

**Land Use/Farming System and Livelihood
Changes in the Upper Catchment of Lake
Naivasha, Kenya**

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Land Use/Farming System and Livelihood Changes in the Upper Catchment of Lake Naivasha, Kenya

by

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Abstract

Agriculture plays an important role in Kenya's economy which employs 70% of country's labor force or around 10 million people. As an agro-based country, land is one of the most important resources in the country. Land resource in Kenya faces major challenges particularly due to population growth. This creates pressure on land resources and leads to poor land use practices such as intensification of cultivation, expansion of cultivated land, overgrazing and harvesting of trees for fuelwood. As the consequences, the degradation of the environment would finally leads to lower productivity of natural resources. For smallholder farmers who have high dependency on natural resources, this becomes a threat to their livelihood.

Lake Naivasha watershed in the Gregory Rift Valley, Kenya is one of five permanent water basins in Kenya. Over the years, the landscape has undergone major changes in land use and vegetation cover as the result of increasing human population which dependent on natural resources for their livelihood. Rural farmers in the area tend to plant low revenue crops such as maize and require extensive land to produce enough and make some profit to full fill their needs. This lead to land expansion for settlement and agriculture, causing deforestation and improper land use activities. This contributes to decline in water quality and quantity arriving downstream. The challenge in Naivasha watershed is to improve the welfare of the people while ensuring the use of environment and natural resources in sustainable way. Therefore, understanding the livelihood of the people, their interaction with natural resources and how it is changes due to internal and external factors is very important.

The general objective of the research is to examine the relationships over time in the past 20 years between land use/farming systems and livelihood of smallholder farmers in the upper catchment of Lake Naivasha. Combination of farming system and livelihood approach is used for the analysis. Social economic data on livelihood and spatial information were collected from household interviews and participatory rapid rural appraisal (P-RRA).

Land use/farming system and livelihood in the upper catchment of Lake Naivasha have undergone several changes since the first immigrant came in 1964. The dominant change is the increase of cultivation area at the expense of forest, grass land and woodland. Although the primary source of income still farming and dairy, the smallholders farmers tend to diversify their source of income into non farm agriculture natural resources based and off farm activities. The drivers of changes in land use/farming system and livelihood are categorized into demography shift, environmental trends, changes in national and regional economy, and policies of national development. There is a tendency of expanding horticulture industry to the upper catchment.

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1. Introduction

1.1. Background

Agriculture plays an important role in Kenya's economy. It supports 80% of the population and employs 70% of country's labor force or around 10 million people (Alliance, 2005). However, its share to Kenya's GDP is only over 25% since most of those working in agriculture sector are smallholder farmers. These smallholder subsistence farmers make up 80 percent of agricultural population (Praneetvatakul, Janekarnkij, Potchanasin, & Prayoonwong, 2001) and they are among the poorest in Kenya.

As an agro-based country, land is one of the most important resources in the country. Around 90 percent of the population is living in the rural area and derives its livelihood directly from land. However, of total area 582,646 km² only 17% are suitable for rainfed agriculture. The rest is a non-arable land which comprises of 2.2% of forest reserve and 82% grassland and savannah rangelands (Alliance, 2005). Land resource in Kenya faces major challenges particularly due to population growth. At independence, Kenya had a total population of seven million people and by the end of 1999, the population has reached 29 million. In the 1980s, Kenya population grew at the rate of four percent per year. As most Kenya population live in rural areas, as a result, rural densities are extremely high. This creates pressure on land resources particularly since only 17% of the land is suitable for rainfed agriculture and it becomes very difficult for children to inherit a feasible farm. It also leads to poor land use practices such as intensification of cultivation, expansion of cultivated land, overgrazing and harvesting of trees for fuelwood leading to deforestation.

Furthermore, those lead not only to deterioration of land but also to other life support system such as air and water. Inappropriate farming methods that reduce vegetation cover, encourage soil erosion and allow heavy siltation contribute to degradation of water resources. As the consequences, the degradation of the environment would finally leads to lower productivity of natural resources. For smallholder farmers who have high dependency on natural resources, this becomes a threat to their livelihood.

Livelihood is defined as "the activities, the assets, and the access that jointly determine the living gained by an individual or household" (Ellis, 1999). It has been realised that most of rural poor diversify their livelihood strategies as one way to spread the risk. They do not specialise only in farming activities, instead they combine a range of activities and occupation as source of income. (Ellis, 1999) defines livelihood diversification as 'the process by which households construct a diverse portfolio of activities and social support capabilities for survival in order to improve their standard of living'. According to pro poor growth policy guidelines (Development Committee Assistance, 2006), there are three types of economic activities that provide livelihood diversification opportunities for agricultural household outside their own agricultural production activities (off the farm):

- non farm, rural based agricultural enterprise
- rural based, non agricultural enterprise
- urban based employment which promote rural-urban migration

Off farm activities have been found to have positive correlation with income and offer pathway out of poverty (Ellis, 1999; Holden, Shiferaw, & Pender, 2004). Furthermore, many evidence in number of places non agricultural rural employment as alternative to farming (Bryceson, 1993).

Lake Naivasha watershed in the Gregory Rift Valley, Kenya is one of five permanent water basins in Kenya. It has high importance for the country with diverse ecological zone that contribute to the region socio economic development. Over the years, the landscape has undergone major changes in land use and vegetation cover as the result of increasing human population which dependent on natural resources for their livelihood. The rural poor in Naivasha watershed are mostly peasant farmer with subsistence agricultural practices. Rural farmers in the area tend to plant low revenue crops such as maize and require extensive land to produce enough and make some profit to full fill their needs. This lead to land expansion for settlement and agriculture, causing deforestation and improper land use activities. This contributes to decline in water quality and quantity arriving downstream (WWF, 2006). The main economic activities in the Naivasha watershed rely heavily on natural resources.

In contrast, over the last two decades, the area has also grown into the main site of Kenya's horticultural industry. This industry covers an estimated 50 km² of land around the lake and yield return around US \$ 63 million a year (WWF, 2006). For the rural poor, this can be the opportunities for their livelihood diversification strategies working as a labour in the industry. It also creates market for their agricultural products. This other income sources might influence their interaction with natural resources. The challenge in Naivasha watershed is to improve the welfare of the people while ensuring the use of environment and natural resources in sustainable way. Therefore, understanding the livelihood of the people, their interaction with natural resources and how it is changes due to internal and external factors is very important.

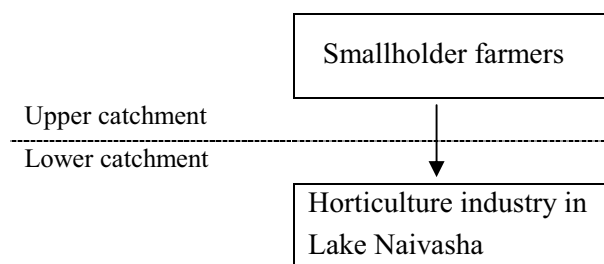


Figure 1.1 Linkage between upper catchment and lower catchment/Lake Naivasha

1.2. Research problem

Studies looking at the linkages between poverty reduction, economic development and environmental sustainability have identified livelihood diversification as a household response as well as policy instrument (Bhandari & Grant, 2006; Soini, 2005). Rural household have been found to diversify their income sources to reduce livelihood risk which is often necessary in subsistence agriculture (Reardon & Vosti, 1995). Income diversification can be achieved by pursuing off farm employment or producing variety of crops.

The horticulture industry in Lake Naivasha creates job opportunities for local people as well as attracts labours from outside the area. It provides employment for over 30,000 people (WWF, 2006). The small holder farmers also benefited from this as one of alternative for their livelihood, outside agriculture activities. The research will investigate how important this is for the smallholders of Kinangop and upper watershed.

The impacts of livelihood diversification on the environment are case specific (Ellis, 1999). It can reduce the demand for land through investment in agricultural intensification but it can increase the demand of land due to investment that requires more agriculture land. This raises question of how livelihood diversification in the area interact with land resource. Land resource is important natural resources where agriculture is the main economy activities. It also plays important role in environmental degradation in Naivasha watershed due to land expansion and improper land use activities. This situation also generates diverse conflicts; among those is conflict between upstream and downstream communities including horticulture industry sector over management of natural resources in the upper catchments that affects the quality and quantity of water arriving downstream, such as the potential of siltation of rivers and lake. Although researchers said that this conflict is exaggerated and the threat of siltation is not that high, control over activities in the upper catchments is crucial to maintain the availability of water and to control erosion (Boix Fayos, 2002). To address the challenge in the area, it is necessary to understand this interaction.

The research problem is looking at changes in land use/farming system of smallholder farmers and understanding its relation with livelihood. Not many researches have been done looking at this interaction in the area. This research is to fill the gap and serve as the basis for planners and decision makers to improve the welfare of the people and protecting the environment in the context of watershed management.

1.3. Research objectives

The general objective of the research is to examine the relationships over time in the past 20 years between land use/farming systems and livelihood of smallholder farmers in the upper catchment of Lake Naivasha. From the above general objective, four specific objectives are derived as follow:

1. To identify land use and farming system changes over time in the upper catchment of Lake Naivasha
2. To identify livelihood diversification, and the underlying causes of changes in livelihood, in the upper catchment of Lake Naivasha
3. To analyze the relationship between land use/farming system changes and livelihood diversification
4. To identify and analyze any linkages between these changes and the horticulture sector in Lake Naivasha area

1.4. Research questions

In order to achieve the above research objectives, the following research questions are formulated to address the research objectives.

No	Research Objectives	Research Questions
1.	To identify land use/farming system changes in the upper catchment of Lake Naivasha	<ul style="list-style-type: none"> - What are the main types of smallholder farmers in the area? - What are the characteristics and assets of smallholder farmers? - What are land cover changes over time? - What are the land use and farming system changes over time? - What are the drivers of the changes?
2.	To identify livelihood diversification, and the underlying causes of changes in livelihood, in the upper catchment of Lake Naivasha	<ul style="list-style-type: none"> - What are the main livelihood activities? - How livelihood activities changes over time? - What are the drivers of the changes? - Are there any spatial differences in the livelihood diversification in the area?
3.	To analyze the relationship between land use/farming system changes and livelihood diversification	<ul style="list-style-type: none"> - What are the relationships between livelihood diversification and land use changes over time? - What are the relationships between livelihood diversification and farming systems changes over time?
4.	To identify and analyze any linkages between these changes and the horticulture sector in Lake Naivasha area	<ul style="list-style-type: none"> - What are the linkages between the changes in the upper catchment and the horticulture sector in Lake Naivasha?

In order to answer research objectives and research questions, primary and secondary data were required and were collected using some data acquisition methods.

Objectives	Research Questions	Sources	Acquisition methods
1.	<ul style="list-style-type: none"> - What are the main types of smallholder farmers in the area? - What are the characteristics and assets of smallholder farmers? - What are land cover changes over time? - What are the land use and farming system changes over time? - What are the drivers of the changes? 	<ul style="list-style-type: none"> - Satellite images - Household and community interviews - Previous researches on land cover/land use changes 	<ul style="list-style-type: none"> - Sketch mapping - Time line and trends line - Interviews
2.	<ul style="list-style-type: none"> - What are the main livelihood activities? - How livelihood activities changes over time? - What are the drivers of the changes? - Are there any spatial differences in the livelihood diversification in the area? 	<ul style="list-style-type: none"> - Household interviews - Secondary data - Land cover/land use changes 	<ul style="list-style-type: none"> - Interview with questionnaires - Timeline and trend line
3.	<ul style="list-style-type: none"> - What are the relationships between livelihood diversification and land use changes over time? 	<ul style="list-style-type: none"> - Household interviews - Land cover/land use 	<ul style="list-style-type: none"> - Interviews with questionnaires

Objectives	Research Questions	Sources	Acquisition methods
	- What are the relationships between livelihood diversification and farming system changes over time?	changes	- Data integration
4.	- What are the linkages between the changes in the upper catchment and the horticulture sector in Lake Naivasha?	- Household interviews	- Interviews with questionnaires - Data integration

Primary and secondary data were collected during field work. Social economic data on livelihood and spatial information were collected from 60 household interviews and participatory rapid rural appraisal (P-RRA) in three sub locations as case study, during four weeks of field work.

1.5. Research conceptual framework

The research will use case studies approach. It will combine farming system/land use and livelihood analyses emphasizing temporal change. Land use/farming system analysis is done to analyze the land use/land cover changes including changes in farming system and natural resources management. Livelihood analysis is conducted to analyze changes in smallholder farmers' livelihood diversification. These two analyses are then combined to see the interaction between land use/farming system changes and livelihood diversification in the upper watershed of the Naivasha basin. The possible linkages between those changes with horticulture industry in Lake Naivasha are also analyzed.

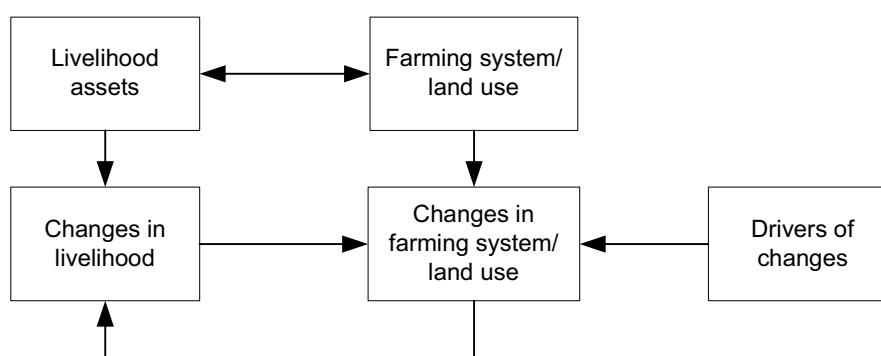


Figure 1.2 Conceptual framework

The unit analyses in this study are households and sub location levels. Farming system/land use analysis will use Farming System Approach (FSA) from Food and Agriculture Organization (FAO,2001). FSA is focus on the farm household as the centre of resource allocation. It also shows the variety of natural resources available to farm families such as land and water and also human, social and financial capital. The functioning of any individual farm system is strongly influence by the external rural environment, including policies and institutions, markets and information linkages. This framework is much in common with the Sustainable Livelihood Approach (SLA). Thus the analysis combines this framework with livelihood framework approach from Department for International Development (DFID, 2001). The analysis comprises of livelihood assets in term of natural capital (land, livestock, trees, and crops), physical capital (road and electricity), human capital (age, gender,

and education), financial capital (access to credits and financial institutions, off-farm jobs) and social capital (community group). Smallholder farmers use these assets to conduct their livelihood activities. The livelihood activities which are analyzed consist of natural resource based such as on farm activities, dairy and off farm activities. Farming system also analyzes marketing channel, use of agricultural input and conservation practices. Over time, land use/farming system develop and changing which influenced by factors such as population, market, technology and policies. These changes might influence the livelihood diversification of smallholder farmers in the upper catchment.

1.6. Significance of study

The study is focused on identifying the changes in land use/farming system and livelihood diversification of smallholder farmers in the upper catchment of Lake Naivasha. The knowledge generated from this study can be useful to planners and decision makers to improve the welfare of the people and protecting the environment in the context of watershed management. It also shows the relationship between land use changes and livelihood changes thus can be relevant to further socio economic studies such as migration and socio economic relationship between upper watershed and Lake Naivasha.

1.7. Scope and limitation

The scope of this research covers the identification of land use/farming system and livelihood and how they change over time in the upper catchment of Lake Naivasha, based on the community perspective. Fieldwork was conducted for four weeks in September – October 2007. Many of the interviews were conducting in local language which needed translation. The quality of translator more or less affected the result of the interview. Due to time limitation and image availability, land cover changes analysis is derived from land cover classification from Were (2008). No reference data available for accuracy check of generated land cover maps in 1986 and 1995. In addition, detail statistics data on population, agriculture and social economics at sub locations and district level are limited. Analysis done is emphasized more on Geta due to familiarity to study area and time limitation.

1.8. Thesis structure

Chapter 1

This chapter discusses the background of the research, description of research problem, research questions, research objectives and general methodology.

Chapter 2

This chapter discusses theoretical background related to the study by reviewing relevant literature on farming system, land use and livelihood.

Chapter 3

Characteristics of the study area are discussed in this chapter. In addition, it also discusses on research approach for the fieldwork, data required, data collection as well as data processing and handling.

Chapter 4

This chapter will discuss the land use/farming system and smallholder farmers characteristics in the area, and the changes occurred.

Chapter 5

The changes in livelihood are discussed in this chapter including the driving factors of the changes. Linkages to horticulture industry are also discussed here.

Chapter 6

This chapter present the conclusions and recommendations of the research.

2. Concept of farming system, land use and livelihood

In order to analyze the changes in land use/farming system and livelihood, it is necessary to understand the concept of farming system, land use and livelihood. This chapter discuss about definition and concepts related to farming system, land use and livelihood.

2.1. Farming System and Land Use

2.1.1. Farming system

Farmers view their farms as system in their own right. Farm household is defined as rural households consisting of three basic sub systems which closely interlink: (1) the household as decision making unit, (2) the farm and its crops and livestock activities, (3) the off farm component (FAO, 1990). It also shows the variety of natural resources available to farm families such as land and water and also human, social and financial capital. Each individual farm has its own characteristics from variations in resource endowment. The household, its resources and the resources flows and interactions at individual farm level are referred as farm system (Dixon, Gulliver, & Gibbon, 2001). The functioning of any individual farm system is strongly influence by the external rural environment, including policies and institutions, markets and information linkages.

A farming system is defined as population of individual farm systems that have similar resource bases, enterprise patterns, household livelihoods and constraints, and for which similar development strategies and interventions would be appropriate (Dixon, Gulliver, & Gibbon, 2001). The classification of farming systems can be based on two criteria which are available natural resource base and dominant pattern of farm activities and household livelihoods.

Figure 2-1 shows Farming System Approach (FSA) with its focus on the farm household as the centre of resource allocation. This FSA has much in common with the Sustainable Livelihood Approach (SLA). It represents the interrelationship of key determinants of farm systems and by extension, farming system. Some of these factors are internal or part of farming system whereas others are external factors. The principal external factors which influence the development or changes of farming systems are policies, institutions, public goods, markets and information.

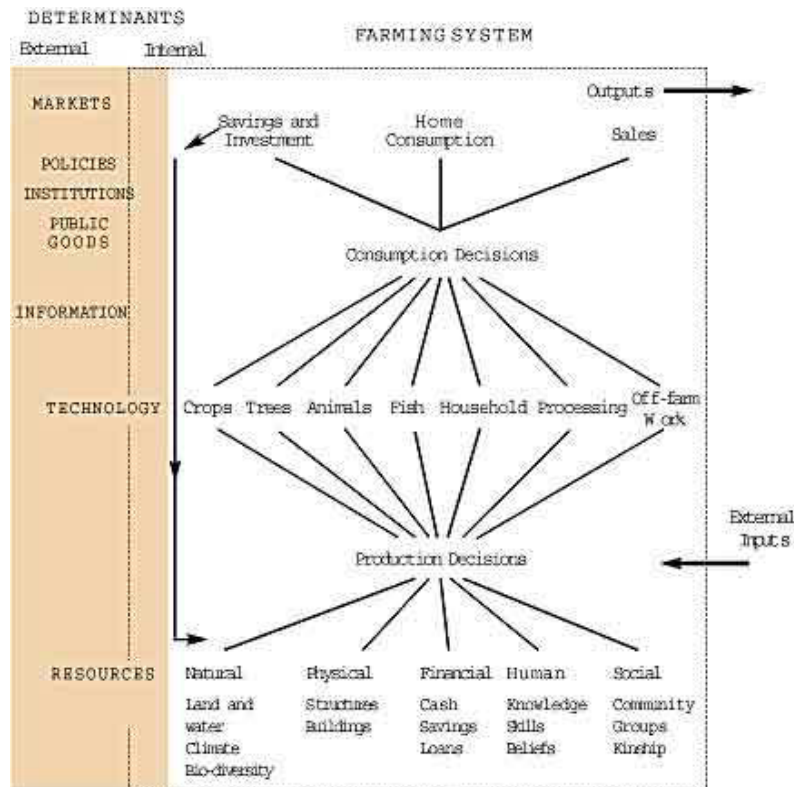


Figure 2.1 Systematic Representation of Farming System Approach
(Dixon, Gulliver, & Gibbon, 2001)

2.1.2. Land use/ land cover

Land use is characterised by the arrangement, activities and inputs people undertake in a certain land cover type to produce, change or maintain it (FAO, 1993). Land use systems are frequently defined in terms of dominant crops such as maize/tobacco system and similar land use and economy forms farming system. Whereas land cover is defined as “the observed (bio) physical cover on the earth’s surface” (Gregorio & Jansen, 1998) inclusive of natural, man made, vegetative and non vegetative aspects. Land use is more an abstract concept, mix of socio economic, cultural and policy factors whereas land cover is concrete and directly measurable by remote sensing. Land cover is affected by land use and changes in land cover affects land use.

