LAND USE CHANGES IN THE LAKE NAKURU CATCHMENT:-*Implications on Environmental Planning and Management.*

By

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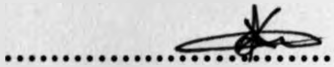
DECLARATION

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



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John Karanja Kihagi

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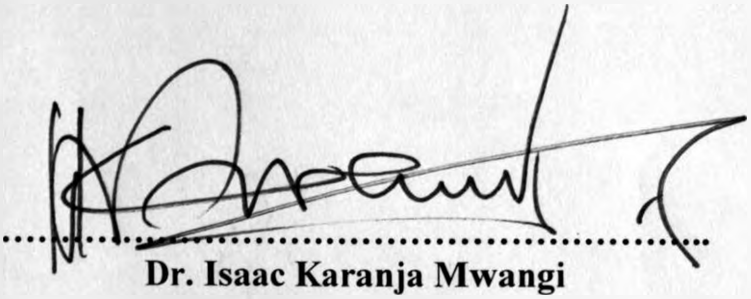

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Dr. Isaac Karanja Mwangi

DEDICATION

To Onesmus, Margaret, Sammy, Naomi, Mary and David. I owe you this and much more.

ABSTRACT

Lake Nakuru Catchment covers an area estimated at over 1837 square kilometers. It has a fragile ecological system which has increasingly had permanent human settlements locating there over the last one hundred years. Within this period, land use conditions have dramatically changed, causing major concerns on environmental sustainability of the entire catchment.

This study undertook to investigate the actual land use changes that have taken place in the catchment in the past twenty-six years. It also analyses the biological and physical characteristics of the catchment in order to reveal the environmental implications of changes in land use and recommend appropriate planning interventions

The Study reveals major changes in land use over the study period. This includes changes in the proportions of land area covered by forests from 42 percent of the entire catchment area to 22 percent. Small-scale farmlands accounted for 39 percent of the total catchment land are in 1999 as compared to 9 percent in 1973. Other changes include a reduction in the proportion of land areas covered by large-scale farmland from 29 percent to 14 percent. In contrast, reduction in the number of large-scale farms has taken place in tandem with an increase in urban land from 1 percent to 14 percent.

Institutional mandates, strengths and weaknesses together with the legal framework under which they operate are analysed with a view to coming up with an effective framework under which land use planning within the catchment should be undertaken in the future. The study especially notes the lack of application of modern technology in land use change information acquisition

and analysis namely Satellite Remote Sensing and Geographic information Systems (GIS) within the Catchment.

The study arrives at the conclusion that land use change in the catchment is evolving in such a way that continued growth in the number of small-scale farmlands should draw special attention of urban and rural planners and conservationists in the catchment. The study takes particular note that transition of land use into the small-scale land units is a transitory step and that this transformation process points towards a land conversion process from rural/agricultural land use to urban use.

Some areas in which the study makes recommendations include remedial measures that focus on farmer conservation training and community involvement in conservation efforts. It also recommends intensified urban and regional planning and institutional collaboration in land use change monitoring, planning and control as a means towards sustainable land use within the catchment. In particular, the study identifies the need for establishment of a Lake Nakuru Catchment Authority to be responsible for environmental management within the area and to serve as a coordinator of all the other institutions currently having specific environmental mandates. As a means of achieving its objectives, the authority should establish a land use and environmental information system utilizing Geographic Information System (GIS) and Remote Sensing Techniques.

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LIST OF ABREVIATIONS

CBS	Central Bureau of Statistics
DRSRS	Department of Resource Surveys and Remote Sensing
DURP	Department of Urban and Regional Planning
FAO	Food and Agriculture Organization
GIS	Geographic Information System(s)
KISM	Kenya Institute of Surveying and Mapping
KWS	Kenya Wildlife Services
LA21	Localizing Agenda 21
LNC	Lake Nakuru Catchment
LNCDP	Lake Nakuru Catchment Development Programme
LNNP	Lake Nakuru National Park
MCN	Municipal Council of Nakuru
NRC	Non-Residential Cultivation
RCSMRS	Regional Center for Services in Mapping and Remote Sensing
RS	Remote Sensing
SOK	Survey of Kenya
UNCHS	United Nations Center for Human Settlement (Habitat)
UNEP	United Nations Environmental Programme
UON	University of Nairobi
WWF	World Wide Fund for Nature

CHAPTER ONE

INTRODUCTION

1.0 Background to the Study

Land is normally defined as a physical entity in terms of its topography and spatial distribution. A broader and more comprehensive view of land also includes natural resources such as soils, minerals, water, animals and plants that a particular land area contains. These components organise in systems of biological and physical relationships called ecological systems or ecosystems. Ecosystems work and exists such that they provide for the maintenance of life support systems and the productive capacity of the environment (UNCHS, 1992).

As alluded above, an eco-system consists of the physico-chemical environment (abiotic components), and plants animals and microbes (or the biotic components), which interact in geographic space. The dynamic interaction of all parts of the environment, especially the transfer of material and energy is a major concern in the study of ecological systems. Matter and energy moves from the biotic to the abiotic components of an ecosystem in food webs and bio-geo-chemical cycles. The biotic components then exert a demand on the ecosystem in terms of food and shelter requirements. Man is especially significant in exerting such demand. In pursuit of food, shelter, energy and recreation activities, man has more than any other specie on earth exerted profound demands on land and its resources.

While land and its resources are finite, the size of human population relying on it for survival has continued to increase. This has led to an ever-increasing pressure on land resources, creating competition and conflicts. There is a strong competition between urban

development, agriculture and conservation of the natural environment (Langdalen, 1985). In the urban areas, there are conflicting demands of land for industry, housing, commerce, agriculture and open spaces for recreation. In the rural areas, unsustainable practices include exploitation of marginal lands and the encroachment on ecologically fragile areas by the ever-growing landless rural populations.

The pressure for land results in unsustainable use of land and its resources including deforestation, overgrazing, cultivation and habitation of land ordinarily unsuitable for human settlement. Forests that act as water catchment areas and also contain essential biodiversity species have been encroached on either by commercial interests or by rural peasant farmers. High loss of forestland has led to loss of biological diversity; soil erosion and siltation, drying up and pollution of water and other land based resources, and the emergence of erroneous hydrological regimes among other forms of environmental degradation.

Man has for a long time admitted that Land as a basic resource belongs to a wider family consisting of the dead, the living and countless numbers of unborn (Farvacque and McAuslan 1992). Many communities have then for a long time viewed land as a form of inheritance to be passed on to succeeding generations. This realisation has however not prevented man from plundering the resources that nature provides without due respect to the sustainability of such use. At the global level, there is now awareness that if future generations are to enjoy the benefits of land resources, better and more careful management of these resources is needed. Sustainable development must be achieved by implementation of ecologically sound, economically viable and socially acceptable policies. This recognition led to the 1992 *United Nations Conference on Environment and* Development (UNCED, Rio de Janeiro Summit) and its plan of action, the *Agenda 21*

1.1 Agenda 21 and Environmental Planning

Agenda 21 is a programme of action for sustainable development world-wide. Its origin is the declaration on Environment and Development and the statement of principles for sustainable management of the environment adopted by more than 178 governments at the United Nations Conference on Environment and Development, the Earth Summit[1]. Its prelude was the calling in 1989 by the United Nations General Assembly for a global meeting to devise integrated strategies that would halt and reverse the negative impacts of human behaviour on the physical environment and promote sustainable development in all these nations.

