (Republic of Kenya, 2009). These adverse effects are accelerated by the government failure to ensure that there is public awareness and sensitization on the available land use policies governing the various systems of agriculture and land use.

The Constitution of Kenya in Article 67 established a National Land Commission (NLC) that, was to conduct investigations into “historical land injustices” and recommend appropriate redress among other things (Republic of Kenya 2010). In addition, Article 68 requires Parliament to enact a law that will “enable the review of all grants or dispositions of public land to establish their propriety or legality”. The constitution of Kenya confers to Parliament the obligation to suggest the least and maximum land holding acreages with regard to private land and to control the way in which any land may be changed from one classification to another. However, this is yet to be enacted, and therefore, it clearly depicts a gap in the proper implementation of the available policies governing land use and land use change especially with regard to change in farming systems and in turn agricultural land productivity. The following should be recognized and improved as per the requirements of the National Land Policy. First, land-use design, analyses of the policy and legal structure for land-use planning, and secondly, involvement of the public in the planning process. The Physical Planning Act (Cap 286) of 1996 is in charge of controlling the preparation and execution of physical development strategies in all areas of the country, and is therefore critical in the rule of land use. However, the situation in Subukia Sub-County has not changed even with the new National land policy requirement in place.

This was seen as a result of ineffective implementation of the available policies governing land-use where some land uses, such as; forest cover and agricultural land collectively accounted for 79 percent of land cover have been given more priority over shrub and grassland, water resources and urbanization (Table 2).

In agriculture, the study findings showed that the Agriculture Act (Cap 318), 2012 is the main regulation governing agricultural undertakings, and is geared towards encouraging agricultural growth in Kenya. This Act is expected to make sure that the change of arable land is in agreement with comprehensive land management and farming practices. However, the power to dictate such practices has been vested in the Minister for Agriculture who coordinates with the local governments in the case of this study the Nakuru County Government. This creates a problem in implementation as the layers of bureaucracy erode the efficiency with which management practices can be disseminated to the farmers. Of all the respondents, 83 percent reported having employed soil management practices although they confirmed they were not government led initiatives.

The results of the study further indicate that agricultural land use is the most prioritized form of land use in Subukia Sub-County with about 72 percent of the land being occupied by small scale and large scale farms as of 2015 (Table 2). With this in mind, there are gaps in the effective implementation of the Agriculture Act (Cap 318). These gaps are as a result of violation of regulations governing agricultural land use, such as, the cultivation of valleys and riparian land, encroachment into wetlands for purposes of grazing and cultivation (Republic of Kenya, 2013), and failure to fully promote farm forest cover of at least 10 percent of the agricultural land holding among others, as stated in the agriculture (farm forestry) rules of 2009 (Republic of Kenya, 2012). This has also brought about degradation of the soil resource especially reflected by a reduction in annual farm yields for the past decades hence necessitating the adoption of intensive farming and increased fertilizer application as a means of trying to improve the farms productivity levels by the farmers.

For the water resources, the legal and policy framework has experienced major changes in the past decade, first in Sessional Paper No. 1 of 1999 on Water Resource Management and Development (Republic of Kenya, 1999). The main objective of the policy is to improve sustainable and integrated development and management of the water sector.

The Water Act sets mechanisms for the management, conservation, use and control of water resources and for the directive of water use and supply rights not forgetting sewerage services, setting detailed guidelines and institutional arrangement to ensure the realization of its objectives.

A major milestone was the enactment of the Water Act of 2002 which created the Water Resources Management Authority (WRMA) as the lead agency in water resource management. Every farmer using any water resource or catchment area for irrigation or other commercial venture is required to register with the agency which charges a fee and monitors water usage on any or such water catchment area. In relation to the provision of Water Act, a publication was made by the Minister for Water and Irrigation on the first National Water Resources Management Strategy for the period of 2007 to 2009. A new policy was developed for the period 2010 to 2016, with the main areas of interest being, the acknowledgment of water as a limited and rare resource, the need for public involvement in the managing of water resources, and the use of Integrated Water Resource Management principles in handling of water resources.

The findings of the study indicate that, the land occupied by the water resources in Subukia Sub-County has not been significantly affected by the continuous change in land use (Table 2). This though, does not entirely mean that the land occupied by water bodies have remained unchanged with time. It only helps to explain that there are other means of water acquisition such as; man-made dams and wells, for purposes of irrigation and household use. The implementation of regulations governing water bodies has not been without challenges. This is attributed to the fact that, water is a basic need and has several uses. Some of these challenges include; water pollution, especially dues to release of raw sewage and dumping of solid in water bodies, poor public participation on matters to do with water resource management in the study area with 92 percent of the respondents reporting they have never participated in the formulation of any land management policies. Therefore, there is a knowledge gap on the land use policies especially governing agricultural land use and this has adverse effects on the way the soil resource is managed to ensure sustainable agricultural productivity for posterity.