The pattern of land use and land cover are attributed by complex interactions between the biophysical environment and societal (economic, social, political, and technological) processes at local, regional and global scale (Aspinall & Hill, 2008). In Senegal, the principal drives of agriculture land use are climate, population growth, development project, land ownership, cash crop production, and forestry practices (Wood, Tappana, & Hadj, 2004). Water factor, soil condition and government policy were also influencing land use changes in Ethiopia (Amsalu, Stroosnijder, & Graaff, 2007). In China, urbanization, industrialization and economic measures were the socio economic drivers of land use/land cover change (Long, Tang, Li, & Heilig, 2007).

This complex interaction creates pressure on land. In addition to unprecedented rate of population growth, externalities related to global change are also becoming a constraint to sustainable land management. The symptoms of the problem of pressure on land resources are manifested both in

terms of impacts on people, and in the deterioration of land or impacts on other natural resources (FAO & UNEP, 1999) as can be seen in Figure 2.2.

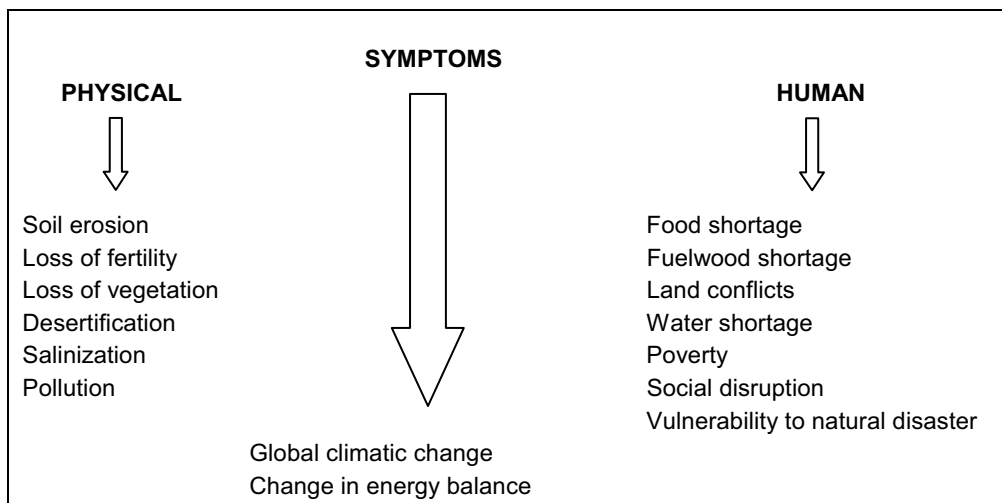


Figure 2.2 Symptoms of the problem of pressure on land resources (FAO & UNEP, 1999)

2.2. Livelihood approach

2.2.1. Livelihood definition and framework

The definition of livelihood has been extensively discussed among academics and development studies. Common consensus that livelihood is about the ways and means of making a living. Livelihood is defined as “a livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household”(Ellis, 2000). DFID’s sustainable livelihoods group define livelihood as” the capabilities, assets (including both material and social resources) and activities required for a means of living”.

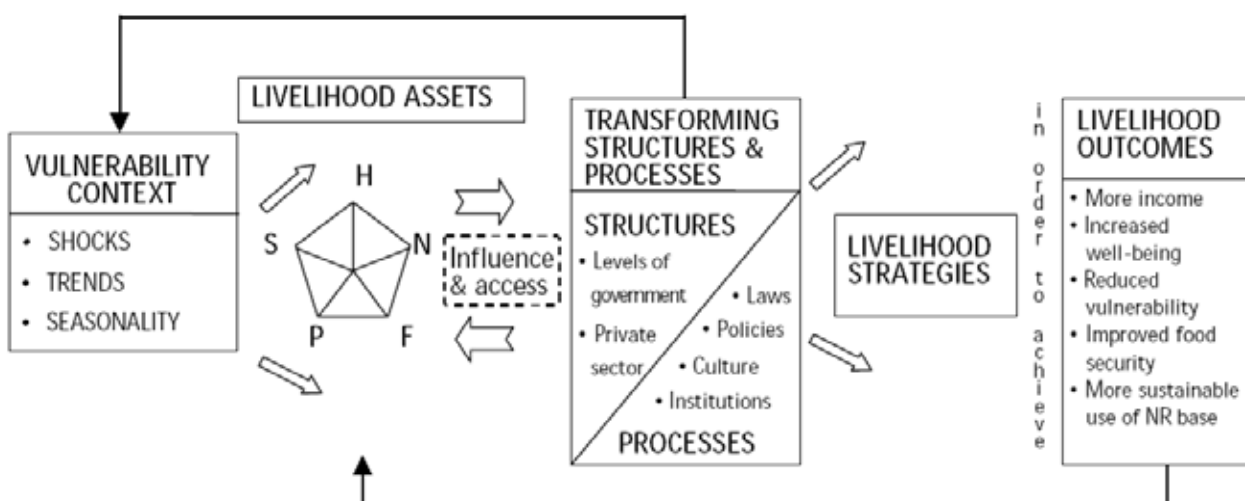


Figure 2.3 Sustainable Livelihood Framework (DFID, 1999)

The livelihood approach is usually set in form of a framework that bring together the principal components that are thought to comply with the livelihood definition and demonstrating the interaction between them (Allison & Ellis, 2001). There are many different diagrammatic representations of this framework. Figure 2.3 shows sustainable livelihood framework developed by DFID.

The framework summarises the main components and influences on livelihood which can be adapted to meet the needs of understanding livelihood. At center of this framework are the capital assets of communities which comprise of:

1. Natural capital : the natural resource stock which useful for livelihood (land, water, biodiversity, environmental resources)
2. Social capital : the social resources (networks, membership of groups, relationships of trust, access to wider institutions of society)
3. Human capital: the skills, knowledge and health needed to pursue different livelihood strategies
4. Physical capital: the infrastructure (transport, shelter, water, energy and communications) and the production equipment which enable people to pursue their livelihood
5. Financial capital: moneys (whether saving, supplies of credit or regular remittances or pensions) which provide them with different livelihood issues

Table 2.1 A Framework for micro policy analysis of rural livelihoods

A	B	C	D	E	F
Livelihood platform	Access modified by	In context of	Resulting in	Composed of	With effects on
<i>Assets</i> Natural capital Physical capital Human capital Financial capital Social capital	<i>Social relations</i> Gender Class Age Ethnicity <i>Institution</i> Rules and customs Land and sea tenure Markets in practice <i>Organisations</i> Associations NGOs Local admin State agencies	<i>Trends</i> Population Migration Technological change Relative prices Macro policy National econ trends World econ trends <i>Shocks</i> Storms Recruitment failures Diseases Civil war	Livelihood strategies	<i>NR based activities</i> Fishing Cultivation Livestock Non farm NR <i>Non NR based</i> Rural trade Other services Rural manufacture Remittances Other transfers	<i>Livelihood security</i> Income level Income stability Seasonality Degrees of risk <i>Env. Sustainability</i> Soils & land quality Water Fish stock Forests Biodiversity

Source : Allison & Ellis(2001)

Allison and Ellis (2001) suggest a framework for micro policy analysis of rural livelihood as shown in Table 2.1. The starting point of this framework is five main assets (natural, physical, human, financial, and social capital) owned, controlled or in some other means by accessed by the households. Access to these assets and activities is enabled by the policy and institutional context of livelihood which include social relations, institutions and organizations. It is also affected by external factors which sometimes refer to as vulnerability context comprising of trends and shocks that are

outside the control of the household. The access gained permit household to construct livelihood strategies which composed of portfolio of activities, which may be natural resource based or non resource based. Finally this framework points out the outcomes of livelihood strategies which can be distinguished between livelihood security effects and environmental sustainability (Allison & Ellis, 2001).

2.2.2. Dynamics of livelihood

Understanding livelihood changes is challenging since it rarely affects all household equally. ODI (1999) argue that there are two views to look at the causes of changes. First, factors which are viewed as shocks, trends and cycles. As can be seen in Table 2.2, shock has a rapid result and immediate impact. For example, contagious disease and collapse of commodities' price. Trends have a longer gestation such as the effect of soil erosion on the productivity of the field whereas cycles refer to seasonality which is more predictable.

Table 2.2 Causes of changes at different level

Household Level		Structural Level
Unexpected death of economically active household member	Shocks	Change in regulations governing land ownership
Rising education level over generation	Trends	Rising prices of agricultural inputs, expansion of transport
Changing dependency level in household	Cycles	Seasonal variation of rainfall or agricultural labor demand

Source: ODI (1999)

Second view is according to the level at which they occur. This refers to internal and external factors of households. Some internal factor to households that causes changes such as natural cycle of the family, ill health condition, changes in preferences, priorities and management abilities of the family. Other causes of change are resulted from outside the households such as changes in market and structure of economy (prices, new technologies, regulation etc).

Livelihood diversification is defined as “the process by which economies become more diversified”(ODI, 1999). At household level, it means adding new activities as such growing new varieties of crops or undertaking small enterprise, casual labor or migration. Livelihood diversification also defined as “the process by which households construct a diverse portfolio of activities and social support capabilities for survival and in order to improve their standard of living” (Ellis, 1999).

Income diversification and migration are increasingly important in contributing to the livelihood in rural areas (Dalal-Clayton, Dent, & Dubois, 2003). Combinations of agriculture and non agriculture activities constitute income sources of the household. Agriculture or farm income is derived from activities that based from natural resources include producing food and cash crops and various forms of livestock products whereas non agricultural income sources include remittances, pensions, business, rents etc. The number of sources and distribution of income among those sources described the diversity of a household's livelihood (Perz, 2005).

In rural household, agriculture or natural resource based activities alone rarely provides sufficient means of survival due to variety of reasons. Ellis (2001) argue that some of the reasons are (1) land sub division at inheritance resulted in less viable plots for household food security, (2) adverse environmental change or cyclical trends which increase the risk related to natural resource based activities, (3) declines in agricultural markets, (4) rises in input cost due to removal of subsidies, (5) deterioration in access to rural public services such as health or education due to poor economic condition. In addition, Bryceson (1993) also proposed that the negative impact of structural adjustment program of natural resources based livelihood has accelerated livelihood diversification. This process called deagrarianisation defined by Bryceson (1993) as “long term process involving four main elements: occupational adjustment, income earning reorientation, social identity transformation and spatial relocation of rural dwellers away from strictly peasant modes of livelihood”. Some causes that fit this hypothesis mentioned by Ellis (2001) are removal of agricultural price support, removal of input subsidies, and higher price risk due to market liberalization.

According to Perz (2005), motivation for livelihood diversification can be differentiate as out of necessity or by choice or the combination of the two possibilities. Households may diversify out of necessity due to crises such as loss of land tenure, environmental degradation or climatic events like droughts. On the contrary they may also choose to diversify to achieve specific goals. Factors influencing diversification may vary, among them are as the following (ODI, 1999; Perz, 2005):

1. Seasonality: reducing the effects of off peak periods where agriculture labour demand and or income from harvest are low
2. Risk reduction: diversifying risk among activities such as diversification into crops or into non agriculture activities to avoid crisis
3. Coping mechanism: as a response to crisis and often include diversification into new income source
4. Presence of labour market: which provides opportunities for diversification out of agriculture into wage labour
5. Limited credit markets: when activities require working capital but people do not have access to credit, they may take some other activities to generate cash to pay for the input.
6. Building on complementarities: some diversified activities may build on existing skills, experience and information.

Dixon *et al* (2001) suggest five main household strategies to improve livelihood which are (1) intensification of existing production patterns, (2) diversification of production and processing, (3) expanded farm or herd size, (3) increased off-farm income, both agricultural and non agricultural, and (5) complete exit from the agricultural sector within a particular farming system. OECD (2006) stated that in developing countries, the core economy activity for agricultural household is on agricultural production (on the farm) and proposed livelihood diversification opportunities outside their own agricultural production (off the farm) through three economic activities as shown in figure 2.4. Those activities comprise of:

1. Non farm, rural based agricultural enterprise
2. Rural based, non agricultural enterprise
3. Urban based employment

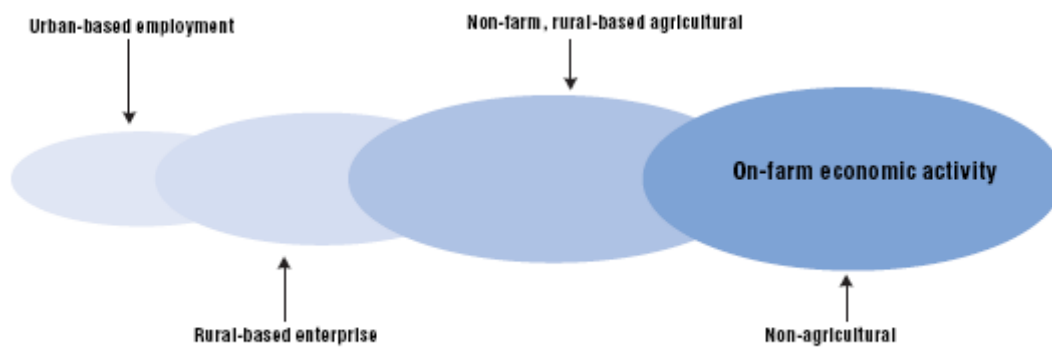


Figure 2.4 Three Spheres of Diversified Livelihood Opportunities for Agricultural (OECD, 2006)

Non farm, rural based agricultural enterprise includes agricultural processing and marketing, input supply and services and related industries. It represents the backward and forward linkages with agro-industry, the services and trade sectors. Rural-based, non-agricultural enterprise provides income through enterprises that are easy to enter and exit and have low transaction costs. These activities require limited capital and skills, located in local market and are based on self-employment. Urban-based employment from temporary migration and commuting has become a routine part of the livelihood strategies of the rural poor. The mobility of labour between rural and urban areas has increased with better roads and communication networks (OECD, 2006). A review of 25 cases in Africa indicated migration earnings (both within rural areas and to urban centres) were as low as 20% of the total non-farming income in villages far from major cities – while this rose to 75% in villages near major cities (Reardon, 1995).

ODI (1999) revealed the result of study in India on general pattern of diversification by different actors group shown in figure 2.5. It indicates that the very poorest are unable to diversify and remaining dependent on agriculture. Those who were better off often those who had diversified into the high return economic opportunities.

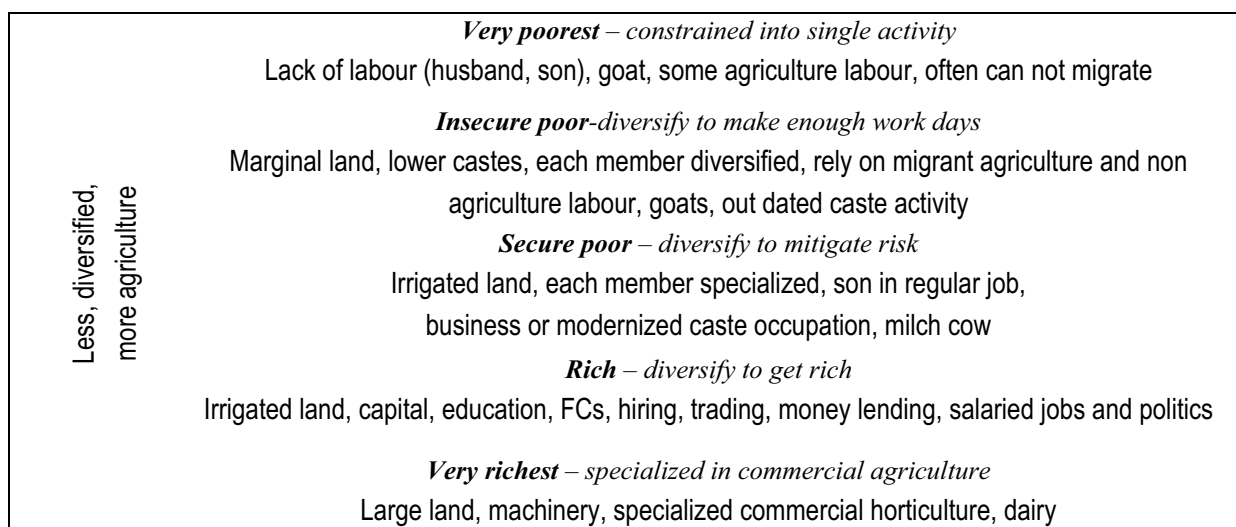


Figure 2.5 Patterns of Diversification (ODI, 1999)

2.3. Participatory Rapid Rural Appraisal

Participation is essential if the process of development to be made acceptable to society as a whole (Dalal-Clayton, Dent, & Dubois, 2003). The purposes for participatory can be categorized into (1) facilitation to promote outside project; (2) empowerment to encourage and reinforce local decision making and local responsibilities; (3) collaboration or mediation in order to make links between outside project and local needs and priorities (Michael K McCall, 2004). According to Mukherjee (1997), natural resources phenomena's are best understood by at local level. They know the best of local availability of such resources, its location, quantity and quality, different use of natural resources etc. Participatory approach is a method for interacting with local people and learning from and with them about natural resources and related issues. There are various methods of participatory aimed at evoking and organizing participation to make it creative, interactive and analytical. The methods can be verbal and visual.

Among the various approach of participatory approach, the best know are rapid rural appraisal (RRA) which emerged in the late 1970s and evolved into participatory rural appraisal (PRA). RRA is intended as an efficient means for outsiders to obtain local information, whereas PRA is meant to promote local abilities to collect and analyse their own information, plan with it and act upon it (Michael K. McCall, 2005). Application of RRA is enormous and mostly found in natural resource management including among others watersheds, land policy, farming system research, agriculture or forestry. However, RRA has its own limitation. Compared to detailed, formal survey, RRA is criticised by its lack of scientific validation and it could become one sided process of information collection i.e. valid enough in comparison with earlier approaches but liable to produce image distorted by the researcher with his/her biases (Michael K. McCall, 2005). Some of the methods for RRA are through direct observation, learning from local with interview with key informants and focus group discussions, temporal tools such as time lines and trend lines and spatial tools such as participatory mapping, image interpretation and participatory GIS.

Participatory mapping is a facilitation technique for discussing landscape and their characteristics. It involves local people in the geographical identification, definition and description of resources and points of reference of their surrounding. There are several purposes for participatory mapping such as to understand local perceptions of landscapes and ecosystems, to understand customary property rights and boundaries, to assists local people in documenting traditional land use systems, to empower rural people to defend traditional boundaries and negotiate with stakeholders (Evans et al., 2006). It involves spatial drawing of any area, drawn on ground, paper or other materials by local people to show and explain their locality and other related areas (Mukherjee, 1997). Participatory mapping includes a range of methods from simple sketch maps to more complex cartographic techniques.

Transect walk is cross section of the community, showing ecological, cultural, economic and land use condition. This spatial tool was applied in a participatory way while conducting reconnaissance to confirm the village sketch map. In addition to ground truthing, it was also conducted to gather additional information regarding location of resources and their state. There are several goals in using the transect which includes (1) confirming sub zones set out in the sketch map, (2) enabling to look at both problems and opportunities, (3) serves as important entry point to interact with community in non-threatening ways through casual and informal conversation (Kumar, 1993).

Timelines and trend lines are temporal tools to learn from the community from historical perspectives. Time line is an overview of past events, as seen from the present situation. The goal is to learn from the community to understand what it considers being important in its history (Kumar, 1993). The time line provides insight into community's historical perspective on changes in livelihood, land use and farming system. Timelines represent subjective views, but it incorporates local historical knowledge unobtainable elsewhere. Trend line is methods where local people describe trends in different variables from historical perspectives. Trend in ecological surrounding can also be demonstrated through this method such as past trend in number and density of trees, water resources and biodiversity (Mukherjee, 1997).

3. Study area and methods

3.1. Study area

Lake Naivasha catchment area covers two provinces i.e. Rift Valley and Central provinces of Kenya. The watershed is surrounded by 2 highlands, the Mau escarpment and Kinangop Plateau and the Rift valley plains in between those two highlands. It has population of over one million people with mixed groups. Large portion of this population comes from immigrant workers who work in horticulture industry, tourism and other business sector. The population within 5 km from the lake has increased from 50,000 in 1977 to 250,000 in 2001.