> Agenda 21 then stands for a comprehensive blueprint for action to be undertaken globally in the 21st Century in every area in which human activity is impacting on the environment. It tries to address pressing problems created in the 20th Century and to prepare the World for the challenges of the 21st Century. (UNDPI, 1997)[2]

Chapter seven of the Agenda 21 specifically deals with *promotion of sustainable human settlement development.* It outlines eight areas in which countries should set frontiers in accordance with their national plans and objectives. Among these is the promotion of sustainable land use planning and management. It recognises land resources as the basis for human and other living systems. Land requirements for the development of human settlements must then be provided relying on regional and local planning. It must also rely on land use policies and practices that take environmental factors, especially ecological processes into consideration. The successful implementation of Agenda 21 is dependent on national strategies and plans, the broadest public participation and the active involvement of NGOs and other groups. The Agenda is also a dynamic programme that should be carried out according to the local situations, capacities and priorities.

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[1] The summit was held in Rio de Janeiro, Argentina between 10-19th August 1992
[2] United Nations Department of Public Information

1.2 Land and Environmental Planning in Kenya

Land is considered the most valuable resource and therefore the most sought asset. When in mid 20th century Kenyan Africans went to the forest to start the war for independence against the British, their army was named the *Kenya Land and freedom Army*. Native land rights were the main agenda in the subsequent negotiations that led to the country's independence in 1963. The demand for land did not end with independence but only took a different form. Individuals and organizations continued to seek land for their own. Land was then in high demand both as a factor of production and as a way of accumulating and preserving already acquired wealth. Sustained demand for land in post-independence years has then led to conflicts in the use and management of land.

1.2.1 Land Pressure and Conflicts

Kenya extends over a terrestrial area of 582, 646 square kilometres. However about 80 percent or 466,117 square kilometres of this land area is either arid or semi-arid and supports only 20 percent of the total national population. The remaining 20 percent or 116,529 Square kilometres of the land supports 80 percent of the national population (GOK, 1994). With the current population of 28.5 million people, (GOK, 2000), the average population density on this productive land area is approximately 200 people per square kilometre. The demands that the population puts on the land are therefore many and often create tremendous pressure and user conflicts. Rural and urban human settlements have continued to expand at high rates in such high potential areas with major effects on the carrying capacity of the natural environment.

> The main land use conflict in Kenya is between the physical expansion of towns and retention of arable agricultural land. The other conflict area involves encroachment by human activities on environmentally fragile land such as mountain forests that act as water catchment areas. This has resulted to erroneous hydrological patterns and the subsequent low water levels in national reservoirs.

> Another conflict area is between wildlife retention for tourism and foreign exchange earnings and access to resources by the local communities. Conflict also exists in the form of introduction of arable agricultural practices in arid and semi-arid lands (ASALs) and the allocation of land, especially open spaces to other uses through change of user approvals (GOK, 1992).

The effects of these conflicts are manifest. Nairobi has for example continued to expand towards the agriculturally rich Kiambu district while Nakuru is expanding towards Njoro and Bahati, both areas of high agricultural potential. The current water and energy crisis in the country is directly attributable to clearing of vital water catchment areas around the Mount Kenya region.

The absence of a comprehensive land use policy has in turn led to inappropriate land use in both rural and urban areas. Vital water catchment areas and wetlands are destroyed while arable land parcels continue to be subdivided into uneconomical land units. Exotic land use practices have also been introduced by immigrants to numerous areas without due consideration of their impact on the environment. Sub-division of rangeland areas into very small land parcels have resulted to a decrease in their carrying capacity with subsequent reduction in productivity and also presenting major environmental degradation threats as a result of overstocking and over-cultivation.

Sustainable Land use planning is the only alternative in order to ensure that land is used in ways that results to optimal benefits accruing to users while at the same time implying minimum externalities to the environment. This calls for a review of land use policy, planning and management approaches and the relevant legislation so as to appraise the environmental implications of the social, economic, cultural and political changes in the country.

1.2.2 Environmental Policy in Kenya

The main law that governs spatial planning in Kenya is the Physical Planning Act of 1996. Prior to enactment of this act, both the Town Planning Act and the Land Planning Act were used for controlling land use and development on land. These two legislation have been the main guides in land use and environmental management in Kenya. Other legislation that have influenced land use and environmental management includes the Land Control Act (Cap 302), the Local Government Act (Cap 265), Government Lands Act (Cap 280), Trust Lands Act (Cap 288), Registered Land Act (Cap 300), Registration of Titles Act (Cap 281), Land Consolidation Act, Land Acquisition Act (Cap 295), Land Adjudication Act, Survey Act (Cap 299), Water Act (Cap 372), Agriculture Act (Cap 318) and the Forest Act (Cap 385) of the Laws of Kenya.

These pieces of legislation cater for certain aspects of sustainable land use and conservation of land resources but they lack integration of both policy and practice. This has mostly arisen due to the numerous institutions and roles they are given by the many legislation. Consequently enduring institutional conflicts and lack of co-ordination of effort has led to no clear roles and hence conflict. In Kenya, the importance of environmental conservation has attracted government attention in the 1990s, partly in response to trends in other parts of the world and partly due to internal initiatives. The result of this has been the formulation of a national environmental policy in form of the National Environmental Action Plan (NEAP) in 1994.

The objectives Kenya's environmental policy as, stated in the NEAP are;

a) To facilitating optimal use of the national land base and water resources,
b) To promote sustainable use of natural resources,

c) To treat environmental conservation and economic development as integral parts in the process of creating sustainable development, and
d) To generate income and meet national and international obligations by conserving biodiversity, reversing desertification, mitigating effects of disasters, and maintaining the ecological balance of the earth. (GOK, 1994)

The main strategies aimed to help achieve these objectives include the retention of protected areas and creation of others based on existing biological diversity in order to generate and earn income through tourism. It also includes the formulation of a comprehensive land use and settlement policy to guide human conduct in carrying out economic activities with a view to minimising potential negative impacts on the environment and to improve land use decision making. Effective environmental education and efficient information systems that are accessible by all users are identified as being crucial in order to achieve the NEAP objectives. The 1994-96 National Development Plan also detailed the government's commitment to integrate environmental consideration in development programmes .

Various other advances have been made towards better land and environmental management. These include the consolidation of the Town Planning Act and the Land Planning Act into the Physical Planning Act of 1996. The integration and enactment of this act is expected to promote better use and development of land through local and regional planning. A review of both the Water Act and the Forest Act is also being undertaken to making them more relevant to the current development and environmental conservation challenges. There has also been enacted an environmental management and co-ordination Act.