The diversity of laws in Kenya, responsible in the management of land related resources has over the years resulted to the establishment of several agencies liable to oversee their implementation (Nyangena, 2008). Administration of the diverse sectors involved in land use is not coordinated, hence the bodies are biased in their approach (Mwangola 2001, 2008). This therefore results to confusion and conflicts between different sectorial laws, such as; the Constitution of Kenya (2010), National Land Policy (2009), Forest Act (2005), Water Act (2002) and Agriculture Act (2012) (Wamukoya and Situma 2000; Mbegerea 2004). According to Masinde and Shakaba, 2004, the different sectorial laws many a times cross, thus, none of the laws are executed appropriately hence, supporting my study findings that there are land use policies in place, especially in agriculture, but their implementation have been ineffective to ensure sustainable land use and enhance soil resource management. Therefore, the issue of soil resource management necessitated by a change in farming systems due to preference of some land uses as opposed to others well explains the need for effective implementation of land policies in ensuring that there is sustainable land use change.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study showed that, small scale farming was the most predominant land use at 64% large scale farming having reduced by 13% in the past three decades. Other land uses which had changed significantly were; urban settlements, water resources and shrub land. More so, 97% of the farmers had adopted extensive farming as opposed to intensive farming.

There were no significant differences between intensive and extensive farming systems in terms of soil pH, phosphorus and potassium. However, the two systems differed in terms of soil organic carbon and nitrogen with intensive farming system having more organic carbon and nitrogen.

In light of soil fertility management practices adopted by farmers, the use of organic fertilizers was more preferred by over 60% of farmers from both intensive and extensive farming systems, as opposed to inorganic fertilizers.

In addition, there are good land use related laws and policies in place, for sustainable soil resource management, but their implementation is ineffective.

5.2 Recommendations

Based on the findings for this study there is need to educate farmers on:

i) The various sustainable land use practices and farming systems to ensure environmental conservation for posterity.

ii) The benefits of appropriate application of inorganic and organic fertilizers to ensure sustainable fertility management practices of the soil resource.

iii) The need to ensure that there is public sensitization on the available policies relating to land use starting at household level for sustainable development.

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APPENDIX 1

RESEARCH QUESTIONNAIRE FOR FARMING HOUSEHOLDS

Questionnaire Number:	Interviewer:
Date:	GPS Co-ordinates:
Picture Number:	

1.1 *Introduction*

1. Full Name: ……………………………………………………….

2. Gender

   Male [ ]

   Female [ ]

3. Indicate your age from the choices below

   16-25 years [ ]

   26-35 years [ ]

   36-45 years [ ]

   Over 45 years [ ]

4. Marital status

   Single [ ]

   Married [ ]

   Others (specify)

5. Level of Education

Never went to school [ ]

Primary level [ ]

Secondary level [ ]

Diploma level [ ]

Degree level [ ]

Masters level [ ]

Others (specify)

6. Occupation ………………………………………………………….

1.2 *Household and farming characteristics*

7. How many people are in your family?
8. Do you have a farm? (If yes, how big is your farm?)
9. What types of crops do you grow?
10. How do you grow your crops?
11. How long have you been doing farming?
12. What farming methods do you use?
13. Do you use any inputs in your farm? (If yes, which ones?) If no, why?
14. Where do you obtain your inputs from?
15. How many bags of yield do you harvest annually?
16. Do you get any extension officer advice? (If yes, which one?) If no, why?
17. Have you attended any seminar or workshop in regards to farming? If yes, what did you learn? If no, why?

1.3 Land management practices

1. Have you planted trees in your farm? (If yes, what percentage?) If no, why?
2. Do you know any soil management practices? If yes, which ones do you practice?
3. Do you practice irrigation farming? If yes, where do you get your water from?
4. Is your farm close to a water resource? If yes, what is the distance between the water resource and your farm?
5. Have you been involved in any formulation of land management policies? If yes, which ones? If no, why?

APPENDIX 2

KEY INFORMANT SEMI-STRUCTURED INTERVIEW WITH AGRICULTURAL EXTENTION OFFICER

1.1 *Farming area and village characteristics*

- How many plots of land are used for farming in the area?
- What percentage of land would you classify to be under intensive and extensive farming patterns?

1.2 *Cropping system and soil fertility*

- What types of soil are present in the area? (basis of identification- characteristics of each)
- What type of crops are being produced in the area?
- How many bags of yield are produced annually for the last 3 decades in the area?
- What is the general soil fertility in the area?
- What are the different kinds of land tenure in the area?

1.3 *Farming practices*

- What farming patterns do the farmers practice?
- What percentage of farmers practice the above mentioned farming patterns?
- What different inputs do they use in the farming process?
- What percentage of farmers use the above mentioned inputs?
- Where do the farmers get their inputs from?
- Do you hold any workshops or seminars with the farmers in the area?

1.4 Policies on land management

- What percentage of farmland is under tree cover?
- Which soil management practices are undertaken in this area?
- What percentage of farmers practice irrigation farming?
- Are the policies governing the riparian zones properly observed?
- Is there public participation in the formulation of policies governing the soil resource?