The Lake Naivasha catchments area is around 3,200 km² with elevation ranges from 1800-2700 m.a.s.l. The lake upper catchments comprise of five upland forests i.e. Mau, Eburru, Kipipiri, Kinangop and Aberdas. These forests form important water catchments for Lake Naivasha, Rift Valley basin, and its surrounding areas. The study area were located in the upper catchment of Lake Naivasha belongs to Nyandarua South districts, Central province. The Nyandarua South district consists of the Kinangop Plateau, Oljororok Plateau and the Ol Kalou Salient, both situated in the rainshadow of the Nyandarua Range. The district consists of six divisions namely: North Kinangop, South Kinangop, Kipipiri, Oljororok, Ndaragua and Ol kalau. There are 26 locations and 75 sub-locations.

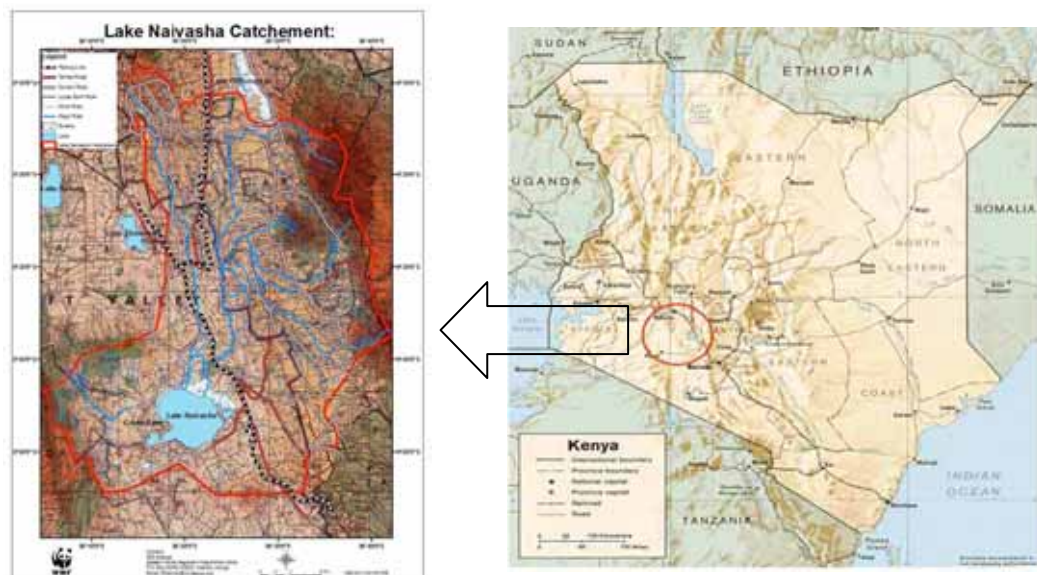


Figure 3.1 Location of study area
(WWF, 2006)

3.1.1. Climate and topography

The climate conditions in the study area differ according to altitude and landforms. However since it is located near the equator it has tropical type of climate with relatively cool condition. The climate in Rift Valley is semi arid and sub humid in the highland with maximum temperature between 24.6 C and 28.3 C in average and minimum average temperature between 6.8C and 8.0 C (Boix Fayos, 2002). The annual rainfall varies from 1000-1400mm per year in the eastern side to 600-800 on the western side (Arwa, 2001). It has two rainy season and the short rainy season (October to December) and long rainy season (March to June). The main climatic problem is the low night temperature. Cold air, generated during clear nights on the moorlands of the Nyandarua Range, flows down to the Kinangop Plateau and Ol Kalou Salient, causing night frosts which makes maize cultivation too hazardous (GTZ, 2007).

The altitude is estimated to vary from 1,900m asl to 4000 m.s.l . The catchment is divided into three topographical regions: The upper catchment with an altitude of up to 3,000m asl, while middle catchment is characterized by the North Kinangop plateau at an altitude of 2,240 masl (Ndunyu Njeru and Engineer). The lower catchment (Gatamaiyo, Karati, Malawa location) at an altitude of 2,000 m asl. Lake Naivasha itself when full has a water level of about 1882m a.s.l.

Upper catchments

The upper catchments comprise hills and ranges formerly known as the Aberdare Mountains and now Nyandarua ranges. Naivasha catchments and the Malewa river basin lie to the West of the Nyandarua (Aberdare) ranges. The major centres in the area include Geta, and Tulaga in Engineer location.



Figure 3.2 Photo of (A) Upper Catchment, (B) Middle Catchment

Middle Catchments

In between the upper catchments and lower catchments is North Kinangop plateau internationally designated as one of the International Important Bird areas (IIBA). The centres in the Kinangop plateau include, Ndunyu Njeru, Engineer and Njambini location, see photo in figure 3.2.

3.1.2. Land use

Agriculture is the main land use within the catchments and serves as the main economy activities in the area. Around the lake and the lowland comprise of irrigated agriculture. Most of the activities are

large scale horticulture, flower, vegetables, fruits, wheat and extensive cattle farms. In the upper catchments areas, rainfed agriculture takes place and crops grown include maize, beans, potatoes, vegetables, wheat, and pyrethrum. Livestock farming also takes place as an important source of livelihood in the area. The vegetation varies from semiarid type dominated by Leleshwa and Acacia species in the lower catchment in Naivasha district, and a variety of shrubs with different grass species and herbs in the middle catchment, to multi-species of both indigenous and exotic tree species, in the upper catchment.

3.1.3. Population

Nyandarua district is the most expansive in Central Province, occupying an area of 3,304 km². Moreover, it is the least densely populated. According to the Population and Household Census of 1999, the total population was 479,902 people while the total number of households was 104,401. Population density rose from 66 persons/km² in 1979 to 145 persons/km² in 1999. At present, the population is estimated around 1.4 million people which mainly composed of Kikuyus ethnic group. This phenomenal population growth rate is partly due to internal migration from the neighbouring districts. It suffices to note that its population has doubled in the last two decades resulting in a greatly increased pressure on land use resources.

3.1.4. Characteristics of the three sub locations

The research selected three sub-locations located in Lake Naivasha upper catchment as case study. The sub locations are Murungaru, Mkungi and Geta that belongs to Nyandarua South District. Those sub locations represent a middle and upper catchment of Malewa river basin which is the primary source of water for Lake Naivasha. Figure 3.3 shows the location of Murungaru, Mkungi and Geta in the upper catchment.

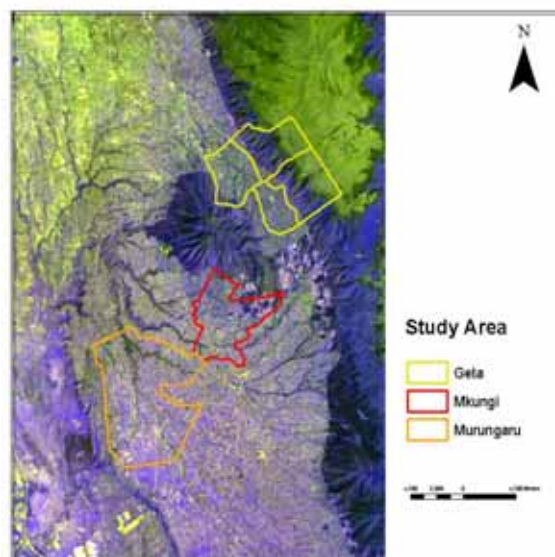


Figure 3.3 Location of Geta, Murungaru and Mkungi in the upper catchment
(source: generated from ITC Naivasha data base)

Murungaru and Mkungi are categorized as middle catchment (2200-2600 m asl). Most part of Murungaru belongs to agro-ecological zone of UH 3 and some part belongs to UH 2, whereas Mkungi belongs to UH 2. Geta is in the upper catchment area (2800m asl) located between Kipipiri and Abardere forest and belongs to UH 1 and UH 2 of agro-ecological zone. Table 3.1 presents the characteristics of the agro-ecological zone.

Table 3.1 Agro-ecological zone of the sub locations

Agro-ecological zone	Altitude in m	Annual temperature (in C)	Annual mean rainfall (in mm)
UH 1 (Sheep and dairy or forest zone)	2400-3000	14.6 - 10.0	1150-1600
UH 2 (Pyrethrum – wheat zone)	2400-3000	14.6 - 10.0	950 -1100
UH 3 (Wheat-Barley zone)	2370-2430	14.7 - 13.7	800 -1100

Source: (Jaetzold, Schmidt, Hornetz, & Shisanya, 2006)

Based on local expert knowledge, the areas were identified to be important for Malewa river catchment. In addition the areas were also chosen due to its accessibility, logistics, connection with local institutions, interests of local community in the research topic. Murungaru and Mkungi sub locations belongs to North Kinangop division, whereas Geta is in Kipipiri division. Based on 1999 statistics census, the population in the area is depicted in Table 3.2.

Table 3.2 Population in Geta, Murungaru and Mkungi in 1999

	Male	Female	Total	Households	Area in Km2	Density
Geta	9436	10096	19532	4129	64.7	302
Mkungi	3105	3153	6258	1290	30.6	205
Murungaru	5525	6071	11596	2381	72.6	160

Source: (Jaetzold, Schmidt, Hornetz, & Shisanya, 2006)

3.2. Application of research methods

The research consists of three phases which are pre field work, field work and post field work.

3.2.1. Pre field work

The first phase of the research focuses on desk study to define research context and field work preparation. Research context is defined through literature review including from Naivasha database of ITC research studies to formulate problem definition, research objectives, research questions, and identify data requirements including defining livelihood assets criteria. Field work preparation consists of selecting villages for the case study, preparing questionnaires for interview, determining sampling design for respondents. The preparation also includes spatial data collection to generate temporary unclassified land use/land cover map which then compare and verify during field survey. Geo-referenced, radiometrically calibrated and ortho-rectified Aster and Landsat TM for 2007, 1995 and 1996 were acquired from the United States Geological Survey, Centre for Earth Resources Observation and Science (USGS-EROS) and Global Land Cover Facility's (GLCF) website. Quick bird and IKONOS were also acquired for the purpose of participatory mapping. Table 3.3 shows the metadata of the remote sensing images.

Table 3.3 Metadata of satellite images

Satellite sensor	Spatial resolution	Spectral resolution	Date of Acquisition	Source
Aster	15 m	14 bands	01/23/2007	USGS
Landsat TM	30 m	7 bands	01/27/1986	GLCF
Landsat TM	30 m	7 bands	01/21/1995	GLCF
Quick Bird	2.6 m	4 bands	06/02/2003	Digital globe
IKONOS	4 m	4 bands	03/06/2002;9/10/2002	Geo Eye

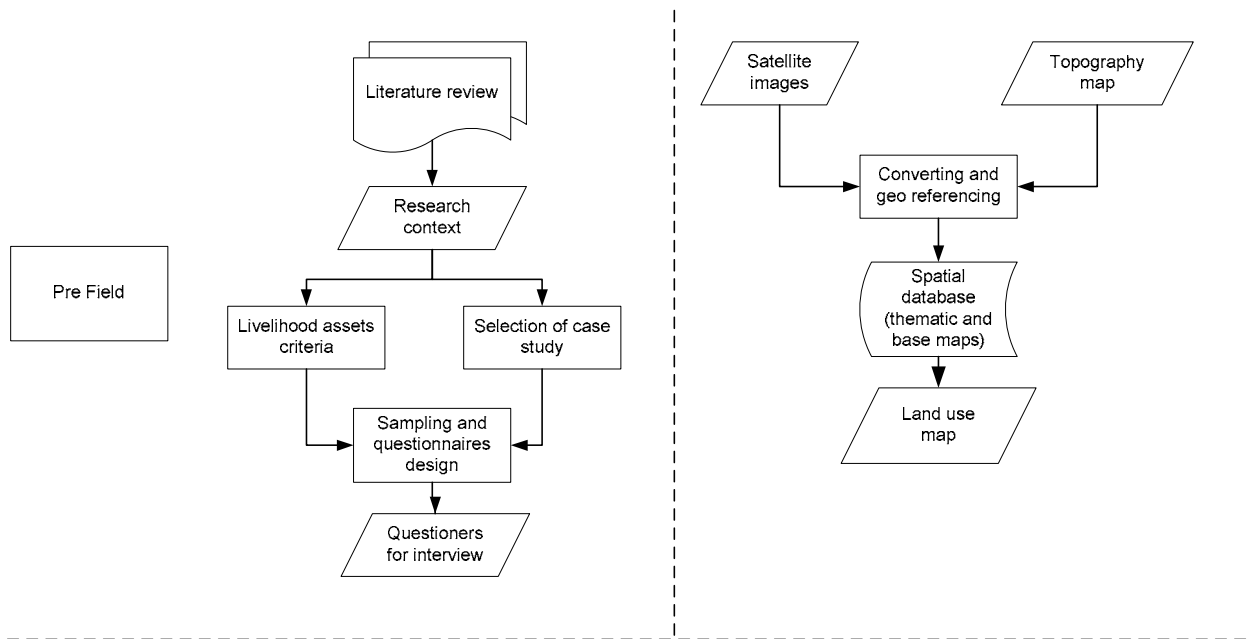


Figure 3.4 Pre Field Work Process

3.2.2. Field work

The second phase of the research is data collection in the field to gather secondary and primary data. The field work was conducted for one month in September-October 2007. Secondary data is collected in parallel with primary data collection. Data in digital and hard copy format of project reports, statistics report, article and official policy documents is gathered from NGOs and government. Primary data acquisition in the field involved two approaches, first involving participatory rural rapid appraisal (P-RRA) approach and second survey approach.

1. Participatory rapid rural appraisal approach

In this study, participatory approach involved sequence of methods comprise of interview with key informants, group discussion and participatory sketch mapping and transect walk. These methods are aimed at obtaining qualitative and quantitative information on biophysical, agronomic and socio economic factors that influence community access to and utilization of land resource and changes in village land use and its contribution to the livelihood of the community. Rapid appraisal was conducted to learn about the village landscape, to meet key informants and preparing respondents for household interview. Interview with key informants included community leaders, village elders, NGO workers, and government officials from sub location to district level.

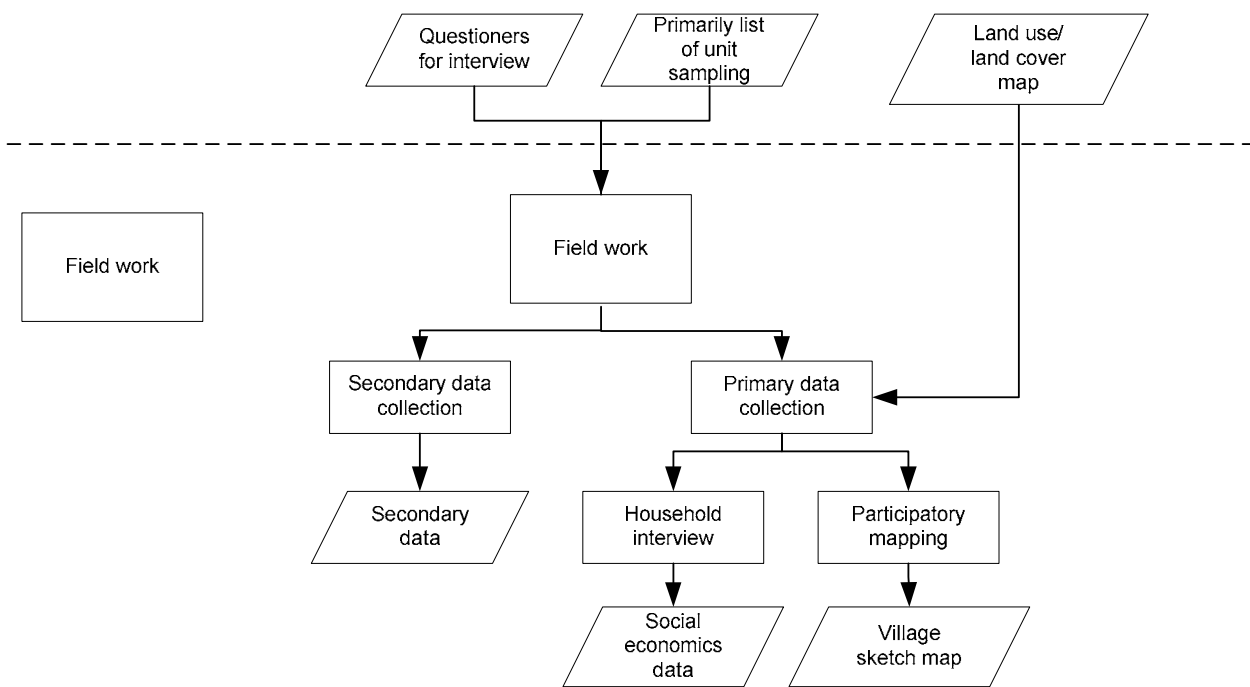


Figure 3.5 Field Work Process

a. Historical time line and trend line

Historical time line and trend line was conducted in order to capture the changes. The time line provides insight into community's historical perspective on changes in livelihood, land use and farming system. It represents subjective views, but it incorporates local historical knowledge unobtainable elsewhere. The exercise was conducted within the three sub locations, in small groups of farmers community elders and government officials. In total 10 respondents were present in Murungaru and Mkungi, whereas in Geta 15 respondents were participating. The exercise went well in Geta sub location since they have done this practise before. In Murungaru and Mkungi, the exercise was not really successful due to language barriers with translator and only few community elders were present.

b. Participatory mapping and transect walk

Participatory mapping was conducted at each sub locations using sketch maps together with small group of community members and government officials to capture village land use and the changes. Land use, boundaries, roads, rivers, public facilities were drawn onto paper. At first, the community were presented with satellite images of Aster, Quick Bird and IKONOS as well as topographic map scale 1:50000 and asked to draw the sketch on top of the images. However, the community was having difficulty using the images and preferred to do sketch map based on their own knowledge. They were also having difficulty in showing detail land use for cultivated land. They could only state in addition to rivers and public facilities (school, shopping centre) are mixed farming area and grazing land. Similarly, in expressing changes that happened from 90s to the present in the village, the community preferred to state verbally instead of drawing. They could not tell the specific location of the changes for agriculture land. For them, the changes occurred within the villages was not too significant and the general land use tends to stay the same. However, the community notice several significant changes such as less grazing area and the expansion of shopping centre. They were more

able to see the changes within they own farm such as changes in the land size due to land division, purchasing or renting, and the land use of their farm such as from grazing area into crop production area or vice versa.

The transect exercise was conducted together with key informants such as elders, NGO and government officials. It was done by walking straight line, following the road from one side of the sub location to the others. Observable details like types of soils, cropping pattern, farm size, water resources, and socio economic factors were recorded. Informal discussion and brief interviews held along the transect route to provide information on observed condition and critical issues such as natural resources problems and opportunities.

2. Social survey approach

Survey approach was conducted to gather information needed for livelihood analysis. Household is used as unit analysis in order to provide further insight at household level. It was done by taking sample from population using stratified random sampling. Using the satellite image and topography map, each sublocation was divided into 5 areas and each area, 4 households were interviewed. Twenty households at each sub location were selected, resulting sixty respondents in total. Interview guided by semi structure questioner was conducted to obtain information on social and economic data on households and farming characteristics. The questions consist of three main sections. First section referred to personal information of respondents such as name, age, marital status, education. Second section provide information on household characteristics related to livelihood assets such as family size, source of income and composition, migration and work history, labour composition, land ownership. Third section asked about farming characteristics such as access to land, extension assistance, land use, crop production, and conservation practices.

3.2.3. Post field work

Post field work phase involve data processing and data analysis. Result from participatory rapid rural appraisal and survey approach were recorded, coded and processed. Data analysis consists of three steps. The first step is land use/farming system analysis. Due to time limitation, landuse/land cover analysis is conducted using land cover classification in Lake Navaisha drainage basin for year 1986, 1995 and 2007 done by Were (2008). Landsat TM image of 1986, 1995 and Aster image 2007, taken in January was used for the classification. During field survey, 430 sample points were taken and sorted out based on the bio physical attributes to developed land cover classification. The classification was based on standard land cover classes, defined by natural resource department ITC. Image classification was done using object oriented approach by partitions the image into meaningful homogenous objects by taking into account not only the spectral information inherent in it but also the spatial attributes such as shape, compactness, size, smoothness and other topological feature (Were, 2008). Classification for 1986 and 1995 images was done using sample objects based on extracted land cover map for 2007 (backward classification) and available reference materials. The classification resulted in 91% accuracy for year 2007. However, due to lack of data and references, accuracy assessment for 1986 and 1995 is not reported. The images classified by Were (2008) then subset with the sub locations boundary to generate land cover map for the sub locations and analyzed

using Arc GIS 9.2 and ERDAS imagine. The result of land cover map then confirmed with sketch map and interview result.