1.3 Problem Statement

Lake Nakuru Catchment provides an excellent example of an area with a wide range of land use and environmental conflicts. The conflicts emanate from the need to conserve wildlife and its natural habitat, the existence of large and smallholder farming activities and rapid

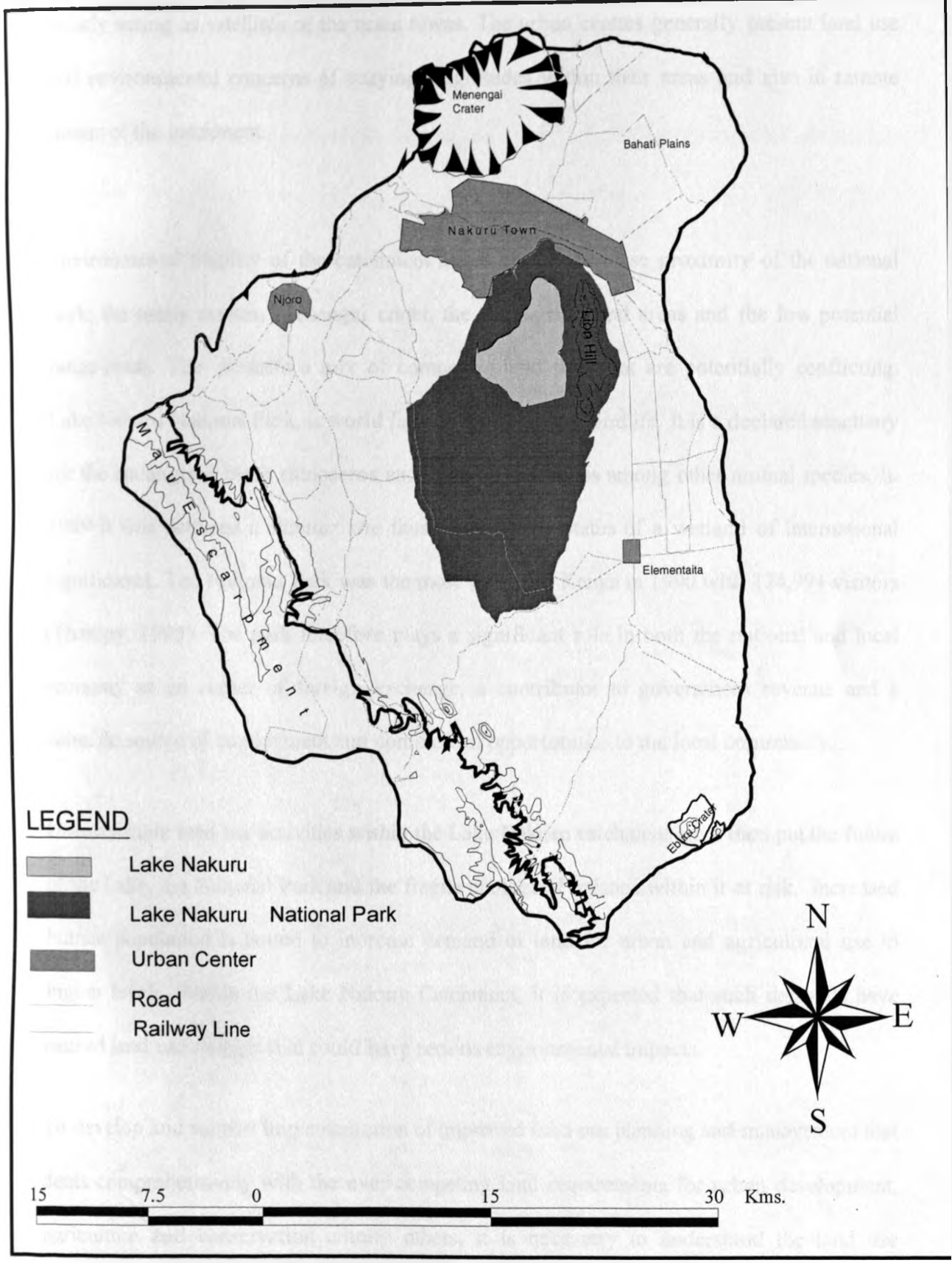
urban development of Nakuru Municipality, all in an area of 1837 square kilometres. Lake Nakuru Catchment is considered here to be all that area of land draining into Lake Nakuru. The catchment contains Lake Nakuru National Park, Nakuru town, Menengai crater, the fertile agricultural areas of Bahati, Njoro and Mau-Narok and the low potential rangeland areas around Elementaita. The close proximity of these features is elaborated by figure 1.1 below. The catchment has a unique ecological system with three main features. These are a high urbanisation rate, geological instability and environmental fragility.

Urbanisation of the Lake Nakuru Catchment is closely tied to the development and expansion of Nakuru Town. The town was founded in 1904 as a railway outpost, 160-Km Northwest of Nairobi. At present, the town is the fourth largest town in Kenya after

Nairobi, Mombasa and Kisumu. The Town is the headquarters of Rift Valley Province. From a mere 17,000 people in 1948, Nakuru's population has grown to an estimated 360,000. The population growth rate is currently estimated at 5.68% per annum. The town has also experienced a high rate of industrial development. There are currently about a hundred registered industries operating within the town. Some of these industries emit toxic effluents thus raising important environmental concerns. (MCN, 1996).

Within the catchment is Njoro town, another urban centre whose rise was also inspired by the railway construction. Although the town has not grown to the size of Nakuru, it has had significant expansion both in size and function. In 1979, its population stood at 9,026 people, this rising to 22,023 in 1989. It is currently estimated at 44,000 people. Apart from the high concentration of population, Njoro also contains some industrial establishments that raise environmental concerns. Within the catchment are numerous other upcoming urban centres

Figure 1.1 : General Features of Lake Nakuru Catchment



Source; Adopted From Survey of Kenya 1;50,000 Map Series

mostly acting as satellites of the main towns. The urban centres generally present land use and environmental concerns of varying magnitudes within their areas and also in remote coners of the catchment.

Environmental fragility of the catchment arises out of the close proximity of the national park, the urban centres, Menengai crater, the rich agricultural areas and the low potential range-lands. This presents a mix of competing land uses that are potentially conflicting. Lake Nakuru National Park, is world famous for its unique birdlife. It is a declared sanctuary for the endangered black rhinoceros and home to flamingos among other animal species. In 1989 it was declared a *Ramsar site* thus attaining the status of a wetland of international significance. The National Park was the most visited in Kenya in 1990 with 174,994 visitors (Thampy, 1995). The park therefore plays a significant role in both the national and local economy as an earner of foreign exchange, a contributor to government revenue and a valuable source of employment and commercial opportunities to the local community.

Unsustainable land use activities within the Lake Nakuru catchment have then put the future of the Lake, the National Park and the fragile ecological balance within it at risk. Increased human population is bound to increase demand of land for urban and agricultural use to higher levels. Within the Lake Nakuru Catchment, it is expected that such demands have caused land use changes that could have serious environmental impacts.

To develop and support implementation of improved land use planning and management that deals comprehensively with the ever competing land requirements for urban development, agriculture and conservation among others, it is necessary to understand the land use process, the relationship between the various causatory factors and the recent trends in land

use. As a way of understanding the land use change process and anticipating the impact of projected changes. there is need for an inventory of land use and a framework for monitoring land use change. For a fragile ecology like the Lake Nakuru Catchment, such monitoring will aid in both detailed and general land use planning and in the preparation of environmental impact Assessment reports.

For the Lake Nakuru catchment, such an analysis should ideally start from the late 19th Century AD when European settlement started. But although it is true that European settlement in the area brought the first major changes in land use, the most significant land use changes, from the environmental conservation perspective occurred from the late 1960s when the independent government started settlement scheme programmes to settle land less Africans. This started in Bahati in 1967 and then Njoro and Mau-Narok in 1968 (Karanja *et al.*, 1985). Over the ensuing three decades, more settlement has occurred accompanied by extensive changes in the demand for land. There is then need for the rationalisation of land use activities within the area. This should start with an inventory of current land use and the regular monitoring of its change with a view to assessing the likely environmental effects.

Land use survey, monitoring and analysis are an important step in land use and environmental planning;

> In a dynamic scenario, the conservation and management policies and practices that have influenced changes in land use are also of importance. In order to detect and measure changes in land use, a periodic monitoring process and a method by which time series may be analysed are required. The execution of such a task requires a tool for mapping landscape and analysis of change. Remote Sensing backed by fieldwork that is predicated on a sound methodology to help gathering of land use data and Geographic Information Systems (GIS) technology to help organise, store and retrieve information when it is required provides such a tool. (Peccol et. al. 1996).

Burrough (1996) notes that quick access to large volumes of data, ability to link different data sets and analyse their inter-relationships is an essential spatial analysis tool in land resource assessment and environmental planning.

This study is concerned with investigation and analysis of the land use changes that have occurred within the catchment of Lake Nakuru in the last twenty-six years. The focus is on the changes as they affect environmental sustainability of the catchment, with the lake's ecosystem acting as the centre of focus, and with a view to highlighting the areas facing high risk of degradation. For this, the study analyses the land use changes in relation to the biophysical characteristics (hydrology, soil, topography and conservation areas), thus identifying the possible environmental impacts and the necessary planning interventions. The main land use classes analysed are urban, agricultural, forestland and conservation areas.

1.4 Objectives of the Study

The overall goal of the study is to investigate, quantify, analyse and demonstrate the fundamental changes in land use that have taken place in Lake Nakuru Catchment from 1973 to 1999. Although major land use changes started occurring within the catchment from the time of colonial settlement and then accelerated with the attainment of independence, there was previously a problem of documentation of such changes. Land use change information was however made easy beginning the early 1970s by the emergence of satellite based sensor systems that could capture and store information on land cover and land use in expansive areas at a certain instance. The earliest such imagery for the Lake Nakuru area is dated 1973. The study is therefore based on the use of multi-temporal Satellite Remote Sensing imageries to perform land use survey, and Geographic Information System (GIS)

analysis to assess land use change over the past twenty-six years mainly as a consequence of population growth, urban expansion and settlement policies. The specific objectives are;

1) To carry out a land use survey within the Lake Nakuru Catchment using both Remote Sensing and ground survey methods in order to quantify and demonstrate the current pattern of land use.
2) To prepare land use maps for 1973 and 1987 for the catchment using satellite Remote Sensing data and hence quantify and demonstrate historic land use in the catchment for the respective years. These are the years when historic satellite data is available for the area of study. They also roughly coincide with periods when settlement policies that changed land use scenarios were implemented in the catchment.
3) To relate absolute and relative land use change with the prevailing biophysical characteristics of the catchment. This will help in identification of the potential environmental threats in specific areas of the catchment as a result of changes in land use.
4) To recommend land use planning approaches and management measures as interventions in the existing land use trends. This will be with a view to making adjustments to the existing legislative, institutional and methodological framework in land use planning and environmental management.

1.5 Research Assumptions and Questions

As a framework for this study, the main assumption is that land use change is bound to cause environmental degradation. This assumption arises out of the fact that human interference on the natural environment always causes instability and unsustainable conditions. The less the natural environment is interfered with, the more stable and sustainable it is assumed to be On the contrary, the more artificial or disturbed a natural environment is, the more unstable it is assumed to be. From these two perspectives, urban land is taken to be less preferred to farmland, which is less preferred to forest and recreational areas. In the same context, natural forest is preferred to plantation forest. The study also assumes that unless intervention measures are taken, the trend taken by the land use pattern over the past twenty-six years is bound to continue. This follows the common extrapolation concept where past and present land use patterns are assumed to be the guide to the future land use pattern.

Based on these assumptions and the objectives, the following questions were formulated to guide the study;

i. What is the current land use pattern in Lake Nakuru catchment?
ii. How has this pattern changed from 1973 to the present?
iii. How does this change in land use relate to the biophysical characteristics of the catchment and what environmental implications does this trend imply in the foreseeable future?
iv. What land use planning and management intervention measures are necessary to influence land use change in the catchment so as to ensure the minimum environmental degradation?

1.6 Scope of the Study

The study deals with land use change within Lake Nakuru catchment as a natural region. The catchment is one ecosystem, and therefore the environmental problems in a localised area in the catchment, especially the higher parts are a reflected elsewhere in the catchment. Land use change is then analysed for the entire catchment, covering an area of 1837 square kilometres. Biophysical data are also acquired and analysed for the entire catchment. Sample areas were however chosen for detailed study and analysis of especially socio-economic factors relevant to land use and environmental conservation.

The focus of the study is land use change and its implication on environmental sustainability and the possible planning approaches and management measures for intervention. The effects of this change on soil erosion, water pollution and forest depletion are investigated. Although most of these effects are experienced in the urban and rural-urban fringe areas, land subdivision, agricultural intensification and forest depletion are taking place in areas of the catchment outside pockets of population concentration. These remote areas are often neglected in analysis, yet they are the areas of profound effect, especially due to their role as water catchment areas. The study then gives a bias to these areas as the ones most likely to

have experienced rapid land use change in the recent past and ones that will continue to experience the negative effects of population increase and urban development. Land use change in these areas is analysed in relationship to physical environmental factors (topography, hydrology, geology and rainfall), and generally, as it affects soil erosion, water pollution and forestry depletion.

The study recognises the fact that the effects and relationships between bio-physical characteristics and environmental degradation like soil erosion and water pollution are specialised disciplines in their own right. It is however important to relate these processes to human activity on land so as to explore the extent to which these have aided natural phenomena in environmental degradation. While not attempting to make deep scientific analysis of these factors, the study borrows from these knowledge areas holding the physical environment as a constant and land use as the variable. The output of the various land use patterns is then the status of the environment.

The study also seeks to provide a general policy, institutional and methodological framework for land use change monitoring, evaluation and planning in the Lake Nakuru catchment. The use of Remote Sensing and GIS technology in land use change monitoring and analysis is emphasised out of the belief that efficient acquisition, management processing and dissemination of land use information leads to better environmental management. It is however expected that future change in technology, economic, social and political situations will necessitate continuous review of such a framework

1.7 Significance of the Study

Within the Lake Nakuru catchment, settlement policies, population growth and the urbanisation phenomenon have caused most of the environmental problems. As the urban centres keep on expanding, more pressure is placed on agricultural land, which in turn encroach on forest land and conservation areas. In an area of fragile ecological balance like Nakuru, these land use dynamics ought to be closely monitored. Data on such changes are necessary in order to show the magnitude of change and the likely environmental effects. A time series analysis of such changes will also help in predicting the future direction of change and hence the necessary intervention measures.

While many environmental studies have been carried out in the catchment, most of them are by natural scientists who failed to give the necessary regard to human activity[3]. Most of the studies also concentrated within the National Park, Nakuru town and the areas adjacent to the park.[4] Recent change in resource management paradigms has however shifted the emphasis from preservation to conservation. In this paradigm, the co-existence of man and his natural environment is of prime important.

Taking this shift in paradigm, the Kenya Wildlife Services (KWS) and the World Wide Fund for Nature (WWF), initiated the Lake Nakuru Conservation and Development Project (LNCDP) in 1988. The Project took a watershed approach in promoting adoption of sound conservation practices in the development of the Lake Nakuru catchment. This Programme recognises the effect of land use in remote parts of the catchment to the ecological balance of the park. Since then, LNCDP has sponsored studies and community development

[3] Includes Karanja *et al.* (1985) and Kimani *et al.* (1992)

programmes related to environmental management and conservation in the area. In its second phase, the project proposes the following core programmes;

i) Environmental education programme
ii) Environmental conservation programme
iii) Environmental monitoring and assessment programme
iv) Environmental planning programme (Thampy 1995).