Second step is related farming systems and livelihood diversification analysis. Temporal changes and linkage to horticulture sector will be emphasized. Descriptive analysis is performed to describe household and farm characteristics, as well as livelihood diversification of smallholder farmers. Relationship between livelihood diversification, farming practices and natural resources management is analyzed using descriptive statistics. The third step is linking land use/farming system changes and livelihood diversification. Linkage between the changes and horticulture industry is also analyzed. Social and economic data is processed and analyzed using Microsoft Excel and SPSS software.

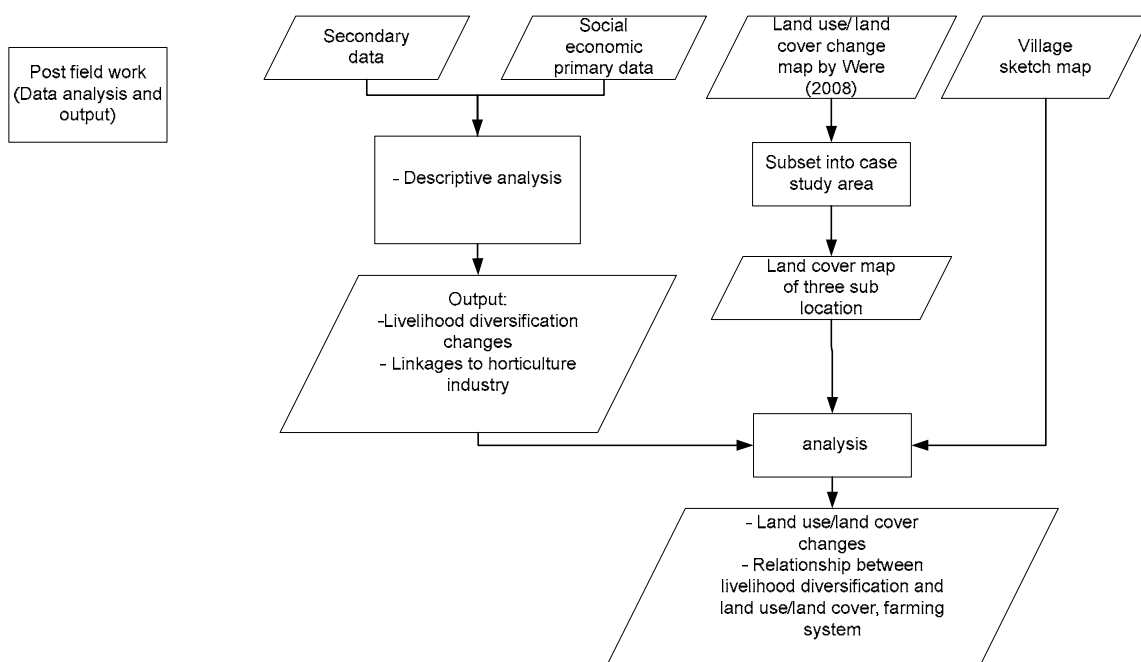


Figure 3.6 Post Field Work Process

4. Land use and farming system: current and changes over 20 years

This chapter discusses about the land use/farming system and livelihood characteristics in the study area. This includes land cover/land use, livelihood assets of smallholder farmers, marketing channel and conservation practices. Changes in those elements are also discussed.

4.1. Land cover/land use

4.1.1. Present land cover/land use

Figure 4.1 and 4.2 show the land cover maps in 2007 of Geta, Murungaru and Mkungi, derived from land cover changes analysis of Lake Naivasha basin by Were (2008). Using Landsat TM for 1986 and 1995 and Aster for 2007 taken in the month of January, based on bio-physical attributes, the land cover are classified into nine classes i.e. grasslands, croplands, forest, woodlands, shrubs lands, built-up, barelands, water bodies and moorlands with 91% accuracy. Table 4.1 presents the description of land cover classes.

Table 4.1 Description of land cover classes

Land Cover	Description
Grasslands	Areas dominated by grasses (0-0.2m) and herbs (0.2-2m)
Croplands	Areas covered by growing crops, ploughed fields and horticultural farms
Forests	Areas predominantly covered by tree (>5m high) with closed canopies (>40% cover)
Woodlands	Areas dominated by scattered trees (>5 m high) with open canopies (<40% cover)
Shrubs lands	Area characterized by a high percentage of shrub cover (2-5 m high)
Built-up	Areas with commercial or residential structures and or constructed materials
Bare lands	Either completely non vegetated areas or areas with very low percent vegetation cover
Water bodies	Areas covered by open waters, rivers and the lake
Moorlands	Wetter areas, mostly in the upper highlands and tropical alpine zones with low growing vegetation on acidic soils.

Source : Were (2008)

The trend shows that the dominant land covers are cropland, woodland, grassland and forest as presented in Table 4.2. In Geta, croplands and woodlands each contribute approximately 34% of the total area, followed by forest (16%) and grassland (around 6%). This picture is similar with Mkungi area although forest is less than grassland. However, in Murungaru, in addition to cropland, grassland is the dominant land cover followed by woodland. Field observation, sketch map of village land use and transect walk also confirmed the finding from the satellite image.

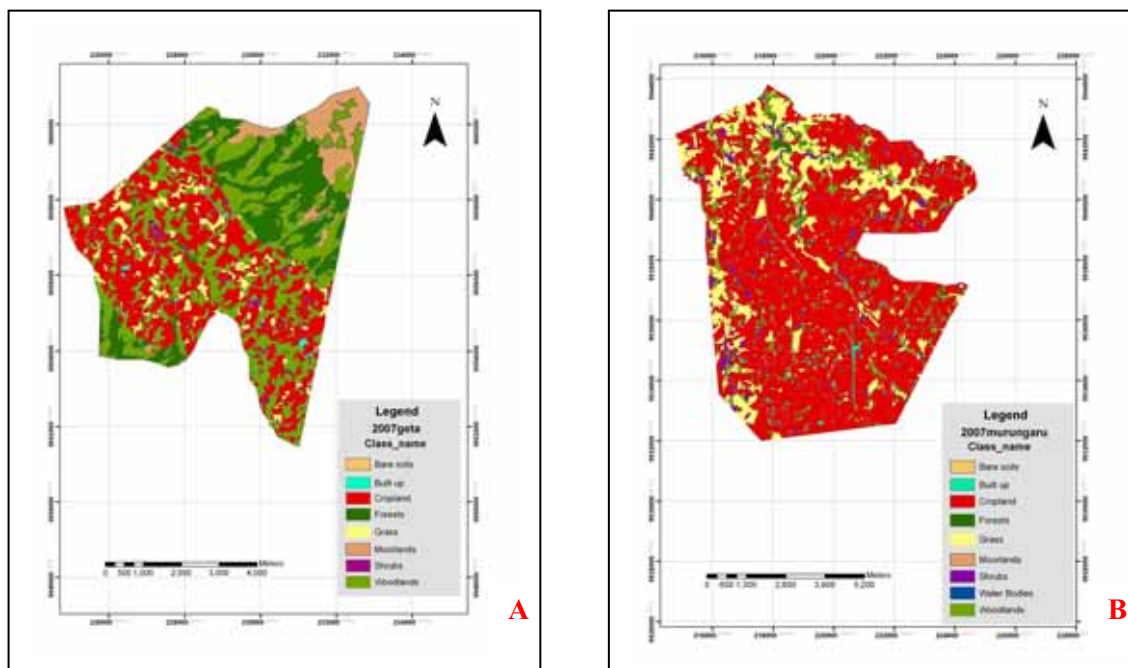
Nyandarua district is predominantly based on subsistence agriculture with major crops include wheat, pyrethrum, and maize. Livestock farming, especially dairy and sheep, is also important. The district is divided into several agro ecological zones (Jaetzold, Schmidt, Hornetz, & Shisanya, 2006) each of the

zones is characterized by a different combination of major land use. Geta is part of UH 1 (sheep and dairy or forest zone) and UH 2 (pyrethrum-wheat zone). However, unlike the name of the zone, mixed farming of horticulture crops such as potatoes, kales, peas, onion leaves and carrots and cabbages, cut flower, fruit trees, agro-forestry and forest reserve are the dominant land use. In some part of Geta, farmers also started to plant maize. Murungaru belongs to agro-ecological zone of UH 3 (wheat-barley zone) and some part belongs to UH 2 (pyrethrum-wheat zone), whereas Mkungi belongs to UH 2. Field observation shows that the dominant land use classes are annual crops such as wheat and maize; horticulture (potatoes, carrots, cabbages), grazing land and agro-forestry. Different with Geta and Mkungi, Murungaru does not have forest reserve. Minor land uses in the areas include non-agriculturally productive land such as settlement and public facilities and water bodies.

Table 4.2 Land cover areas in Geta, Murungaru and Mkungi in 2007

Land cover type	Geta		Murungaru		Mkungi	
	in m2	%	in m2	%	in m2	%
Grass	2,403,900	5.8	12,047,400	15.8	2,311,200	7.8
Cropland	14,333,400	34.4	53,255,700	70.0	18,434,700	62.5
Forest	6,774,300	16.3	610,200	0.8	1,403,100	4.8
Woodlands	14,429,700	34.6	6,496,200	8.5	6,123,600	20.7
Shrubs	473,400	1.1	2,266,200	3.0	1,061,100	3.6
Built up	156,600	0.4	895,500	1.2	102,600	0.3
Barelands	0	0.0	424,800	0.6	70,200	0.2
Water bodies	0	0.0	52,200	0.1	0	0.0
Moorlands	3,103,200	7.4	32,400	0.0	6,300	0.0
Total	41,674,500	100	76,080,600	100	29,512,800	100

Source: Derived from land cover map



*Figure 4.1 Land cover map 2007 of Geta (A) and Murungaru (B)
(source: generated from Were, 2008)*

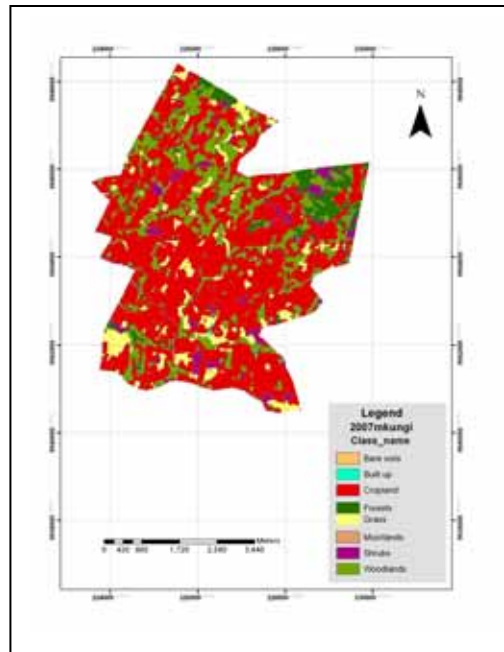


Figure 4.2 Land cover map 2007 of Mkungi
(source: generated from Were, 2008)

4.1.2. Land cover/land use in 1984 and 1995

Figure 4.3 to 4.5 shows the land cover maps in 1986 and 1995 of Geta, Murungaru and Mkungi. However, the accuracies of the land cover maps for 1986 and 1995 is not known due to the lack of reference data to assess their quality (Were, 2008). Hence, there is possibility of error especially due to the image resolution and the mix land cover in the area. One pixel can represent several land cover classes. In addition, misinterpretation in the classification can also contribute to the error such as grass which can be misinterpreted as shrubs due to its spectral confusion (Were, 2008). Nevertheless, the general trend shows that in 1986 and 1995 cropland, woodlands, forest and grass land were the dominant land covers in the area. In Geta area, woodland (around 45%), cropland (around 30%) and forest (around 20%) are the dominant land covers of the total area. For Geta, the proportion of the land cover in 1986 and 1995 is not much different.

Table 4.3 Land cover 1986 and 1995 in Geta

Land cover type	Geta			
	1986		1995	
	in M2	%	in M2	%
Grass	39,600	0.1	43,200	0.1
Cropland	13,525,200	32.5	12,730,500	30.5
Forest	8,555,400	20.5	7,524,000	18.0
Woodlands	18,651,600	44.8	18,698,400	44.8
Shrubs	124,200	0.3	134,100	0.3
Built up	18,900	0.0	105,300	0.3
Barelands	0	0.0	0	0.0
Water bodies	0	0.0	0	0.0
Moorlands	751,500	1.8	2,507,400	6.0
Total	41,666,400	100	41,742,900	100

Source: Derived from land cover map

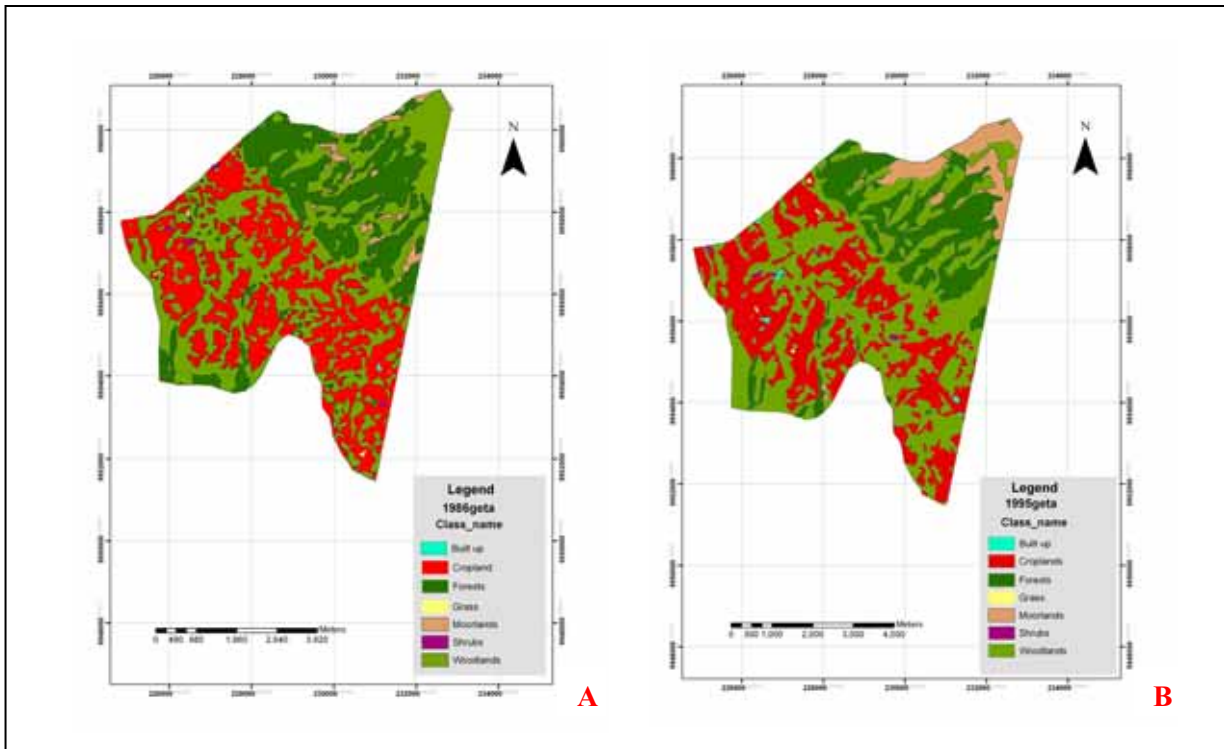


Figure 4.3 Land cover map 1986 (A) and 1995 (B) of Geta
(source: generated from Were, 2008)

Different with Geta, in Murungaru, the dominant land cover in 1986 and 1995 were cropland, woodland and grass land respectively. As can be seen in table 4.4, the proportion of land cover was slightly changing although with the same order. Grass land for grazing and woodland decreased whereas cropland for agriculture increased.

Table 4.4 Land cover 1986 and 1995 in Murungaru

Land cover type	Murungaru			
	1986		1995	
	in M2	%	in M2	%
Grass	16,511,400	21.7	14,136,300	18.6
Cropland	42,975,900	56.5	50,611,500	66.5
Forest	44,100	0.1	0	0.0
Woodlands	7,752,600	10.2	7,156,800	9.4
Shrubs	5,351,400	7.0	3,608,100	4.7
Built up	282,600	0.4	441,900	0.6
Barelans	3,041,100	4.0	78,300	0.1
Water bodies	83,700	0.1	60,300	0.1
Moorlands	0	0.0	0	0.0
Total	76,042,800	100.0	76,093,200	100.0

Source: Derived from land cover map

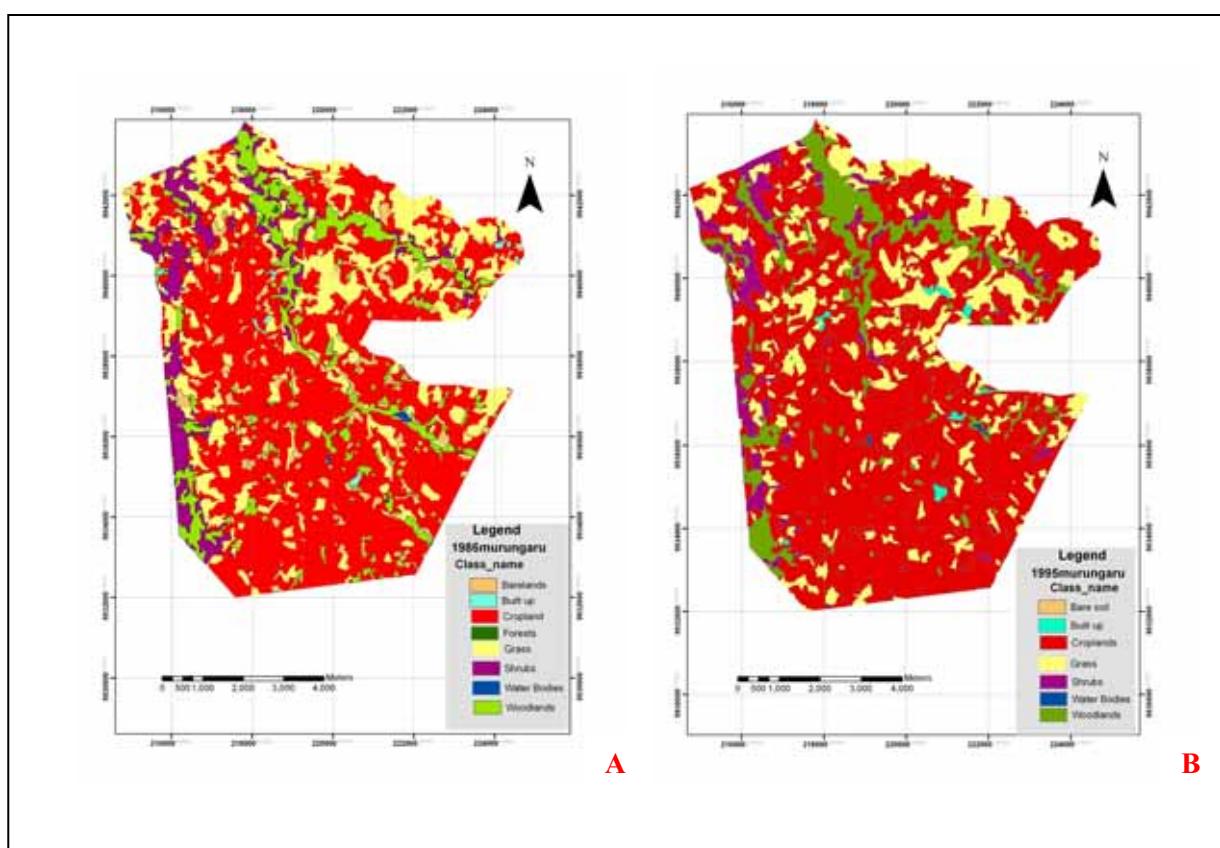


Figure 4.4 Land cover map 1986 (A) and 1995 (B) of Murungaru
(source: generated from Were, 2008)

As can be seen in from table 4.5, land cover in Mkungi dominated by cropland, woodland, grass land, and forest. The proportion of grass land, forest and woodland were decreasing whereas cropland increased.

Table 4.5 Land cover 1986 and 1995 in Mkungi

Land cover Type	Mkungi			
	1986		1995	
	in M2	%	in M2	%
Grass	3,885,300	13.2	2,535,300	8.6
Cropland	16,345,800	55.4	18,372,600	62.3
Forest	2,447,100	8.3	1,818,000	6.2
Woodlands	6,202,800	21.0	6,042,600	20.5
Shrubs	546,300	1.9	500,400	1.7
Built up	88,200	0.3	50,400	0.2
Barelands	0	0.0	18,900	0.1
Water bodies	0	0.0	0	0.0
Moorlands	0	0.0	161,100	0.5
Total	29,515,500	100.0	29,499,300	100.0

Source: Derived from land cover map

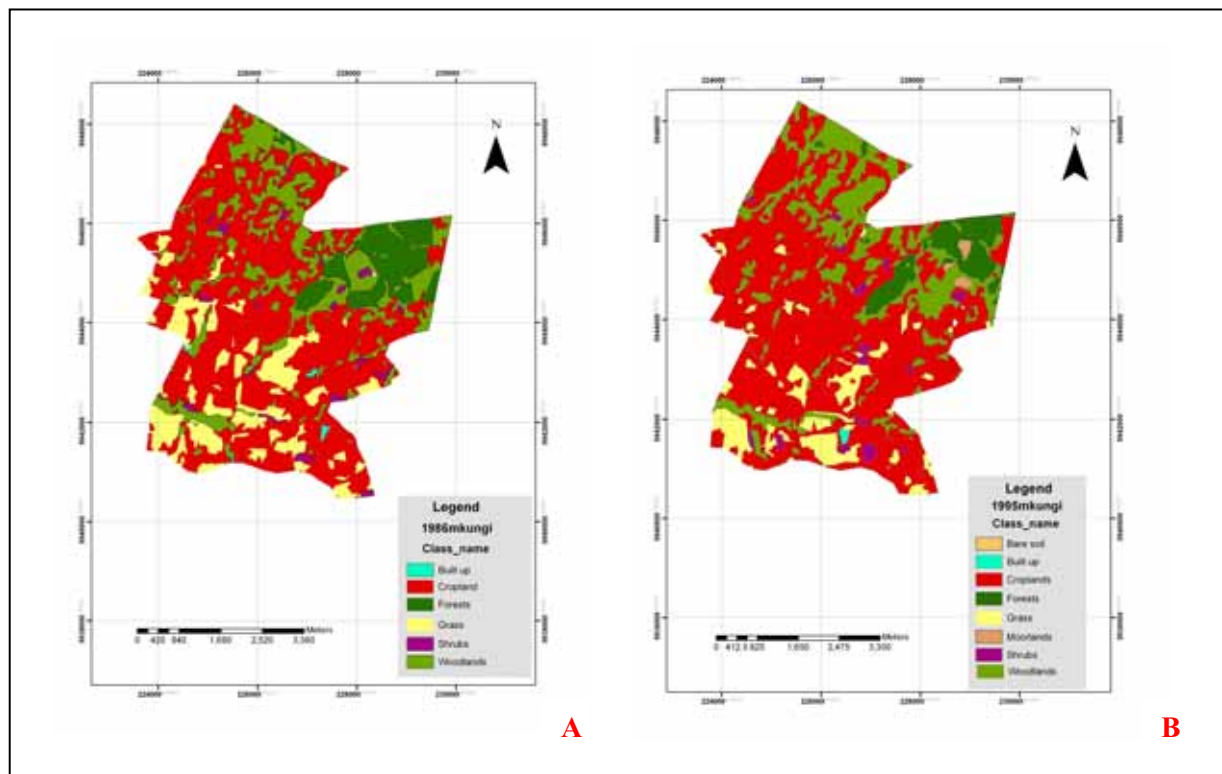


Figure 4.5 Land cover map 1986 (A) and 1995 (B) of Mkungu
(source: generated from Were, 2008)

4.1.3. The historical changes in land cover/land use

Early changes

In identifying changes in land cover/land use, the result of land cover map from satellite images, historical time line and sketch map are used. Like other areas in Nyandarua district, Geta, Murungaru and Mkungu areas used to be part of the “white” highlands specializing in the wheat, barley and pyrethrum farming as well as dairy and sheep production by large European farm. In 1963 at independence, the area was set aside for settlement as part of the one million acre settlement scheme. Since then it has been transformed into a small and medium scale mixed farming area which portrays uniform size and organization. Kenyans were given 40 acres of farmlands per household in Murungaru and Mkungu. Geta settlement scheme was set in 1969, later than Murungaru and Mkungu to settle those who can not be accommodated in earlier scheme. Geta was previously a forested area with high soil fertility and rainfall. In 1970, 8000 acres of Geta forest cleared to give way for cultivation and settlement for 2000 households, each household received 4 acres portions. Road linking to Wanjohi was constructed and first primary school and shopping center were established.

At that time, pyrethrum crops was introduced as well as potatoes, beans, peas, carrots, cabbages, and onions among other cultivation crops. Kikuyu grass was also introduced since there was no grass in the forest. In Murungaru and Mkungu wheat, barley and small scale of maize (due to unfavourably frosty wheater) were persisted. The Kenya breweries company limited were giving incentive for cultivation of wheat and barley through financing and marketing. Farmers also began planting trees

mainly cypress and eucalyptus trees. In mid 70's dairy cattle and fruit trees such as plums, pears and apples were introduced in Geta. In early 80's pyrethrum production reduced as pasture was introduced for dairy cattle. Sub division and sale of land also started to commence.

Changes in mid 80 to 2007

Table 4.6 indicates the land cover changes from 1986 to 2007 in percentage. A negative sign before the value means a decrease in land cover types. Woodlands and forests show a declining trend whereas croplands and build up areas shows an increasing trend. However, the heterogeneity of land covers types and the spectral similarity between classes especially croplands, barelands, grasslands and shrub lands resulted error in the classification. In addition, the classification of Landsat TM 1986 and 1995 is not automatic as good as Aster 2007 because the difference in their spatial resolutions (Were, 2008). Classification error might be seen in the grassland in Geta. It increased by almost 5500% in the period of 1995 to 2007 which by field observation was not possible. In Murungaru the changes in forest and moorland in 1995-2007 periods can not be calculated since the area of forest and moorland in 1995 shows 0 m2. The same case occurred in Mkungi for barelands and water body. This fact can not be ignored; especially the accuracies of generated land cover maps for 1986 and 1995 was not assessed. Hence, it is difficult to assess the changes particularly detail changes using board spectral and coarse spatial resolution of Landsat TM and aster especially on mix area. Since the data was not reliable to capture the changes, this is not used for drivers of changes analysis. However, the data is used to show general trends which then confirmed by the result from sketch map discussion and field observation.

Table 4.6 Land cover changes in Geta, Murungaru and Mkungi

Land Cover Type	Geta (%)		Murungaru (%)		Mkungi (%)	
	1986-1995	1995-2007	1986-1995	1995-2007	1986-1995	1995-2007
Grass	9.1	5464.6	-14.4	-14.8	-34.7	-8.8
Cropland	-5.9	12.6	17.8	5.2	12.4	0.3
Forest	-12.1	-10.0	-100.0	-	-25.7	-22.8
Woodlands	0.3	-22.8	-7.7	-9.2	-2.6	1.3
Shurbs	8.0	253.0	-32.6	-37.2	-8.4	112.1
Built up	457.1	48.7	56.4	102.6	-42.9	103.6
Barelands	0.0	0.0	-97.4	442.5	-	271.4
Water bodies	0.0	0.0	-28.0	-13.4	-	-
Moorlands	233.7	23.8	0.0	-	-	-96.1

Source: Calculated and analyzed from land cover map

There is an increasing trend in the build up areas from 1986 to 2007. In Geta, build up areas increase by almost 450% in the period of 1986 to 1995. The same trend occurs in 1995 to 2007 period although with slower rate (almost 49%). This also confirmed by the discussion during village sketch map. The increase of settlement, trading centers, schools and road contributes to the increase in build up areas. The increase of build up area is also due to the increased population. In Geta, from 2000 households since the first settlement, the household size has increased to around 4129 with density of 302 according to 1999 census. The increase population also creates demands on land for cultivation. In Geta, cultivated land increase by almost 13% in 1995-2007.

Compare to ten years ago, the area was not highly populated as it is now and the land was also not subdivided. Cultivated area and settlement are increasing. Number of school increase from five to fourteen and trading centre increase from two to five. It used to be more trees in the farm and in the forest. Grass land for grazing also continued to decrease. (Source: Geta community)

Expansion of agriculture land is in the expense of other land cover such as grass, forest, woodland and grass. Table 4.7 and 4.8 presents land cover conversion for 1986-1995 and 1995-2007 in Geta. The conversion of land use from mostly grasslands and woodlands to cropping is similar process occurring elsewhere in semi arid regions of Kenya and other African countries (Olson, 2004).

Table 4.7 Land cover conversion 1986-1995 in Geta

1986	1995 (km ²)									
	Grass-land	Crop-land	Forest	Wood-land	Shrub	Build-up	Bare-land	Water-bodies	Moor-land	Total
Grass	0	2.43	0	1.44	0	0.09	0	0	0	3.96
Cropland	1.98	717.57	13.68	599.94	8.55	7.38	0	0	3.24	1352.34
Forest	0	17.01	446.13	331.11	0	0	0	0	61.29	855.54
Woodland	2.34	528.66	274.23	897.12	4.32	3.06	0	0	155.43	1865.16
Shrubs	0	6.39	0	5.49	0.54	0	0	0	0	12.42
Build up	0	0.99	0	0.9	0	0	0	0	0	1.89
Bareland	0	0	0	0	0	0	0	0	0	0
Waterbodies	0	0	0	0	0	0	0	0	0	0
Moorland	0	0	18.18	32.31	0	0	0	0	24.66	75.15
Total	4.32	1273.05	752.22	1868.31	13.41	10.53	0	0	244.62	4166.46

Source: calculated from land cover map

Table 4.8 Land cover conversion 1995-2007 in Geta

1995	2007 (km ²)									
	Grass-land	Crop-land	Forest	Wood-land	Shrub	Build-up	Bare-land	Water bodies	Moor-land	Total
Grassland	0	2.34	0	1.17	0.45	0.36	0	0	0	4.32
Cropland	112.86	709.65	17.64	397.35	17.91	10.89	4.41	0	2.07	1272.78
Forest	3.87	35.28	318.24	309.87	0.45	0	0	0	84.69	752.4
Woodland	121.32	667.17	313.83	656.82	28.53	4.32	2.34	0	75.51	1869.84
Shurbs	1.26	8.55	0.27	3.24	0	0.09	0	0	0	13.41
Build up	0.63	6.75	0	3.15	0	0	0	0	0	10.53
Bareland	0	0	0	0	0	0	0	0	0	0
Water bodies	0	0	0	0	0	0	0	0	0	0
Moorland	0.45	3.42	27.45	71.37	0	0	0	0	148.0	250.74
Total	240.39	1433.16	677.43	1442.97	47.34	15.66	6.75	0	310.3	4174.02

Source: calculated from land cover map

In order to satisfy the demand for cultivation land, whereas available land is limited, farmers have encroached into the reserve forest areas (Lambrechts, Woodley, Church, & Gachanja, 2003). Changes also occurred in the type of crops. In line with the phenomena at district level, pyrethrum started to decline due to delayed payment by Pyrethrum Board of Kenya (PBK). Of the total respondents, less than five percent claimed still plant pyrethrum. Figure 4.6 shows the trend in area, production and yield in Nyandarua district. In 1980, the area for pyrethrum reached 3764 ha, and in 2004 it decreases to 1,120 ha. During field interview, only few people claimed that they still plant pyrethrum. However,

this trend might increase again since the government tries to revive the PBK and encourage the people to replant it.

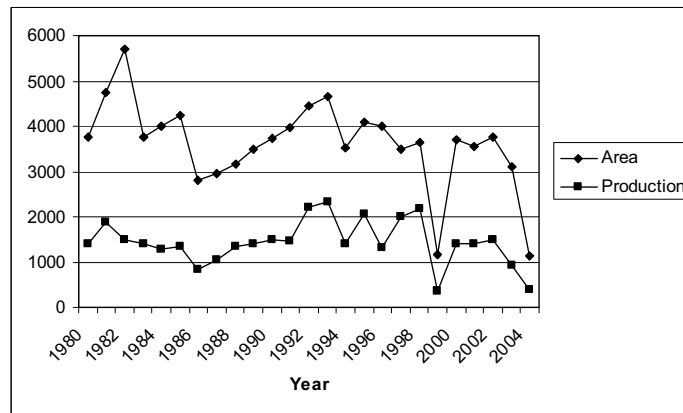


Figure 4.6 Pyrethrum Area and Production in Nyandarua District 1980-2004
(Jaetzold, Schmidt, Hornetz, & Shisanya, 2006)

In some part of Geta, farmers started to plant maize due to the change of climate. Before, it was not possible to plant it due to frosty weather. These phenomena also occurred in Mkungi. Hence, it might also explain the increase of maize area at district level. From figure 4.7 it can be observed that the area of maize in Nyandarua district has increased from 1993 to 2007 by 300% while total production of maize has increased by 250% during the same period. Figure 4.7 also shows that productivity has decreased for land under maize production by 25% during the same period from 20 bags/ha to 17 bags/ha. In addition to maize, due to climate change, drought tolerant crops such as sweet potatoes were also introduced.

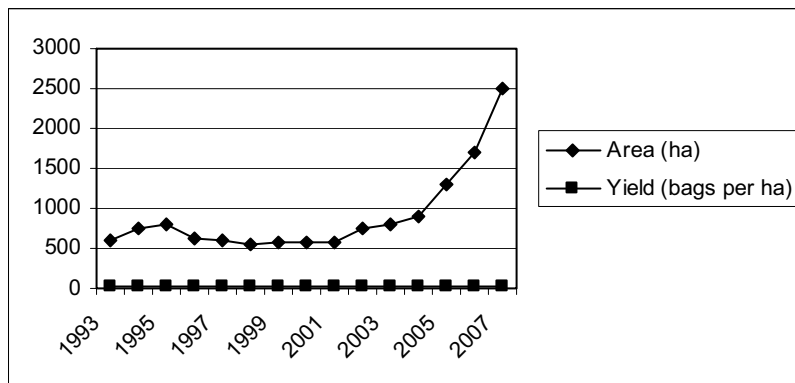


Figure 4.7 Maize Area and Yield 1993 – 2007
(Nyandarua Agriculture District Office, 2007)

Since early 1990's high value crops were introduced. In Geta, cut flowers such as carnation and alstroemelia were introduced in early 1990's through private company from Lake Naivasha. However, this was not last long due to lack of payment. However started in 2006, it was reintroduced through government project. In Murungaru, the community identified two new horticulture farms with average of 40 acres; belong to private company in Lake Naivasha. This indicates the expansion of horticulture industry to the upper catchments. In addition to cut flower, government also introduced snow peas and fruits such as apples and plums.

In contrast with cultivated land, in Geta, forest area shows a decreasing trend. From 1986 to 2007 it decreased 12 % and from 1995 to 2007 decreased by around 10%. The encroachment to the forest is also deriving as from the abuse of shamba system which is introduced in 1985. The shamba system or non residential cultivation is agro-forestry practice which based on the successful experience of establishing teak plantations in Burma (Myanmar) since the middle of the century (Lambrechts, Woodley, Church, & Gachanja, 2003). This system allows local farmers to inter crop annual agricultural crops with tree seedling in forest plantation areas until the third year of tree growth. By the third year, the young tree canopy casts too much shade for normal growth of agricultural crops. At this point, farmers move out and are allocated other plots, if available.

However, abuse of this system led to encroachment into indigenous forest areas. The failure of this system is mainly attributable to inadequate enforcement of law and regulations. For example, contrary to the regulations, farmers are allowed to cultivate the forest plots for long periods (often over three years) and to cultivate on hill top. Unfortunately, this most of the time lead to permanent occupation of forest land. In addition to encroachment to forest for cultivation area, illegal logging of indigenous trees, charcoal production and livestock grazing are contributed to the destruction of the forest. The government then banned the shamba system in 2000 and introduce new forest regulation with sticker punishment for those who caught in the forest illegally. This might explain the slower rate of deforestation in 1995 to 2007 compare to the previous period.

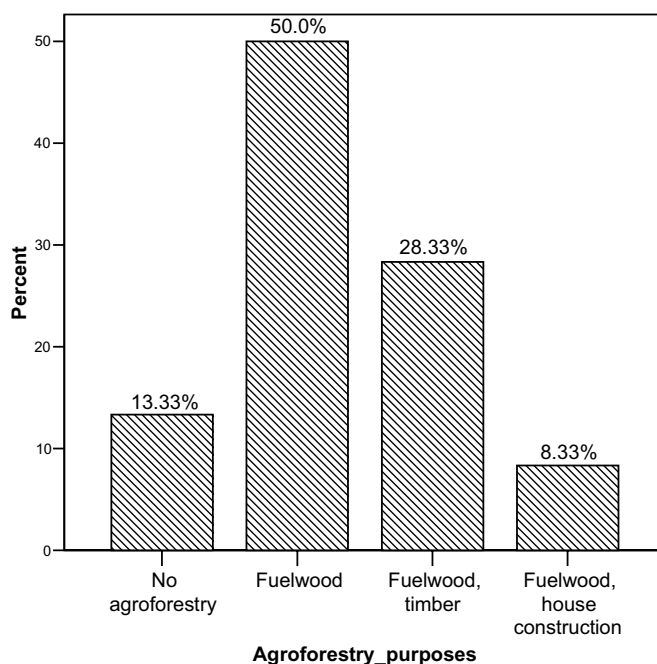


Figure 4.8 Agroforestry purposes
(Source: household survey)

Furthermore, after the mass destruction of forest due to encroachment for agriculture land and illegal logging for fuelwood, charcoal and timber around 1980-1990s, the government promote agroforestry to encourage people to plant trees. Thus, many farmers practise agroforestry for fuelwood, house construction and timber purposes. From the figure 4.8, it can be seen that of the total respondents, 50% stated they plant tree for fuelwood purposes only, followed by fuelwood and timber for

investment. Bluegum or Eucalyptus spp used to be the one of the majority types of tree. However since it was claimed to absorb a lot of water hence accused of causing water problem, farmers are now hesitate to plant them. In Geta, bamboo used to be important trees, but due to the massive cut, it is now rarely to be seen in the area.

In addition to government intervention, NGOs such as Green Belt Movement established by Professor Wangari Maathai and World Wild Fund (WWF) also took part in combating deforestation by encouraging the community to plant trees in late 1990s. Since 2004, WWF fostered conservation of indigenous and exotic trees species along Mkungi river and also promote tree seedlings. The destruction of the forest, also affected the wildlife. Since their habitat was destroyed, they started to go to villages near by forest. In Mkungi, elephants destroy crops in the farm near by Aberdare and Geita forest. To prevent this and also encroachment to the forest, electric fence is build around the forest in 2007 by Kenya Wildlife Service and Friends of Lake Naivasha. Later on, the government added fund to this project.

In exception of Geta, grass land area also shows a decreasing trend from 1986 to 2007. This was confirmed during village sketch map. In Murungaru the rate decreases slightly in 1986-1995 and 1995-2007 periods. Whereas in Mkungi from around 35 percent decrease in 1986-2007 to 8.8 percent decrease in 1995-2007. This indicates that grazing area for livestock is also decreasing. Farmers also stated that they have to control the number of their livestock due to the lack of land for grazing.

4.2. Smallholder farmers characteristics

The survey tried to capture household characteristics of smallholder farmers in the upper catchments. The characteristics and assets of smallholder farmers reviewed includes age, gender, education of head of household, average size of household, land and livestock ownership. In addition, marketing channel and farming methods are also discussed.

4.2.1. Age, gender and education of head of households

Figure 4.9 describes the distribution of age of respondents in this survey. Variable of age is used in this research with pre assumption that the age of smallholder farmers may influence the decision of their choice of source of income and land ownership. It can be seen from the histogram that average of age of the household heads of smallholder farmer found in the upper catchments is 49 years old and second generation of the family since they first settled in the area. The respondents' age is ranging from 20 to 70 years old. However, the majority of respondents are above 40 in which dominated by those between 40 to 60 years old.

In term of gender of the head of household, of total respondents, 70 percent of respondents are male while 30% is female. From observation, most of female head household are either around their 20s of age as single mother and unmarried and above 50s of age as widow. The household size of respondents varies from 3 to 10 persons. On average, the household size in upper catchments is about 6 persons per households.