In the environmental monitoring and assessment programme, the objective of gathering information on the state of terrestrial and aquatic environments within Lake Nakuru Catchment is emphasised. This includes monitoring of changes especially urban growth, land use, land ownership and land tenure. The project would, in liaison with government departments and NGOs involved in development and environmental issues, analyse land use trends and make recommendations to the District Development Committee and the Municipal Council of Nakuru. In doing this, the project proposes the Use of Geographic Information Systems (GIS) for data management and analysis.

Although this study is not part of the LNCDP, it is fashioned to act as a preliminary step to the programme's environmental assessment programme. Since environmental assessment should start with an investigation of current land use and the previous land use dynamics, it is felt that a time series analysis of land use change would be the most crucial starting point in the programme. In this way, the study gives a picture of the land use changes and also helps to understand the likely environmental effects of such change.

The study also aims at initiating appreciation of the value of Remote Sensing and Geographic Information Systems in the study of land use change in habitats where nature and human environmental subsystems relate in a fragile way. It then also provides broad guidelines of the institutional and methodological framework in undertaking detailed land use studies in the catchment. The framework will also aid in establishing a land use and

environmental management information system within the catchment. The study's adoption of a watershed approach is out of the conviction that since land use is intricately tied to the underlying biophysical factors and capabilities, a watershed is then an appropriate landscape unit for planning, management and research.

1.8 Organisation of the Thesis

Chapter one has served as an introduction to the study. In it the background to the study, research problem and objectives, assumptions, questions, scope and justification have been given. In chapter two, literature relevant to the study is reviewed. Chapter three gives the research methodology while chapter four gives details of the study area. Chapter five gives an analysis of the data and research findings. Planning and policy recommendations and conclusions are finally given in chapter six.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter gives an overview of literature related to the topic of study. It starts by looking at the concept of resources and resource management. Land as a basic natural resource and the foundation of all human activity is then looked at, leading to the concept of land use. The relationship between land rights and land use is then reviewed. Here, the factors that lead to land use change are also looked at. This leads to the concept of land use change and environmental conservation. Specific focus is directed at the relationship between land use change and watershed conservation, its effect on soils, hydrology (water quantity and quality), withdrawal and diversion of water. The study goes on to look at land use planning and its role in resource management, land use change research especially its scope and concern, before looking at the institutional aspects in land use and the unique political economy of land in Kenya. The study concludes by establishing a conceptual and defining the operational terms.

2.1 The Nature of Resources

The development of any region is dependent on the amount of resources available. This resource endowment will also determine the level of welfare of the people resident in such a region. Man therefore thrives on exploiting the resources that his environment avails for his use. Zimmerman (1933) observes that neither the environment nor parts of it are resources until they are, or are considered capable of satisfying human needs. The implication of this is that resources are an expression of environmental appraisal and represent a relative and

subjective concept. A substance within the environment is then not a resource without people whose wants and capabilities give it its utility.

In 1951, Zimmerman elaborated his earlier statement. He pointed out that natural resources are dynamic, becoming available to man through a combination of increased knowledge and expanding technology as well as changing individual and societal objectives.

> Attributes of nature are therefore no more than *neutral stuff* until man is able to perceive their presence, recognise their capacity to satisfy his wants and then devise means to utilise them (Mitchell, 1989, Zimmerman, 1951).

Consequently resources could be said to evolve from a three-way interaction of natural, human and cultural assets. Natural resources will be defined by human perceptions and attitudes, technological skills, legal, financial and institutional management as well as by political customs. Perception of the relative importance of substances thus their ranking as resources will then vary from culture to culture. It is from this perspective that resources are perceived as being finite and yet only limited by human ability to recognise utility and develop technology to improve this utility. The limitations in these then compels man to use his resources wisely, leading to the concept of resource management and conservation.

2.2 Resource Management

Mitchell (1989), defines resource management as:

> "A process of decision making whereby resources are allocated over space and time according to the needs, aspirations and desires of man within the framework of his technological inventions, his political and social institutions and his legal and administrative arrangements".

Resource management should then be viewed as a conscious process involving judgement, preference and commitment. It also involves the seeking of certain desired outputs from certain resource combinations through choice among various managerial technological and environmental alternatives.

2.3 Land as a Resource

Land is a basic natural resource and is the foundation for all human activity. Over the span of human history, man has drawn most of his subsistence in terms of food shelter and clothing from land. Davidson (1980), defines land as the interface between the earth's solid surface and the atmosphere, consisting of all the characteristics of the biological and physical (biophysical) environment that have influence on land use. The elements of land include soils, landforms, geology, hydrology, climate, vegetation, wildlife and effects of current and past human activities (FAO, 1976).

Part of man's interest in land and its use lies in its diversity. Land is diverse in the sense that it may range from well-watered highlands and lowlands to arid and semi-arid regions. The uses to which land may be put are equally diverse; ranging from agriculture, industry, residential, transportation, forestry to a myriad of other uses. It is because of these many uses that land is better regarded as a resource base rather than a resource in itself (Mather, 1986). The inclusive term land resource is then often used as encompassing the soil, ground and surface water, fauna and flora and generally everything that constitutes part of natural resource endowment of a place.

2.3.1 The Concept of Land Use

The term *Land Use* is taken to be simple and self-explanatory. But this apparent simplicity is deceptive (Robin, 1981). Clawson (1965) defines land use as man's activities on land. Stamp (1961) defines land use as literally the use that is made by man of the surface of the land. Huque (1987) takes land use to signify the use of land, territorial water bodies as well as the buildings and improvements thereon. He then points out that land use refers to how land and its improvements are used and distributed over the locality.

Land use is then a relative term with the meaning dependent on what one takes land to be. When land is taken as a source of raw material endowed with valuable elements or deposits, then, land use is synonymous with resource use, often measured in terms of its economic productivity. Land use could also be defined in terms of area and places that provide opportunities to locate various functions such as agriculture, urban residential, industrial, recreational and conservation.

The above multiplicity of definitions range between two distinct concepts; the functional use of land for man's purposes (agriculture, residential, recreational) to simply the form of ground cover (crop, trees, houses). Heiling gives a general definition of land use as;

> The accommodation in terms of space, of all man's activities on land and the way in which the land surface is adapted, or could be adapted to serve human needs. Heiling (1995)

Meyer and Turner, (1994) notes that five major uses are usually identified, in land use studies, largely because it is for these categories that statistics are readily available; agriculture, forest and woodland; urban land and other miscellaneous land. These broad categories of land use generally comprise the whole of the earth's surface. For detailed land use studies they could be desegregated into finer subcategories. Agricultural land could for example take subcategories depending on the scale of operation or type of crops grown. The miscellaneous use could also take many forms depending on the local situation.

Due to increasing human population and changing human needs and aspirations, there is an ever-increasing competition between land uses. This is further compounded by the fact that land resources are *finite* and the intensity of their use is increasing with population growth leading to conflicts between the uses (Bernstein, 1993). There is then need to include

adequate information in development planning to minimise conflicts, most of which lead to land degradation and environmental problems.

While recognising the validity of the multiple definitions of the term land use, this study prefers to take the term to imply the accommodation in spatial terms of man's activities and the resultant adoption and modification of the land surface. It is such modifications that result to environmental un-sustainability. Remote Sensing methods are capable of capturing and recording such changes either in digital or analogue form.

2.3.2 Land Rights and Land Use

There are two enduring concepts of land that influence the views of land users.

> On the one hand, land is considered simply as a form of property that may be traded at will. On the other hand, land is seen as more than private property and its possession and use as not just a matter for market forces to determine. In this concept, a sense of stewardship attaches, where land is perceived as a common property, either in the sense of succeeding generations or by extension in the wider sense that the community has an interest in it (Andrews, 1979, Clarke, 1982, Mather, 1986).

It is this aspect of responsibility to the community that is the tenet of land use planning and consideration of sustainability in the use of land resources.

Caldwell (1974) cites several reasons for the necessity of change in outlook towards land; *a new view in which privilege to use replaces ownership rights*. He suggests that since no man made land, no man may possess it as his own. The presumption in this view is that the right of ownership derives from a creative input. There is also the fundamental divergence between the transience of man and the relative permanence of land. This distinction, Caldwell points out, logically leads to viewing the use of land as a privilege, which carries with it a responsibility to pass it along to successive generations in essentially the same conditions in which it was received. He then suggests the redefinition of right to mean the

right to use or occupy land in accordance with criteria established in the public interest, with the right of use or occupancy tied to defined economic and ecological capabilities.

2.4 Factors in Land Use Change

Land use change is a complex phenomenon differing greatly from place to place. The causes of change include personal choice, legislation, governmental policies and plans, decisions of developers or entrepreneurs, the nature of land itself or the availability of technology to develop the land (Hill, 1989, Edmunds and Kyle, 1994). A land use category set up at one point in time can undergo considerable change when one type of subcategory grows or another is reduced, rendering comparison overtime more complex than simple observation of maps (Hill, 1989).

2.4.1 Land Use Plans and Policies

Erickson (1995) identifies a two-way interaction between land use change and land use policy. While Land use change is affected by policies and plans, plans are simultaneously formulated in reaction to existing physical conditions, perceived changes and threats. This cyclical iterative process is inherent in the planning process where plans have the dual functions of reacting to and guiding change. An attempt should then be made to understand not only the regulations impinging on land use change but also the extent to which land use plans respond to and document the variety of land use and its dynamics.

2.4.2 Technology in Land Use

In the evolution of the human specie, huge areas of natural land have been converted into agricultural areas. Large areas of forest cover have been cut down for cultivation and cattle ranching. Forest and woodlands have also been cleared for wood and other forest products.

Urban expansion has also slowly eaten up agricultural land in what can be described as a land use succession. This process was first driven by the agrarian revolution and its consequent population growth, (Poleman and Freebairn, 1973).

During the industrial revolution, land use change became a quite different process. At this time, competition between agriculture and non-agricultural land use emerged. With improving technology land gradually became a less important resource for food production and became increasingly used for other purposes like housing, manufacturing, recreation and infrastructure. The global area under crops has for instance remained unchanged in size since the 1950s. This is despite a doubling of the world population and a more than double increase in world food production. The role of technological advancement has therefore a direct effect on how land use change will take place, (Tolba, 1992).

2.4.3 Physical Nature of the Land

Any change in land use is a potential source of disruption and the task of the planner is to supervise their arrangements so that the disharmony they cause is reduced to a minimum.

> This is derived from two basic concepts, one that every land use has its own site requirements in relation to the natural features of the landscape and the second that land uses brought into proximity to one another are likely to show different degrees of compatibility (Edington, 1977).

Erickson (1995) remarks that well-drained areas with fertile soils are best reserved for agriculture as opposed to urban development. Steep slopes with thin soil layers are best left under forest cover as a way of protection. Geological formations with poor load bearing capacity are unsuitable for housing heavy industrial installations while flood plains are unsuitable for major housing schemes. While to the planner these factor are often considered

together and often in a scientific manner, to the land user few or just one factor may be all that is considered in making a land use change decision. The physical nature of land then remains a major factor in land use change. The more suitable areas will be exploited first before the less suitable ones. With increasing population and demand for land resources, the less-suitable areas will also come to be used This then is the root cause of environmental degradation.

2.4.4 Personal Choice

The concept of personal choice in land use decision making is hinged on the distribution of property rights among land owners and land users (Lier *et al.*, 1994). In many countries, property rights in land have been strongly upheld. Szakal (1994) observes that many private land use decisions will result in external effects as the individual tries to maximise his welfare often at the expense of that of the larger society. Brubaker (1977) notes that another component of such property rights is land speculation. Many writers have discussed the problem of property rights and land use decision making. Most argue that the problems of pollution can be solved by extension and optimal distribution of property rights. The other extreme argues for maximum state intervention and even elimination of private property rights.

Hodge (1990) presents a concept of *alternative property rights* where landowners would have to pay for the right to modify certain land use practices. Elkins (1989) proposes to establish a *co-operative land bank*, which combines individual rights to use land with community ownership of the land itself. While most authors tend to advocate more state control, there are also many who point out that not only market failure exists but also *government failure*. Anderson (1982) states that the comparison is between imperfect market

solutions and imperfect bureaucratic solutions. The main reason for government failure is that state intervention always depend on political pressure of different groups and not necessarily on the interests of all members of the society.

The other main reason is that of getting adequate information and the costs and logistics of enforcing regulations. Willis (1987) proposes that governments measure the product or service involved and identify the parties concerned and their preferences. If the tasks are very costly or can not be performed accurately, he warns that government intervention can leave the community worse off. The conclusion from these analyses is obvious; there is need for a system of property rights and land use decision making that would ensure sustainable land use planning by ensuring the elimination of both market and government failure.

2.5 Land Use Change and Environmental Conservation

Land use change is a multi-sectoral process whose trends are influenced by change in technology, population growth and urbanisation and changes in lifestyles or consumption patterns. These drives other mechanisms such as increased transportation and personal mobility, leisure activities, demand for food and other agricultural products and increased demand for energy and natural resources such as oil, coal and wood. These forces are linked to certain alterations of the physical land surface and its biotic factors. Alterations will be in deforestation, drainage of wetlands, regulation of river water systems.

> In the end, land cover modification can change the regional hydrology, reduce bio-diversity and influence bio-geo-chemical cycles or even the climate. They can also trigger soil erosion and increase sediment transport (Ryszkowski et al. 1991).

Land use change will then vary in size, intensity, duration and impact. While changes in agricultural and forestland use often affect large areas, their duration, intensity and even impact may be short. A forest may be able to generate itself after some years. Urban land use

change on the other hand may cause a relatively permanent land cover change. The effect on forest change may then be more spatially expansive but less intensive than that for urban expansion. The impacts of such changes will then vary. The effects may also reach further than to the directly affected ecosystems and trigger multiple ecological damage and land use change far beyond.

2.5.1 Land Use Change and Watershed Conservation

White (1992) observes that water flows downhill and does so irrespective of the political boundaries. This is the central tenet of watershed management. Ideally, watershed planning and management should include agriculture, soil conservation forestry among other disciplines. Watershed planning is therefore essentially concerned with land use, its change and impact on other watershed interests such as stream quality and biological units in which studies on land use change should be undertaken.

2.5.2 Land Use Change and Effect on Soils

Soils occupy a unique position in the lithosphere and atmosphere. They are a transition that is linked to both the biotic and the abiotic environments. Since many processes are linked within the soil zone, they can reveal more about an area than any other natural factor (Steiner, 1991). Land use and land cover changes have notable impacts on the soil, among them soil erosion and deposition. The two are however segments of the same process of redistribution of mineral materials across the earth's surface. In the process, particles eroded from one site or kind of soil are deposited on another soil at a lower elevation (Ruhe, 1969). Erosion and deposition are natural processes that have shaped the land surface through the history of the earth. Human action however dramatically influence their rate and spatial

distribution. This is through manipulation of land cover and vegetation and the mechanical loosening of the surface of the soil through cultivation (Meyer and Turner, 1994).