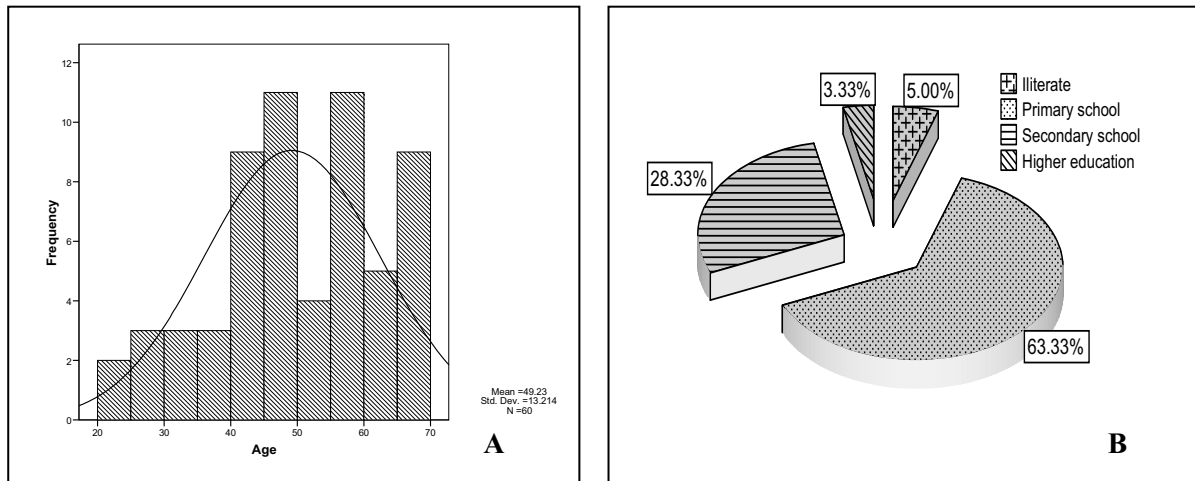


Figure 4.9 Age (A) and education level (B) of the respondents
(Source: household survey)

Figure 4.9 (B) presents the education level of the head of households in the upper catchments. The majority (63%) of respondents has only primary level education, 28% has secondary level. Only 3% of the respondents experienced higher education (college).

4.2.2. Land resources

Land distribution and ownership is highly skewed. Figure 4.10 (A) shows the distribution of land holdings in the study area. The majority of land holding range from 0.25 to 5 acres. On average, the land holding of smallholder farmers is around 4 acres.

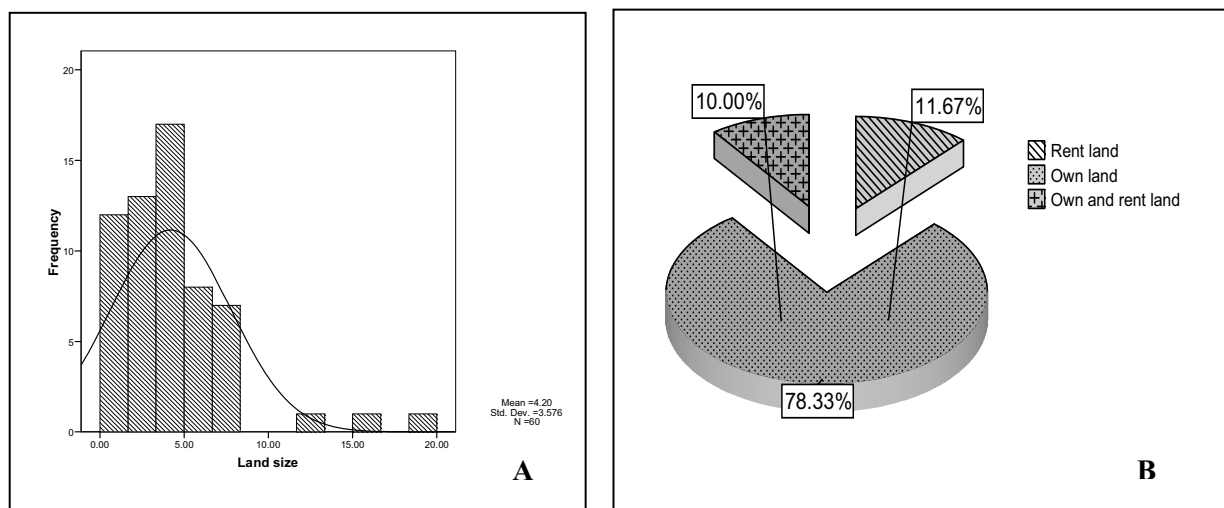


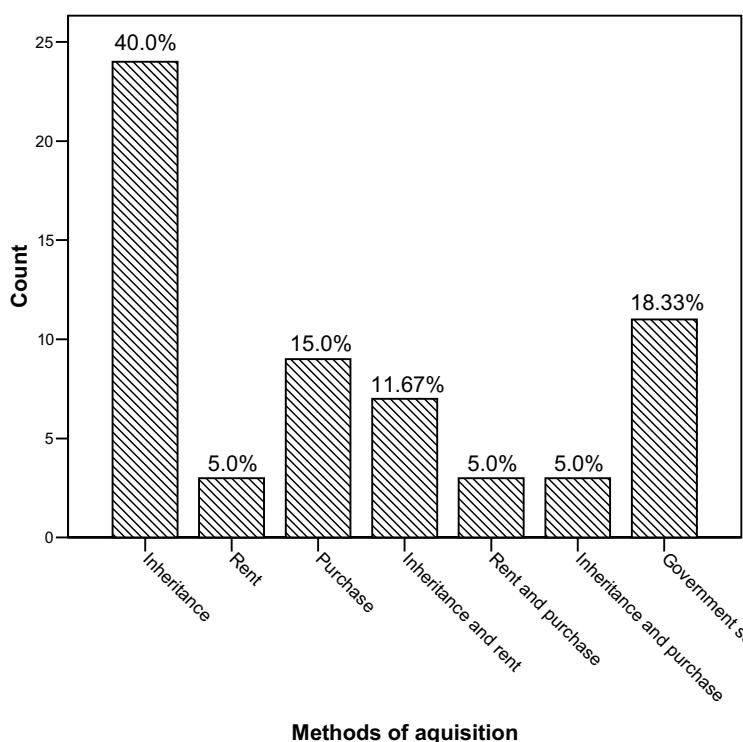
Figure 4.10 Land holding size(A) and land ownership (B) of the respondents
(Source: household survey)

However, there are differences in average land holding size between Murungaru, Mkungi and Geta sub locations. The average land holding in Murungaru is around 6 acres whereas in Mkungi and Geta it is 3.5 and 1.5 acres respectively. One of the reasons for this difference is the size of government settlement scheme. The Murungaru and Mkungi settlement schemes in 1964, allocated land in average

of 40 acres per person. Whereas, the settlement scheme of Geta started in 1968, only allocated 4 acres per person.

In term of status of the land, figure 4.10 (B) shows the distribution of land ownership status for smallholder farmers in middle and upper catchments. The majority of the households (78%) own the land they are living on and 12 percent of the households utilize land through renting. The rest (10%) is those who both own land and also rent land. It is realized that one household can utilize more than one parcel of land within the catchments under the following land tenure: individual owned with and without title deed, borrowed or rented. Those who owned land without title deed is received land through sub division from parents but no individual titles have been issued.

Figure 4.11 shows the methods of acquisition of the land. The majority of the land is acquired through inheritance (40%), followed by government settlement scheme (18%), purchase (15%) and combination of inheritance and renting. The remaining percentage is acquisition through renting, combination of renting and purchasing or inheritance and purchasing. Acquisition through inheritance is the majority in line with the age of smallholder farmers, which is around 49 years old and serves as second generation of the family. In the recent years, not only son but daughter has also started to be given land. Thus, this will lead to even smaller land to be sub divided. Those who rent and buy land are mostly third generation who has not received any land division from their parents or immigrant who come from other areas. The cost of renting land varies between Ksh 800 to 2500 Ksh, with average 1750 Ksh per acre.



Methods of acquisition
Figure 4.11 Methods of Land Acquisition of the Respondents
 (source: household survey)

Figure 4.12 presents sketch map which shows typical household farm in the upper catchment. In a relatively small size of land, the land use is divided into home compound, crops cultivation area, grazing land and on farm agro-forestry.

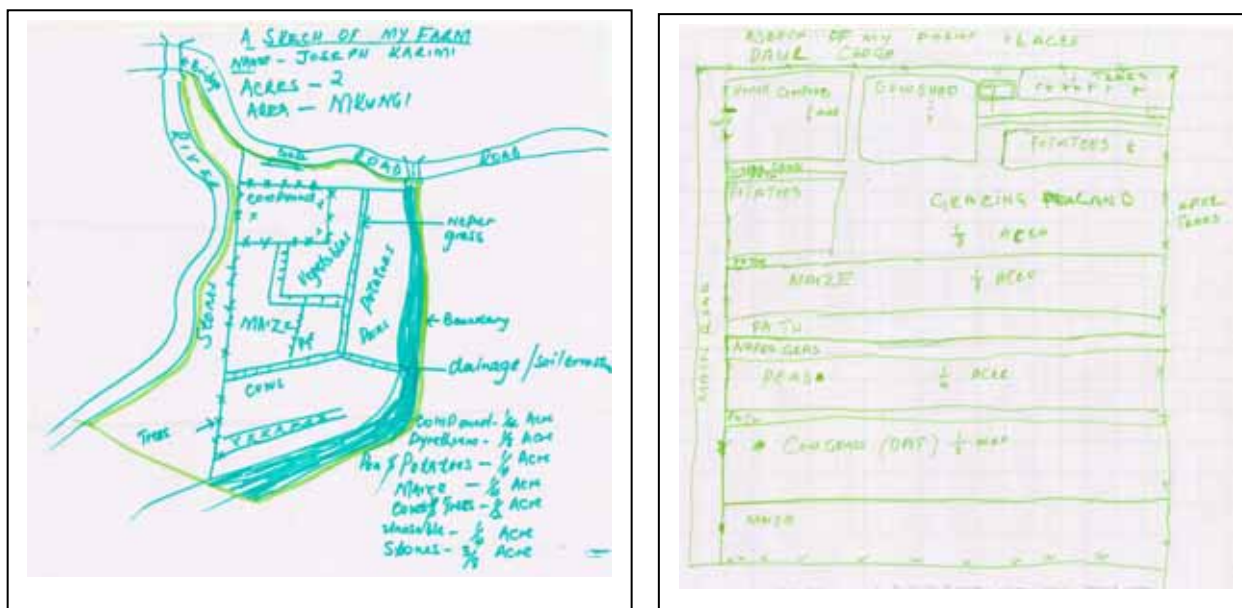


Figure 4.12 Farm sketch map of smallholder farmer

4.2.3. Livestock

Livestock rearing plays important role in the livelihood of smallholder farmers in Geta, Murungaru and Mkuungu. The types of livestock owned by the households are dominated by dairy cattle, sheep and chicken. On average, each household own 3 dairy cattle, 3 sheep and 6 chicken. Murungaru has the highest average of dairy cattle ownership which is 4 cattle whereas Mkuungu and Geta are 3 and 2 respectively. One of the reasons is due to larger land ownership average in Murungaru area compare to Mkuungu and Geta. Forty seven percent of the respondents stated that the number of livestock is decreased compare to ten years ago. Whereas 20 percent said it remains the same and the rest 33 percent said it is increasing. The main reason which forces them to control the number of livestock is due to the lack of land for grazing. Only 10% of respondents practise zero grazing whereas the rest feed the cattle with grazing in the farm. From discussion in Mkuungu area, they were used to be permitted to take the cattle into Geta forest by paying 40 Ksh per cow per month. However, through forest act, now they are permitted to grass freely in certain area if they plant trees as part of forest protection program. The reason for the increase in livestock is due to the good environment in dairy industry.

“ The land is getting smaller and smaller. I only inherited 2 acres from my father and it will be less for my children. We have mix crops and no land can be left fallow. Although the price of milk are getting better, and as much as we want to increase dairy cattle, we have to control the number since there is no land for grazing.” (Source: interview with farmer in Mkuungu)

4.2.4. Marketing channel

Table 4.9 shows various marketing channels and prices of major agriculture product in the area. For crops products, almost 90% of the respondents sell it through brokers/intermediaries and the rest directly to consumers. For milk production, In Murungaru and Mkungi, the majority of milk production is sold through brokers and Muki Sacco cooperative and few directly to processor particularly to KCC and Brookside. In Geta, 55% of milk production is sold through broker and the rest is to Muki Sacco cooperative, directly to consumer and for own consumption consecutively.

Farmers mentioned that selling to intermediaries resulted in low price since they do not have any bargaining position. During the discussion, lack of market for their products and the fluctuation of agriculture price are perceived as one the problems. Based on interview with few brokers, the major market for horticulture products such as potatoes and carrots is Nairobi. Few are selling to Naivasha, Tika and neighbouring market. Although Naivasha is the closest city, they prefer to sell it to Nairobi since it has a bigger market with better price. In early 80's, farmers in Murungaru and Mkungi used to sell their product to food factory called Pan Pasific Board in Naivasha. However, since it collapsed in the end of the 80's, they shifted their marketing channel to brokers. In 2006, food processor factory called Kipipiri Food Ltd was established in Miharati, Kipipiri Division. Still under construction, this factory will produce processed vegetables that will be exported to European countries and a small percentage will be sold locally. This will be a potential market for agriculture products in the surrounding area including for Geta, Mkungi and Murungaru. The local government also express its hope that this factory will create direct employment for 120 workers and indirect employment for over 1000 families through farming activities.

Table 4.9 Marketing channel of agriculture product in Nyandarua district

Produce	Market unit	Market channel	Farm gate price		Remarks
			Low	High	
Milk	Litre	Farmer-processor	10	18	Present processors are KCC, Tuzo, Greenhills, Brookside
		Farmer-broker-processor			
		Farmer-broker-retailer- consumer			
		Farmer-consumer			
Potatoes	110 kg/bag	Farmer-broker-wholesale market-retailers- consumer	400	1000	
Maize	90kg/bag	Farmer-consumer	800	1500	
		Farmer-broker-miller			
Carrots	120kg/bag	Farmer-broker-wholesale	600	1100	
Wheat	90kg/bag	Farmer-miller	1500	1800	
		Farmer-broker-miller			

Source: Nyandarua district office, 2007

In Geta, the construction and improvement of road helped open new market to near by area. Milk buyers now come to the areas. However, for a long time, the road traversing the area has been in a poor state. Although government has improved the road in 2003, still most of the feeder road is not passable during rainy season. Furthermore, mobile phone network which covers the area has also helped some farmers to contact brokers and check market prices. Of the total respondents, 60% of the head of households claimed that they have mobile phone whereas the rest 40% do not have it. In

addition for contacting broker and business clients, the mobile phone is mostly use for communication with member of family who live outside the sub location.

4.2.5. Farming methods

Family labour is more often used than hired labour. Farmers usually hire casual labour during planting and harvesting season. In Murungaru and Mkungi, 70% of respondents use family labour, whereas 30% use family and hired labour. In Geta, 80% use family labour and 20% use family and hired labour. The proportion of using hired labour in Geta is lower than in Murungaru and Mkungi due to smaller land holding average. As can be seen in table 4.10, farmers with more than 6 acres of land tends to use family and hired labour compare to those with less than 6 acres.

Table 4.10 Land holding and labour source

Land holding size	Labour Source (%)	
	Family and hired labour	Family
< 3 acres	18	82
3-6 acres	14	86
> 6 acres	67	33

Source: calculated and analyzed from household survey

The small size of land forces the farmers to practise intensive agriculture and as a result, soil fertility continue to decline. At the end, it leads to the decline of land productivity. This phenomenon can be seen in the case of maize where productivity decreases from 20 bags/ha to 17 bags/ha in the period of 1993 to 2007. The community also confirm the decline of soil fertility and other resources through trend line exercise. The trend lines demonstrate community perspectives over 20 years on changes in resource issues such as land productivity, water availability and deforestation. The exercise was conducted with small groups of farmers in Mkungi and Geta using bean counting. The Table 4.11 shows the result of the exercise on resource trend since 1980s. According to the community, since the first settlement in 1964 to 1970s, soil fertility and land productivity were at their highest potential. However, starting in early 1980s, soil fertility gradually declining due to continuous cultivation and cropping. At that time, there were no conservation measure take place and use of yield enhancing inputs was minimal. In the late 1980's the government start to introduce the use of chemical fertilizer.

Table 4.11 Trend of resources in Geta

	1980	1990	2000	2007
Soil fertility	xxxxxxx	xxxx	xxx	xx
Water	xxxxxxx	xxxxx	xxxx	xxx
Forest	xxxxxxx	xxxxx	xxx	xx

Source: trend line exercise

In terms of agricultural input used by the farmers, in majority, the farmers used combination of chemical fertilizer and manure as can be seen in table 4.12. Almost 60% of respondents stated that they use less chemical fertilizer compare to ten years ago since the price of fertilizer continue to increase, and now they combine it with manure. Fifteen percent of respondents claimed that they did not use chemical fertilizer before and increase the amount due to soil fertility which continues to

decline. Due to the price, only 40% of respondents used pesticides in Murungaru and Mkungi, whereas in Geta only 15%.

Table 4.12 Agriculture input usage of smallholder farmers (in percentage)

	Used of fertilizer	Used of manure	Used of fertilizer and manure	Used of pesticides
Murungaru	20	35	45	40
Mkungi	20	20	60	45
Geta	5	30	65	15

Source: calculated and analyzed from household survey

Table 4.13 shows those who have more cattle tend to use manure. Of those farmers who own less than 5 livestock, 68% use manure whereas those who own more than 5 livestock around than 90% use manure. The use of manure in combination of chemical fertilizer is also one way to overcome the problem of lack of capital to buy agriculture input and limited access to credit facilities as stated by the farmers. At district level, 11 financial institutions available comprise of 4 banks and other financial institution (Nyandarua district office, 2006). However, in contrast to the existence of several financial institutions at district level, only 20 percent of respondents claimed that they have access to credit and the remaining 80% have not. Almost 90% of those who has access are those who live in Mkungi sub location since the access for credit is come from MUKI SACCO cooperative society which is based in Mkungi sub location. However, not all respondents who have access to credit feel benefited due to its high interest (19%) and their fearfulness of risk of debt. The credit is used to buy farm inputs and few cases for family matter purposes.

Table 4.13 Livestock ownership and manure usage

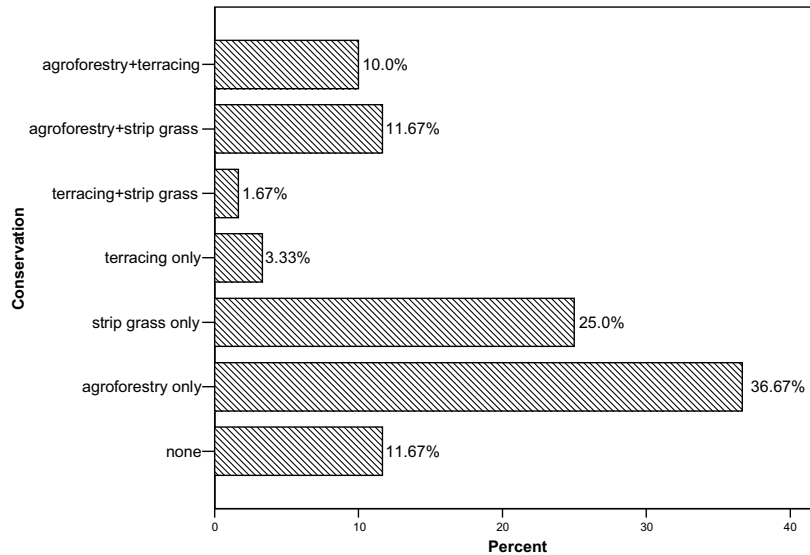
Livestock ownership	Manure usage (%)	
	No use of manure	Use of manure
Less than 5	32	68
Between 5 to 10	5	95
More than 10	9	91

Source: calculated and analyzed from household survey

In addition to the decline of soil fertility, another problem which arises during discussion is erosion in the river bank and steep slope especially in Geta. The introduction of soil and water conservation started in 1983's by agricultural extension officer. At that time, in Geta, the government introduce participatory community catchment approach, which was called *fanya juu* method. *Fanya juu* terraces are made by digging a trench along the contour and throwing the soil uphill to form an embankment. The embankments are stabilized with fodder grasses. The space between the embankments is cultivated. Over time, the *fanya juu* develop into bench terraces. They are useful in semi-arid areas to harvest and conserve water (GTZ, 2006).

Figure 4.13 illustrates current trends of water resource conservation/land conservation methods practised by farmers. Most farmers prefers practise agroforestry by planting beneficial trees such as planting beneficial trees such as gravillia, cypress and caliandra side by side with crops and livestock. Trees such as gravillia and cypress are prominent due to their use in construction, fencing and as timber, while caliandra is grown as livestock feed besides other uses such as firewood. About 37% of

farmers practice agroforestry, followed by strip grass of kikuyu and nymphia, combination of agroforestry and strip grass and agroforestry and terracing. Combination of agroforestry and strip grass is least practiced whereas almost 12% of farmers claimed that they do not practise any conservation methods.