Within the conceptual representation of soil formation as a function of climate, biological organisms, relief or slope, parent rock material and time, mankind has been observed to have predictable influence on soil. Man manipulates natural soil cover for specific reasons. Boul (1994) lists five of the reasons for man's interference with soil cover.

1. Man harvests plants and consumes them at locations distant from where they grew
2. Man is selective in the type of vegetation he requires for food. He therefore alters the natural vegetation cover to favour the growth of those species that satisfy his needs and desires. In doing so he seeks to eliminate crop competition by destroying other plants and animal forms of competition thus leaving the soil surface exposed for various periods of time.
3. Man is impatient. He seeks to grow his desired crops as rapidly as possible to reduce the time between harvests and also to reduce the time in which to protect the crops from competitive species.
4. Man has the ability to alter soil moisture conditions through irrigation and drainage, alter slope by terracing and to augment the soil nutrients by use of fertilisers.
5. In extreme cases, man can completely remove and replace soil by forming new soil as in the restoration of mine spoils or in extreme cases of urban landscaping.

Larson et al., (1984) notes that not all soils in a landscape hold the same potential for erosion. The same amount of accelerated erosion may severely damage some soil and limit the future production, but have little effect on some other kinds of soil. Soil erosion hazard may be considered as the susceptibility of soils to erosion agents. According to Steiner (1991), the rate of erosion caused by water is measured by the universal soil loss equation shown below;

$$A=KRSCP$$

Where,

A= Soil loss per unit area

R= Rainfall

K= Soil erodability

S= Slope factor

C= Land cover factor

P= Erosion control practice.

When the soil surface is not protected by vegetation cover, the rate of erosion is increased. In most of the accelerated erosion scenarios associated with crop land use, erosion occurs when fields are cleared of vegetation to prepare for crop farming or when vegetation is removed by grazing animals. Physical erosion is also made more severe by previous farming methods that reduce soil fertility, slow vegetative growth and expose the soil surface to direct raindrop impact (Steiner, 1991).

Oldeman et. Al., (1990) observe that although globally soil erosion due to water is extensive, only about 10 percent of the adopted mapping units are affected and majority of these only to a light or moderate degree. They however conclude that although such areas are still suitable for use in local human settlement, changes in the land use methods to include conservation practices are necessary to ensure that erosion does not deteriorate and that gradually, these areas can be rehabilitated.

2.5.3 Hydrology and Land Use Change

Newson (1997) identifies four major and direct impacts of land use change on the hydrological cycle and water quality in a watershed. They can cause floods, drought, and change in river and ground water regimes and changes in water quality. While the first three impacts deal with water quantity, the last deals with water quality.

2.5.3.1 Changes in Water Quantity

Changes in Land use and land cover often cause substantial changes in the flow of water. Clearing of forests can cause flooding in local streams. The destruction of vegetation by overgrazing can lead to reduced infiltration into the soil with subsequent impact upon renewal and replacement of the vegetation and increasing desiccation. The disturbance of

land cover can also make less water available for ground water recharge leading to a new regime for the ground water resource. The base flow of perennial rivers can be seriously affected by such a reduction of ground water returns to the rivers with more of the flow being concentrated in flood or peak periods and less during the dry periods (Newson, 1997).

2.5.3.2 Changes in Water Quality

Human use of land may introduce many pollutants into the aquatic ecosystems. Cutting of trees can lead to increments of sediments reaching the streams and such sediments can seriously disrupt the natural aquatic ecosystems. A change in turbidity may disrupt the feeding and breeding of many surface feeders and also inhibit the action of sunlight in stimulating algae growth. Widespread use of fertilisers in agricultural fields introduce large amounts of plant nutrients which accelerate eutrophication, a process which promotes plant growth, depletes dissolved oxygen and which may kill aquatic life, change ecosystems and make water unfit for drinking. Bacterial pathogens, viruses and parasites from untreated sewage can cause diarrhoea and other diseases. Heavy metals and toxic chemicals contaminate sediments and bio-accumulate in fish in plants, exposing organisms throughout the food chain to toxins, which may cause diseases and birth defects (Van Lier et al., 1994).

The sources of the pollutants may be categorised into *point* and *non-point sources*. While agriculture and forestry are the main non-point sources (NPS), of pollution, urban storm runoff and combined sewer overflows are the major point sources of aquatic pollution. Traditionally point sources of pollution have been given more attention, being the most observable causes of pollution. It has of late come to be realised that the NPS contribute more to aquatic pollution than the point sources. Rodgers (1994) observes that in America, NPS contributed more pollution to aquatic environmental pollution in 1984 than the point

sources. The implication of this observation to water quality management is that time has now come to shift emphasis of regulatory programmes away from an *end-of-the-pipe* point source control to control of NPS (Meyer and Turner, 1994). There is consensus among experts that the technological means for controlling NPS runoff exists and that development of technology is no longer the paramount objective. The diffusion and adoption of that technology then takes precedence. This is best achieved by land use control and management practices that take recognition of the need to protect fragile ecological system from Non-Point Pollution involving community awareness and involvement (Rodgers, 1994).

2.5.4 Withdrawal and Diversion of Water

Changes in land use often result to changes in the status of both surface and groundwater resources. The impact of surface activities on subsurface hydrology is especially often neglected. Ground water is important for several reasons; it forms the major water supply source in most parts of the world especially the rural areas. Where not the major source, the inherent values of ground water (purity, constancy and extent), make it an important resource to moderate and modulate the surface water regime and surface ecosystems. Generally, ground water systems react slowly to surface impacts but more profoundly. The costs are also greater in rectification of ground water condition once damage is done (Newson, 1977).

While underground hydrology at the global level has been extensively studied with geophysical techniques to a point where it can be modelled, a major problem of lack of knowledge of subsurface processes exists at the local scale. It is however true that few parts of the earth's land surface are truly impermeable and that subsurface water exists almost everywhere in either deep or shallow aquifers. Surface rivers often interchange water with

the aquifer with important benefits for abstraction by both human and plant communities. In the humid tropics where surface water is bound to be associated with water borne diseases, ground water becomes of paramount importance (Newson, 1997).

Surface water abstraction for irrigation often lead to significant reduction in river flows There are also problems associated with abstraction of ground water at a rate higher than that of the aquifer recharge leading to an overdraft. This depletes the volume of water thus destroying habitat for plants and animals. It also leads to high levels of salination by making it difficult for water bodies to assimilate pollution loads (Rodgers, 1994).

2.6 The Land Use Planning Process

Land use planning is a prerequisite to sustainable development (Habitat, 1994). It has been described as the centre-piece of Urban and Regional Planning, as it is concerned with the best use of land in view of accepted objectives, environmental and social opportunities and constraints (Roberts, 1988). Lovejoy, (1973) describes it as the planning for the most appropriate use of land while Chapin, (1979), views it as being concerned with the location, intensity and amount of land for various space using activities. Dent (1988), describes land use planning as a systematic process for guiding land use decisions such that land resources are put to the most beneficial use while conserving resources for future use.

While the specific objectives of Land use planning will depend on the local situation, the overall concern should be the formulation and implementation of plans, projects, programmes and policies to reach sound use of land. This should include efficiency in the use of land resources, equity between the competing uses and a balance between short-term benefits and long-term conservation of the resources (FAO, 1994). It then becomes evident

that Land use planning may be undertaken at any level of government, private individuals and corporate bodies. Samson (1975) describes Land use planning as the governmental process that directly regulates or influences the use of land not directly owned or directly controlled by the planning agency. This view of Land use planning differentiates it from land management planning and land development project planning.