*Figure 4.13 Conservation practise methods by the smallholder farmers
(Source: calculated from household survey)*

5. Livelihood diversification of smallholder farmers

This chapter discusses about livelihood diversification and the drivers of changes in land use and livelihood. It emphasizes on number of sources and distribution of income among those sources which described the diversity of a household's livelihood. Linkages to horticulture industry are also described in this chapter.

5.1. Income diversification of smallholder farmers

Decline of agriculture productivity over the year and the small land size has resulted in unstable income to the farmers. This has forced farmers' household to diversify their livelihood activities. Several livelihood activities were identified in the area and categorized into on-farm, non farm-natural resource based and off farm activities. On farm activities include crop farming, dairy, and agro-forestry. Crop farming and livestock rearing particularly dairy is the main livelihood activities in the upper catchment and practiced by all respondents. Crop farming includes subsistence crops i.e. only for family consumption and cash crop i.e. growing crops for sale to the market. Non farm-natural resource based activities include charcoal, bee keeping and quarrying.

Off farm activities consist of (1) rural based agriculture related (2) rural based non agriculture related, and (3) urban based employment. Off farm activities that belong to the first category are casual labour, wholesalers or intermediaries. They buy agriculture product from the farmers and sell it to nearby city. Activities that belong to second categories is business/shops. Urban based employment through migration conducted by member of family is also identified as one of source of off farm income in the family through remittance. Of the total respondents, almost 50 percent has member of the family who migrate and work in other cities and districts such as Gilgil, Nairobi, Nakuru and Naivasha and only 12 percent are going to Naivasha. Most who migrate are men (the majority are adult son and some are the husband) and only around eight percent are female. From those who migrate, only 40 percent contributes remittances to the family income with relatively small amount.

Figure 5.1 shows the proportion of livelihood activities as the source of income to total income of the households of smallholder farmers. Farming and dairy contributes almost 80% of total income of the households. Off farm and non-farm natural resource based income contributes 15% and 5% respectively.

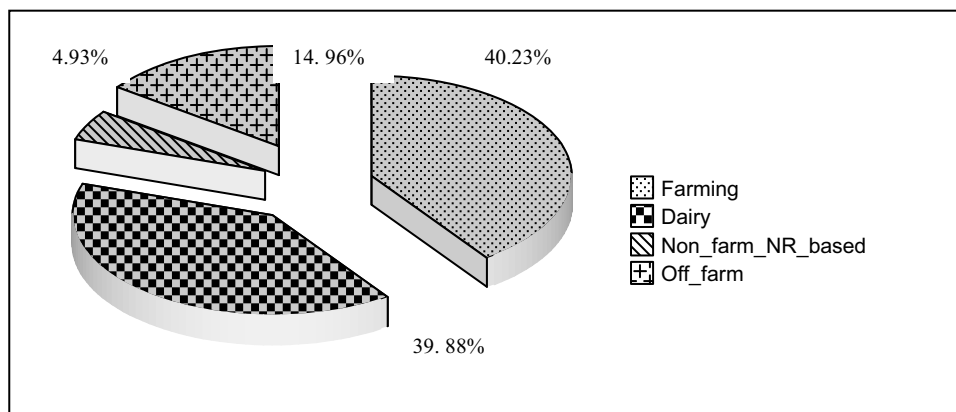


Figure 5.1 Proportion of source of income to total income
(Source: calculated from household survey)

5.2. Livelihood strategies of smallholder farmers

Figure 5.2 shows the combination of livelihood activities of smallholder farmer households which forms their livelihood strategies. From four classified sources of income received by household members i.e. farming includes subsistence and cash cropping, dairy, non farm natural resources and off farm activities, the highest percentage are those who are involved only in farming and dairy (35%). Around 32% of smallholder farmers households combine farming, dairy and off farm activities as their sources of income. Whereas those who do farming, dairy and non farm natural based activities are 23%, followed by households which combine the four categories as their livelihood strategies.

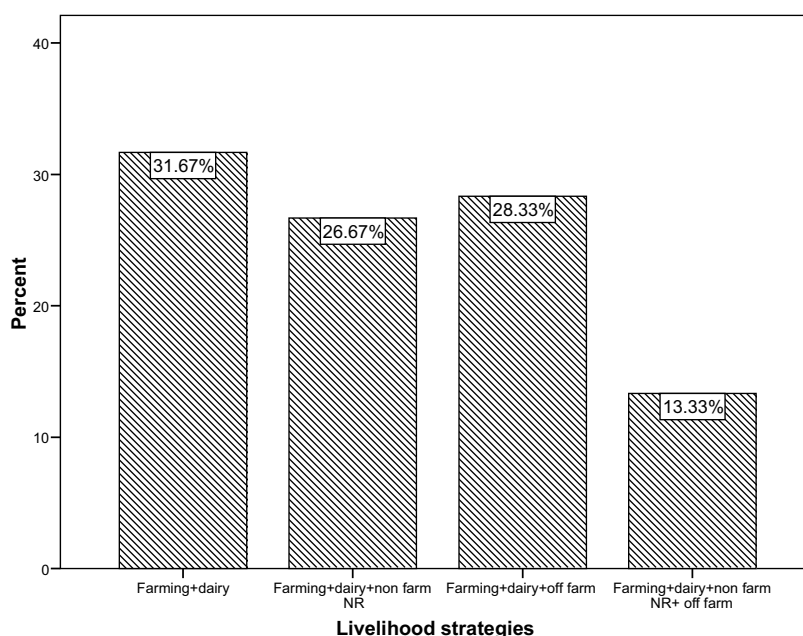


Figure 5.2 Livelihood strategies of the Respondents
(Source: calculated from household survey)

Table 5.1 shows the differences of livelihood strategies in three sub locations. In the middle catchments (Murungaru sub location), combination of farming and dairy is the highest percentage of source of income for the household, whereas those who combine farming and dairy with non farm

natural resource and off farm activities have a similar percentage. This indicates that in Murungaru sub location, farming and dairy activities alone may have been sufficient for their livelihood since the average land holding in the area is higher than in Mkungi and Geta sub locations. In addition, as Murungaru location is closer to urban area such as Naivasha and Nairobi, it gives them better profit due to lower transportation costs. In Murungaru the price of milk reaches 17 ksh/kg whereas in Geta the average is only 14 ksh/kg.

Table 5.1 Livelihood strategies in three sub location (in percentage)

Livelihood strategies	Murungaru	Mkungi	Geta
Farm+dairy	12	8	10
Farm+ dairy+non farm –NR based	10	7	10
Farm+dairy+off farm	10	12	7
Farm+dairy+non farm-NR based+off farm	0	7	7

Source: calculated from household survey

In Mkungi sub location which is located between the middle and upper catchments, the highest percentage is combination of farming, dairy and off farm activities. Off farm activities in the area includes business (shop) and remittances brought by member of family through urban employment migration. Mkungi is located nearby Nduyu Njeru, the location capital. Thus, many people open shops in Nduyu Njeru market. It should also be noted that in Mkungi sub location there is quarrying activity which plays important role in non farm natural resource based activities. The quarries started in 1984 and the number continues to increase compare to ten years ago from four quarries to seven quarries. This also attracts workers from other sub locations. The farmers form a group which consists of six to seven members where they work together and divided the profit among themselves, in average around 15000 KSH per month.

John Ngeroge, a 42 years old, started to work in quarry since 1987. For his family, the quarry contributes 70% of total income in the household. The income from quarry also helped him in buying more land for farming, livestock for dairy and farm inputs. Since he has to work 10 hours a day in quarry, he hires casual labour to help his wife in the farm. For him, the existence of quarry has greatly contributed in improving his family income. (Source: farmer interview in Mkungi)

In Geta, combination of farming, dairy and farming, dairy and non-farm natural resource contributes equally to total income, followed by combination of farming, dairy, off-farm and farming, dairy, non-farm natural resource based and off-farm. A smaller land holding size and population pressure in Geta sub location encouraged farmers to seek sources of income other than farming and dairy, such as casual labour, shops and urban migration for work. Urban migration for employment becomes an alternative for young generation since there are limited job opportunities available in the area.

Aida Wangoi is a 42 years old single mother of 5 children. She inherited 1 acre of land from her father in 1998. However, income from farming alone is not sufficient to feed her family. She then started dairy farming in 2000 and her children started to work as casual labor and broker in Geta, and one of her sons also moved to Nairobi to work there. From the family saving, she opened a duka (shop) in 2005 at Geta shopping centre. This helped them improved their income. (Source: farmer interview in Geta).

5.3. Livelihood diversification of smallholder farmers

Since 1980 to the present, there are changes in the importance of income sources in the community as can be seen in Table 5.2. In 1980s charcoal was considered to be the most important source of income for the community. Dairy, timber and pyrethrum also played an important role as source of income at that time. During 1990s period, dairy and crop farming became the main source of income followed by pyrethrum in early 90s, while charcoal contribution started to decline. In that period timber continue to play an important role for household income. The price of timber was increasing and supply of trees came not only from forest but also from farms as result of tree planting in 1970-1980. Around mid 90's was considered to be bad year by the community along with the decline of national economy. Agriculture products prices went down and when KCC, the major milk processor collapsed, dairy farming also decreased. In addition, Kenya Pyrethrum Board also collapsed and resulted in uprooting of pyrethrum.

Table 5.2 Rank of importance of major source of income

Sources of income	1980	1990	2000	2007
On farm				
- Crop farming	4	1	2	1
- Dairy	3	2	1	1
- Pyrethrum	3	4	-	-
- Agro-forestry	2	3	3	4
Non farm-NR Based				
- Charcoal	1	3	5	-
- Bee keeping	3	4	5	5
Off farm	5	5	4	3

Source: trend line discussion and interview

In 2000s, the role of non farm-natural resource based (forest based) activities started to decline as a result of the issued of forest act. In contrast, dairy started to increase again after new government policy which stabilized the price of milk and reviving KCC. New buyers also entered which increased competition and gave farmers better price. Off farm activities are also continue to increase since 1990s as a result of population increase where second and third generation start to mature whereas land for farming is limited. In 2003, the new government also improved the main road and provided electricity in the market centre. As a result, in Geta, the place started to open and number of buyers and distributors from neighbouring area such as Naivasha, Nyahururu and Nakuru increased. The provision of electricity also creates new type of shops such as photocopy, computer rental and school and hand phone charger.

After the road improved in 2002 and electricity came last year, this place started to open and many new shops emerged. However, this increased the competition among us. Compare to before 2002, the profit for the shops is decreasing. (Source: farmer interview in Geta)

Since 2005, government and NGO's promote new income generating activities using group approach. In the three sub locations, several self help groups were established due to intervention of government project and NGOs. In 2005-2006, Murungaru was selected as one of focal area for National Agriculture and Livestock Extension Program (NALEP). Through this project, 22 common interest group (CIG) was established such as group on dairy cattle production, sheep production, dairy goat

development, horticulture production, bee keeping and commercial trees fruit seedling production. In Mkungu, tree nursery groups were established as part of NGO intervention to create income generating activity as well as to protect the environment. Due to its problem complexity with smaller land size and high population density compare to other location, Geta has been a target for many government project and NGOs. In 2006, Kenya Agriculture Productivity Product (KAPP) project selected Geta as one of its pilot project which aims at increasing productivity. Through this project 10 self help groups were established in the area of dairy, sheep, snow peas, potatoes, cut flower, dairy goat production, potatoes, agro forestry and bee keeping. In addition to groups influenced by government or NGO projects; there are several community initiative groups such as those in Murungaru area which aimed at creating new income generating activities.

MUSTRA group (small scale traders) was established in 2002, initiated by Francis Kariuki, a young farmer in Murungaru sub location. He initiated the group after coming back from Nairobi and working as casual labourer in the area. Realizing it is difficult to find jobs and also because they had no land to farm, he and his young friends formed the MUSTRA group to help them improve their income. Each member pays a membership fee for 100 ksh per day. These money is use to give loan to the members who want to do business such as opening shop or pay for dowry price for those who are about to get marry. In addition, the collected money also used to sell seeds of potatoes, maize and carrots in which the profit received goes to the group and divided among its members. (Source: group interview in Murungaru)

5.4. Drivers of Changes

Table 5.3 summaries the changes in land use/farming system and livelihood and what factors have influenced the changes. The sources of information for the analysis, are the timelines, trend lines of the villages, field observation, interviews, questionnaires, sketch map discussion, result from land cover analysis and references. Driving factors of the changes are identified and broadly categorized by the researcher into four categories which are demographic shifts, environmental trends, changes in national and regional economy, and policies of national development.

Table 5.3 Drivers of changes in land use/farming system and livelihood

Drivers of change	Impact on land use/farming system and livelihood	Evidence
<i>1. Demographic Shifts</i>		
- Increase of population growth	- Smaller land size holding due to land division	Questionnaires, interview, reference
- Increase in population density	- Increase in cultivation land	Skech map discussion, land cover analysis
	- Encroachment into forest for agriculture land	Interview, reference
	- Grazing area reduced	Trend line and sketch map discussion, land cover analysis
	- Introduction of zero grazing	Interview
	- Off farm activities increase	Interview
	- Decline in soil fertility	Trend line, Interview
- Out-migration opportunities	- Members of family working outside the areas increase	Questionnaires, interview

Drivers of change	Impact on land use/farming system and livelihood	Evidence
<i>2. Environmental Trends</i>		
- Increasing weather variability	- Start to plant maize in some parts of Geta location instead of potatoes - Eucalyptus is reduced (absorbs too much water) - Introduction of drought tolerant crops (sweet potatoes)	Interview, field observation Interview Interview, reference
- Trend on decline of soil fertility	- Introduction of use of fertilizer and manure - Introduction of community based land and water conservation (fanya juu terracing) - Introduction of kikuyu grass	Time line, trend line, interview Time line, reference Time line, reference
<i>3. Changes in National & Regional Economy</i>		
- Export opportunities	- Introduction of fruit trees (plum, apples) - Introduction of cut flower - Introduction of snow peas - Expansion of small and large-scale cut flower industry to the upper catchment by private company	Interview, time line Interview, time line Interview, time line Interview
- Collapse of KCC - Policy on milk prices and milk powder import ban - Collapse of Pyrethrum board - Collapse of Pan Pacific food processing factory in Lake Naivasha - High price of timber	- Shifting of milk marketing channel to broker - Dairy farming revived - Pyrethrum crops decrease - Shifting of vegetable marketing channels to broker - Deforestation through commercial logging	Interview, time line Interview, time line, reference Time line, reference Time line Interview
<i>4. Policies of national development</i>		
- Road and electricity provision by local government	- New types of shops open	Interview
- Government project - New technology by Ministry of Livestock - Establishment of electric fencing of Aberdares NP by Kenya Wildlife Service, Friends of Lake Naivasha and government - Forest Act in 2002	- New market for agriculture products - New income generating activities - Introduction of artificial insemination - Access to forest is restricted - Shamba system stopped - Shift from fuelwood to paraffin as firewood supply from forest decreases	Interview Interview Time line Interview Time line, reference Interview
- Green Belt Movement (nation-side NGO)	- On farm agroforestry restarted	Interview
- WWF project	- Charcoal burning reduced - Tree nurseries introduced	Trend line Interview

Source: derived and analyzed from various sources

1. Demography

During the early stages of development, increased population generally led to expansion in cultivated area and in many cases resulted in conflict between different users of land and water resources (Dillon, 2001). Nyandarua district is the largest district in Central Province, occupying an area of 3,304 km². Moreover it is the least densely populated in the province. Figure 5.3 shows the district population based on 1979, 1989, 1999 census and its projection up to 2010. As can be seen from the figure, the total population shows an increasing trend. In 1979, the total population was 233,000 and in 1999 it has reached 479,902. By 2002, the total population was around 529,844 and according to district development plan, it continues to grow at the rate of 3.3 percent. This mean by the year of 2008, it has reached 645,859. Moreover, population density increases from 66 person per km² in 1979, to 102 and 145 person per km² in 1989 and 1999 respectively. This phenomenal growth rate can partly be attributed to internal migration from the neighbouring districts (Nyandarua District Office, 2001). It is suffices to note that its population has doubled in the last two decades resulting increased pressure on land resources.

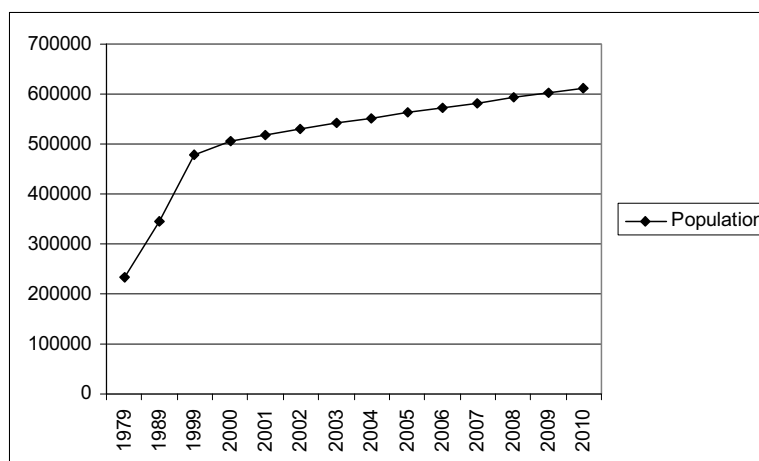


Figure 5.3 Nyandarua district population and projection 1979-2010
(Source: Nyandarua District Office, 2001)

The increase of population in the upper catchment leads to smaller land holding in each generation due to land division. The settlement scheme provided farmers with on average of 4 to 40 acres and due to land division, it decreased to 1.5 to 6 acres per farmers. In addition, as most good quality land is already exploited, the farmers tend to intensification of farming system which resulted in environmental problems such as decline of soil fertility. In addition, lack of land for cultivation areas leads to encroachment into the forest and converting grass land into cultivation and settlement area. Hence, the community requires controlling the number of their livestock. The government now promotes zero grazing to overcome the problem and increase productivity of livestock.

Table 5.4 Population projection of selected age groups

Age group	1999		2002		2004		2006		2008	
	M	F	M	F	M	F	M	F	M	F
6-14	58893	55963	65022	61787	69458	66002	74197	70506	79259	75316
15-64	115145	126766	127128	139958	135801	149507	145066	159707	154964	170604

Source: Nyandarua District Office, 2001

Table 5.4 shows population projection based on selected age groups. As the population continues to increase, labour force (age 15-64) is also increasing. In 2008, it is estimated that the labour force groups reach 325,568. This indicates that the percentage of the district's potential labour force to total population is approximately 50%. The high population of females to males will also mean that females provide labour at the farm levels while males may go out of the district in search of off farm employment. High population pressure is often seen as push factor leading to temporary and permanent out-migration in line with adaptation to farming system (Reardon, 1997). Most of the labour force is unskilled leading to high rates of disguised employment in the farms. As land is also decreasing, male population tends to search for off farm activities within or out of the area. As a result, off farm activities such as shops and broker or intermediaries of agriculture product in the area is increasing. However, the high rate of unemployment, force majority of them to migrate and find work outside the area (see 5.1)

2. Environment Trends

The interaction of natural resources and climate determine the physical basis for farming system. Many evidences suggest that impacts from global climate change will be significant. Average global surface temperature is expected to rise and the frequency of climatic extremes (temperature, rainfall) is expected to increase dramatically. Unpredictable weather and rainfall variability are also one of the problems perceived by the farmers. Moreover, warmer temperature also affect the type of crops. In Geta, farmers start to plant maize is some part of sub location. Before, it was impossible to plant the crop due to low temperature. This partly contributes to increase of maize area. Figure 5.4 describes the pattern of annual rainfall from 1964 to 2004 in the area. There was sharp decline of rainfall in mid 1990s in the district area. Hence, drought tolerant crops such as sweet potatoes were also introduced. However, the rainfall start to increase again but the variability seems to be bigger.

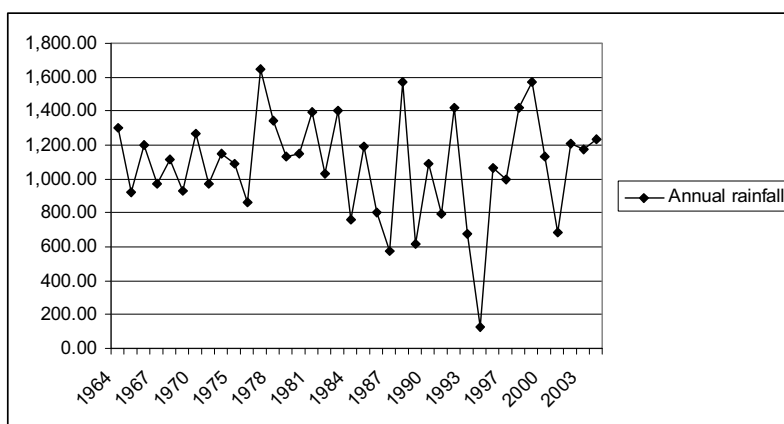


Figure 5.4 Annual rainfall 1964-2004 at Geta forest station
(Source: Naivasha ITC database)

At micro level, long term changes of trend in environmental degradation such as decline of soil fertility and erosion occurring in the areas can be both the effect and a driver of changes. Decline of soil fertility and erosion acts as drivers of change in term of conservation practices. The farmers started to use a combination of chemical fertilizer and manure instead of only chemical fertilizer. The use of manure also related to the increase in dairy industry. Kikuyu grass was also introduced in Geta

sub location as one of the means for conservation practices. In addition, government also promote community based soil and water conservation system called fanya juu.

3. Changes in National and Regional Economy

International, national and regional economic factors in term of trade liberalization and market development have critical role in agriculture development as they form influences on farms, rural and urban economies. The process of trade liberalization and market development is generating changes at all levels, including smallholder farming system in developing country (Dillon et al, 2001). Patterns of production and natural resource usage are also changing in response to market forces.

In the upper catchment, high demand for timber from outside the area has increased the price of timber which made it one of important source of income and drove the farmers to seek timber (illegally) from the forest. This was one of the causes of deforestation in the area. Another change influenced by national economic factors is the introduction of snow peas, fruit trees and cut flowers. Those products were introduced due to their high value with export potential. In Geta, KAPP project under the Ministry of Agriculture promotes the commodities through self help groups. This project also links the groups with the buyers from horticulture industry in Naivasha. Cut flowers were previously introduced by a private company. However due to late payment from the company, the community lost their interest in cut flower. Private companies also start to expand their farm into the upper catchment. Recently, in Mkungi and Murungaru, three large scale horticulture farms with average 40 acres were established (see chapter 4). Market changes such as collapse of agro-industry influence changes in marketing channel. Pan Pacific food processing factory was one of vegetables factory in Lake Naivasha. The factory collapsed in around 80's and as a result, farmers shifted their marketing channel to brokers.

National economic conditions also played part in driving the changes in livelihood. From 1991 to 1993, Kenya had its worst economic performance since independence. Growth in GDP stagnated, and agricultural production shrank at an annual rate of 3.9%. Inflation reached a record 100% in August 1993, and the government's budget deficit was over 10% of GDP. As a result, many industries collapsed, including KCC and Kenya Pyrethrum Board. This also affected the upper catchments in terms of decrease of dairy farming and uprooting of pyrethrum. However, in 2003, the government banned the import of milk powder and set a minimum price of milk at farmer's level. Hence, dairy farming is increasing. As can be seen in figure 5.9, since 2003 there is a sharp increase in milk production in Kenya due to the policy. The revival of KCC, as one of major processor and market for milk production also helped the increase of dairy farming activities in the upper catchments.

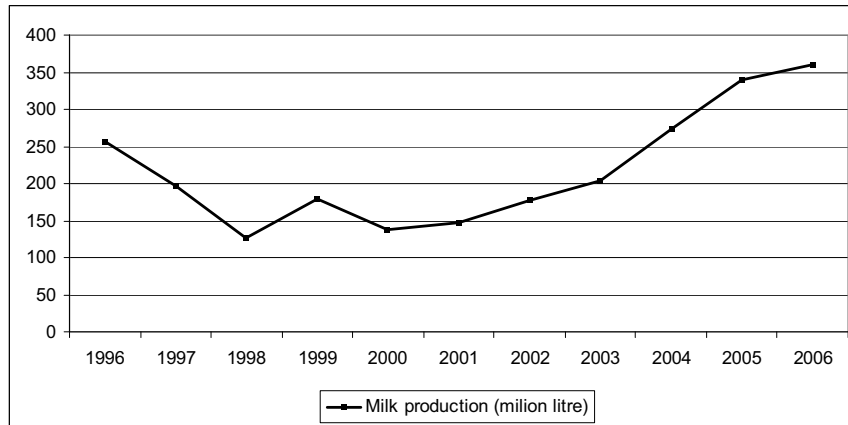


Figure 5.5 Milk production in Kenya 1996-2006
(National Bureau of Statistics, 2007)

4. Policies for National Development

The development of farming system requires a conducive policy environment. Thus, policy for national development plays important role on the livelihood sources of the community. Provision of road and electricity creates new markets and new types of shops. In Geta sub location, new market opportunities for agriculture products came as road was improved. Previously, the products were only sold locally and to nearby neighbourhood. Now they can access up to the Nairobi markets. This could get better returns in a competitive environment. Various types of shops also developed such as photocopy, mobile phone charger, beauty salon, and many others which require electricity.

Policy on forestry management influences changes occurring in the forest and to livelihood. The banning of the *shamba* system in 2002, and government and NGO's initiatives to encourage farmers to take up farm agro-forestry. This resulted in the slower rate of forest reduction in 1995-2007 periods. In addition, non farm – natural resource based activities were also declining. There are also shift from charcoal as source of income. In Geta sub location, up to the 90's charcoal plays important role as source of income. However, as the entry to forest were getting harder, and supply of trees decrease, the role of charcoal continue to decrease. The main purpose of agroforestry is for fuelwood and some for timber. Some respondents also stated that since fuelwood is not as easy to get as before, they've started to use paraffin for fuel.

One of the problems faced by the community in Geta and Mkungi sub location is wildlife animal menace (elephant) especially on those who live nearby forest. In order to minimize the conflict between wildlife and human, electric fence was built around the Aberdare National Forest in 2007 by Kenya Wildlife Service. Friends of Lake Naivasha contributed the fund and later on, the government also added fund to this project. It is expected that the fence will reduce illegal encroachment to the forest and reduce elephant menace. Since the program was just started when the research conducted, significant changes are still difficult to confirm. However, from the interview, the respondents stated that elephant damage to crops has reduced compared to the previous year.

5.5. Linkages to horticulture industry

From the results of the field surveys, questionnaires, group interviews and trend lines, the existence of horticulture industry in Lake Naivasha does not seem to contribute much to the livelihood of the people in the upper catchments. Although key informants from ITC expected that it would create new job opportunities for farmers, of the total respondents, only five percent stated that they have members of their family working in the horticulture sector in Lake Naivasha. Most of them are unwilling to go due to the different environmental condition between the Lake and the upper catchments which made them feel uncomfortable working in the industry especially due to temperature and the noise. Moreover, past experience of those who had worked in the industry created a bad impression on the people such as illness as a result of working with chemical inputs. In contrast, those who are willing to go, face difficulty in competing with other workers from other areas due to lack of education. Most farmers also believed that the horticulture industry contributed to the air pollution due to airplanes which are used by the horticulture industry people. Local respondents in the field study stated that the air pollution affected the rainfall variability in the upper catchment.

Lake Naivasha was also expected to create a market for horticulture products from the upper catchments. There is high demand for food supply due to the increase in population around the lake from the workers in horticulture industry. However, not many agriculture products sell to Naivasha market. Most of the products are sold to wholesale market in Nairobi which gives them better price

In the future however, the role of horticulture industry in the upper catchments is likely to increase. There is a tendency of expanding horticulture industry to the upper catchment. Recently, in Mkungi areas, some private company bought 40 acre of land to expand their cut flower farm. This will create job opportunities for the community. However, the environment impact of this expansion should also be taken into account. Other opportunities in linking the upper catchments and Lake Naivasha horticulture industry is through partnership in cut flower farming between the farmers in the upper catchment and the companies in the Lake. The company provides the seeds and later on buys the products. In Geta, this kind of partnership started to reintroduce again with the government acting as intermediaries. In the past, a private company from Lake Naivasha also used this system without government involvement. This did not last due to the delay of payment from the company. Therefore, in order to make the partnership work, it is important to make sure that the farmers have a bargaining position such as official contract with the company.

Furthermore, in term of environment as many downstream communities including horticulture industry concerned, smallholder farmer's use less agrochemical fertilizer and pesticides. Smallholder farmers also conduct water resource/land conservation through agro-forestry and strip grass. Although there is no evidence yet of how effective these practises in influencing the quality and quantity of water arrived at the Lake, however this shows that smallholder farmers also conduct conservation practise.

6. Conclusion and recommendation

This chapter presents the conclusions from the results and discussion. Recommendations for further study are also presented.

6.1. Conclusion

Based on the result obtained and their analyses, the following conclusions are drawn:

1. The dominant land use/farming system in the area is mixed farming of subsistence and cash crops particularly horticulture crops, maize and wheat, grazing land, agro-forestry and forest reserve.
2. The most significant changes in land cover/land use are the increase of cultivation area at the expense of grass land, forest and woodland.
3. Changes in the type of crops have also occurred. Pyrethrum is decreasing whereas high value commodities such as cut flowers and snow peas were introduced. Due to climate change, maize is also introduced in Geta. In addition, changes also occurred in the type of trees such as the decrease of Eucalyptus.
4. Smallholder farmers are characterized by small land holding size due to land division. Land acquisition is predominantly through inheritance. Livestock plays important role in the livelihood of smallholder farmers due to dairy activities. The dominant marketing channel is from farmer to broker/intermediaries. In addition, not many farmers have access to credit facilities. Family labour is more often used than hired labour.
5. Intensive agriculture due to shortage of land resulted in decline in soil fertility thus leading to decline in land productivity. Combinations of fertilizer and manure are mostly used to increase land productivity. The use of manure is in line with livestock ownership. However, the decrease in grass land requires community to control number of livestock. In addition, agro-forestry and strip grass are the main soil and water conservation practiced by smallholder farmers.
6. Livelihood activities are categorized into on-farm, non-farm-natural resource based and off farm activities. Crop farming and dairy is the main livelihood activities. Over time, non farm natural resource based activities (charcoal and bee keeping) declining whereas off farm activities increase. There are also tendencies of increase in off farm activities and out migration to neighbouring districts and cities for job opportunities by members of families. The combination of livelihood activities is different in the three sub locations due to the different in land size holding and the location of the area.
7. The drivers of changes in land use/farming system and livelihood includes demography shift (population growth, population density and out migration opportunities), environmental trends (increasing weather variability and trend on decline of soil fertility), changes in national and regional economy (export opportunities, decline in national economy which resulted the collapsed of agro-industry, policy on milk prices), and policies of national

development (road and electricity provision, forest regulation, government and NGO intervention).

8. The existence of horticulture industry in Lake Naivasha does not seem to contribute much to the livelihood of the people in the upper catchments. In the future however, the role of horticulture industry in the upper catchments is likely to increase. There is a tendency of expanding horticulture industry to the upper catchments.
9. In capturing the changes, satellite images, sketch maps and historical timelines and trend lines have been used. All the methods contribute to the overall findings, but each of them has methodological problems, Due to the complexity in land cover types, it is difficult to assess changes using middle (30 m) resolution images at sub location level. The sketch map provides an overview of village land uses and resources, but unfortunately, it is without scale and is based on people's perception only. In addition, the community does not seem to be able to capture details changes in the village land use as a whole but they were more able to changes within they own farm. Language barriers also create an information bias.

6.2. Recommendation

In view of the conclusions drawn, the following suggestions are made:

1. More detail livelihood studies such as the income, household expenditure and its effect on natural resources; relationship between livelihood diversification and poverty level have not been analyzed. There is a need to undertake research on this issue for further development intervention.
2. A follow up research on finer resolution satellite imagery in order to achieve mapping at detailed level will enhance inventory of land resources for planning and monitoring purposes.

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APPENDICES

APPENDIX 1

a. Historical Timeline for Geta

Time	Events	Remarks
Before 1968	<ul style="list-style-type: none"> Forested areas, high soil fertility, high rainfall, plenty supply of wood, no infrastructure 	
1968	<ul style="list-style-type: none"> Government policy to settle those who can not be accommodated in earlier scheme Land sub-divided into 4 acre portions under SFT programme. Freehold titled issued 	
1970	<ul style="list-style-type: none"> 8000 acres of Geta forest cleared to give way for cultivation and settlement for 2000 households First primary school in Geta centre Pyrethrum cash crop was introduced Forest forest cooperative is established for marketing of pyrethrum Road linking to Wanjohi was constructed Shopping centre at Geta center established Introduced of kikuyu grass since there was no grass in the forest 	<ul style="list-style-type: none"> Main crops: Potatoes, cabbage, carrots, plums, groundnuts, peas, onion and kales Other source of income: charcoal, fuel wood
1970-1972	<ul style="list-style-type: none"> Severe famine caused by frost and too much rain 	
1975	<ul style="list-style-type: none"> Government reconstructed the road which opened up the marketing of potatoes, kales, carrots Introduced dairy cattle 	<ul style="list-style-type: none"> Soil fertility started to decline
1978	<ul style="list-style-type: none"> Fruit trees such as plums, pears and apples were introduced 	
1979	<ul style="list-style-type: none"> Extension staffs were posted in the area Introduction of use of fertilizer Charcoal burning has reduced hence shift in income sources to crop production 	<ul style="list-style-type: none"> The cost of fertilizer prohibited by many
1980	<ul style="list-style-type: none"> Pyrethrum production reduced as pasture was introduced for dairy cattle 	
1982	<ul style="list-style-type: none"> Regulation against felling of indigenous and other trees including charcoal burning Delays in payment for pyrethrum and as a result pyrethrum is uprooted 	
1983	<ul style="list-style-type: none"> Invasion of upper catchments in search of timber, fuel wood and land for cultivation Commercial logging Community based soil and water conservation was introduced (fanya juu) 	<ul style="list-style-type: none"> Land degradation accelerated through commercial logging Increase in population putting pressure on the existing space for food production
1989-1990	<ul style="list-style-type: none"> Introduction to carnation flowers and alstroemelia but lacked of reliable market Due to delays in milk payments and loan default by member, cooperative society was weakened 	
1994	<ul style="list-style-type: none"> Introduction of Erygium standard flower 	
1993	<ul style="list-style-type: none"> Liberalization of economic which resulted break down of cooperative society and evolvement of self help groups and informal groups 	<ul style="list-style-type: none"> Milk and agriculture price decline
1998	<ul style="list-style-type: none"> Excess rainfall due to El Nino resulted in road and crops damage Introduction to cut flower by private company from Lake Naivasha 	

Time	Events	Remarks
2001-2002	<ul style="list-style-type: none"> Farmers lost interest in cut flowers due to lack of payment from the company Grading and murmuring of Geta-Wanjohi road, open more market for agriculture product Forest act was issued, prohibited people to go inside forest 	<ul style="list-style-type: none"> Due to forest act, people start to plant trees again in the farm for firewood and timber Started to use paraffin for fuel
2003-2004	<ul style="list-style-type: none"> Introduction of snow peas in the area Government policy to stop milk powder import and set up minimum price of milk 	<ul style="list-style-type: none"> Milk price increase
2006	<ul style="list-style-type: none"> KAPP project of Ministry of Agriculture started and formed self help groups 	<ul style="list-style-type: none"> Cut flower reintroduced
2007	<ul style="list-style-type: none"> Provision of electricity Electric fence is built around the forest to stop encroachment, illegal logging and animal manace 	<ul style="list-style-type: none"> New types of shops open due to electricity such as fotocopy, handphone charger etc

b. Historical Timeline for Murungaru

Time	Events	Remarks
Before 1964	<ul style="list-style-type: none"> White highlands specializing in the wheat farming, dairy and sheep production by large scale European farmers. 	
1964	<ul style="list-style-type: none"> Land demarcation, land subdivided into between 14 – 100acres Free hold title issued 	<ul style="list-style-type: none"> Source of income: farming and dairy Type of crops: wheat, irish potatoes, beans, peas, maize, pyrethrum
1964-1970	<ul style="list-style-type: none"> Started planting trees 	<ul style="list-style-type: none"> Type of trees: cypress, eucalyptus, pines, fruits
1974	<ul style="list-style-type: none"> Started planting wheat and barley for Kenya Breweries 	<ul style="list-style-type: none"> Major land use: grassland, wheat, dairy farming, barley
1978	<ul style="list-style-type: none"> Illegal logging began , permits issued indiscriminately for logging for commercial purposes Wheat and barley reduced since Kenya Breweries collapse 	<ul style="list-style-type: none"> Protection rules relaxed resulting in uncontrolled logging Charcoal as important source of income
1983	<ul style="list-style-type: none"> Pyrethrum board of Kenya collapse, pyrethrum uprooted 	
1993	<ul style="list-style-type: none"> Liberalization of economic KCC (milk processor in Naivasha) collapse 	<ul style="list-style-type: none"> After KCC collapse, sell milk to broker, milk price decline
1980 – 2007	<ul style="list-style-type: none"> Lowered food production 	<ul style="list-style-type: none"> High cost of fertilizer prohibitive for most of the people. Reduced farm sizes due to population increase.
2000	<ul style="list-style-type: none"> Started to plant wheat and barley again 	
2003	<ul style="list-style-type: none"> New government, price of agriculture products improve including milk price KCC is revived 	<ul style="list-style-type: none"> Dairy farming increasing
2005-2006	<ul style="list-style-type: none"> NALEP project introduce, self help groups is formed NGO Friends of Kinangop introduce wool spinning and other income generating activities 	<ul style="list-style-type: none"> Introduction to fruits growing, goat milk, wool spinning, bee keeping, organic farming

c. Historical Timeline for Mkungi

Time	Events	Remarks
1964	<ul style="list-style-type: none"> Settlement scheme by GOK, farmers settled on farms on parcels of between 7 – 40 acres. Freehold titles issued to those who completed payment for the agricultural plots while leasehold titles for commercial plots in market centres. Start planting trees Forest under strict protection. 	<ul style="list-style-type: none"> Reliable rainfall, forests as yet unexploited due to the protection maintained by the government Start livestock rearing Type of crops: potatoes, cabbages, peas, pyrethrum
1983	<ul style="list-style-type: none"> Stop planting pyrethrum due to delay payment from Pyrethrum board of Kenya Start planting carrots for Pan Pasific factory in Naivasha 	<ul style="list-style-type: none"> Less income after pyrethrum uprooting
1985	<ul style="list-style-type: none"> Forest workers evicted from the forest, settled on small parcels but invaded the forest for cultivation <i>Shamba</i> system introduced–system was practiced, purchased small parcels around the forest edges and settled. However illegal cultivation in the forests continued. 	
1987	<ul style="list-style-type: none"> Pan pacific factory closed, change to other market through broker 	
1994	<ul style="list-style-type: none"> Mild drought 	<ul style="list-style-type: none"> Crops production decrease
1998	<ul style="list-style-type: none"> Excess rainfall due to El Nino 	<ul style="list-style-type: none">
2002	<ul style="list-style-type: none"> <i>Shamba</i> system stopped 	<ul style="list-style-type: none"> Erratic logging still persists
2003	<ul style="list-style-type: none"> Improvement in milk prices 	<ul style="list-style-type: none"> Dairy farming increasing
2007	<ul style="list-style-type: none"> Electric fence is built around the forest to stop encroachment, illegal logging and animal menace 	

Historical Timeline for Mkungi

APPENDIX 2

Transect walk

	Murungaru	Mkungu	Geta
Soil type	Light grey	Rock, light grey, rich volcanic	Brown clay, rich forest
Land cover	Shrubs, grass, planted trees, mixed farming (maize, wheat) pyrethrum	Grass, planted trees, mixed farming (maize, potatoes, cabbages, carrots)	Horticulture (vegetables and fruit), grass, forest
Water resources (rivers)	Turasha	Mkungu, Kinja	Wanjohi, Gathuthi, Kamunju
Land use	Livestock farming, Mixed farming (maize, potatoes, wheat), market	Mixed farming, livestock farming, market, forestry	Forestry, horticulture farming (vegetables, fruit), livestock farming
Land tenure	Title deed, renting	Title deed, renting, private ownership	Title deed, renting
Socio economic factors	Poor settlement, no electricity, no water pipe	Middle class settlement, quarrying activities	Developed market center, poor settlement
NRM issues	Erosion in the river banks, decrease land productivity	Frost and wildlife menace, lack of grazing area	Small land holding, steep slope and susceptible to erosion, decrease land productivity

APPENDIX 3

a. Murungaru Sketch Map



b. Mkungu (A) and Geta (B) Sketch Map