Chapin and Kaisser (1979), identify six distinct elements in the rational Land use planning process. These are problem identification, definition of goals and objectives, determination of alternative solutions, formulation of plans, selection and implementation of the preferred plan and finally monitoring and evaluation of progress. Land use planning is therefore a cyclic process involving continuos scanning of the environment, analysis of the findings and formulation of strategies to help achieve development goals of the community.

The concept of scanning of the environment is of particular importance to planning. Scanning is important in the initial formulation of plan goals and objectives. It also becomes important in monitoring the plan impacts and achievements. For land use planning, scanning involves a survey of the initial land use and then monitoring of the changes in land use over certain epochs of time. Such a monitoring not only helps in knowing the outcomes of certain land use policies but also aids in assessing the likely environmental impacts of changing land use. The aspect of scanning or monitoring is especially important in that it aids in the compilation of a knowledge base for land use planning. It also provides a continuos source of information that could be used to judge the outcomes of plan policies and show where adjustments are necessary (Addink, 1999).

2.6.1 Land Use Decision Making

Decision making in land use is an extremely complex process and its investigation is fraught with difficulties. Few researchers have the necessary breadth and skills in relevant fields such as agriculture, economics, sociology and psychology among other sciences to properly investigate the issue. The problem then requires a multi-disciplinary attention. Mather, 1986 identifies seven factors that influence land use decision making. These are type of land ownership, environmental perception, information available, age, education, personality and socio-personal factors and cultural factors. He also identifies three layers or levels of decision making about use of resources in general and land in particular. To be selected a type of use must be perceived as physically possible, acceptable within the cultural milieu and have a perceived utility (Hill, 1989, Edmunds and Kyle (1991). Firey (1960) sums up these requirements as possible, adaptable and gainful.

2.7 Land Use Change Research

Throughout the world, planners and policy makers have to make strategic decisions on environmental protection, infrastructure development, land development and land administration. In many developing countries, they rarely have access to up-to-date base maps and systematic information on the extent of settlement, land use patterns, environmental problems and infrastructure (Paulsson, 1992). A reliable information base is essential for strategic decision-making. Lack of information contributes to problems, among them the disregard of environmental impact of changes in land use.

In the definition and analysis of the problem, inventories of the natural environment and the existing land use in an area are required. While traditionally such an inventory was used to determine environmental constraints to development, there is currently a growing emphasis

on environmental conservation for sustainable development. New methodologies for inventorying and analysis of natural environmental factors in Land use planning have then been advanced. Changes and trends in land use are of particular concern.

2.7.1 Focus of Land Use Change Research

Although much research has been done in the field of land use change, there is yet to emerge a consensus as to what ought to be the focus of such studies. The question of the focus in land use change research has also been debated with no one answer being agreed upon. The International Geosphere-Biosphere Programme (IGBP, 1993) in its study on *Relating land Use and Global land Cover Change* concludes that;

> The main focus of research on land use change should be in detailed investigation of changes in rural land use change. This view is based on the observation that rural land use comprising of agriculture and forestry occupies most of the land surface on earth. It is estimated that the area covered by built up areas covers less than one percent of the earth's total area. In contrast, areas used for agriculture and pasture cover close to 40 percent of the global area (IGBP, 1993, Meyer and Turner, 1994).

While admitting the spatial dominance of rural land use, Heilig (1995) argues that rural land is just but one of the processes that shape global land use and land cover. He observes that there are other probably more important land use changes which are caused by urbanisation, infrastructure expansion, industrial expansion or changes in consumption patterns and lifestyles. He laments that the effect of such a conception is that;

> Books and papers on land use change are somewhat monotonous, tending to address just the two subjects, (trends in deforestation and agriculture). Such studies treat areas of settlement and infrastructure as being so small in size that they are irrelevant (Heilig, 1995).

Heilig's main concern is in that while changes in the built-up land might affect only relatively small areas as compared to the extensive areas of forests and agricultural land, they are however more persistent and intrusive. Economic modernisation and urbanisation also cause changes in rural land use. Changes in rural land use are then often caused by

driving forces, which emanate from the urban centres. He wonders why researchers on land use change usually view the world as a rural place, portraying areas of infrastructure and settlement as so small in size as to be insignificant. Heilig goes on to conclude that by observing today's rapidly expanding urban areas at the expense of arable and forestland;

> It is absurd from a demographic and economic point of view to focus land use change research on rural and forest areas alone. Urbanisation has become the basic driving force to land use change. Agricultural and forest sectors are no longer driven exclusively by food and resource demands. They also have to provide for the numerous needs and rapidly changing urban lifestyles. Consumption patterns in these areas can trigger fundamental land use changes in the rural areas. Rural land although still large in size is then slowly becoming the hinterland of urban areas, which are more and more determining how land will be used. (Heilig, 1995)

Land use has then to be studied as a multi-dimensional process which links activities in various sectors to changes in land cover. Both rural and urban land uses have to be seen as constituting one phenomenon. The rural land use is important as the dominant contributor to the spatial land cover. Urban land use is also significant because of the intensity and relative permanence of its impacts and its influence on rural land use change. An attempt should then be made to have land use change research address both urban and rural land use.

2.8 Institutional Aspects in Land Use, its Change and Control

Institutions are rules of society or of organisations that facilitate co-ordination among people by helping them to form expectations, which each person can hold in dealing with others (Rutatan and Hayami, 1990). Institutions can also be defined as humanly devised constrains that shape human interactions, whether political, social or economic. They consist of informal constraints and formal rules and their enforcement characteristics. Institutions are then a way of doing things, usually reflecting formal and informal rules and norms influencing the boundaries and interactions between individualism and social co-operation (Mwangi, 1998).

Institutions are usually developed by users of shared resources, as a way of agreeing on a set of rules to govern the use of these resources. Institutional frameworks can have widespread effects upon incentives and disincentive structures that can operate for environmental management. Institutions are central in social bonding, in social functioning and in influencing the relationship among organisations (Pugh, 1996). They have possibilities to express comparative advantage and therefore major impact on social, economic and environmental development.

Various institutions including households, firms, government agencies, Community Based Organisations (CBOs) and Non-Governmental Organisations (NGOs), each has characteristic comparative advantage. Firms have comparative advantage in entrepreneurship, government agencies in policy making, setting property rights and in institutional reform, NGOs and CBOs in mobilising household efforts and households have advantages in some aspects of personal and social development.(Coarse, 1996). Institutions in the context of this study can then be taken to mean arrangements for conducting specific affairs regarding land use planning and environmental management.

Valenzuela, (1989) notes that for effective planning and environmental management, timely, accurate and cost effective information on land use and its dynamics is vital. In the current era of information technology, this calls for the use of modern information technology in the gathering, processing management and analysis of land use change information. Land use information management technology can only be successfully applied after institutional, procedural and information quality issues have been addressed.

Burrough (1986) suggests that in developing a land use change monitoring framework, there must be a management policy dealing with institutional mandates and linkages, strategies, human skill development and financial management. The first step should then include identifying the potential collaborating agencies, defining the information needs, setting priorities and then comparing these with the existing information and capabilities of data producers and users. In improving information management, the major costs are data acquisition, institutional improvement, education and training. Equipment on the other hand will represent less than 20% of the costs in developing and managing such a system. One successful institutional model is to set up a network of information sharing agencies. Different agencies retain responsibility for their own information and agree to share parts that are of interest to others. A separate regional or municipal agency can handle inquiries for data and act as a co-ordinator and a catalyst in the network (Burrough 1986)

Burrough however warns that a high level of technology does not necessarily produce better results. It takes little effort to create the institutional structure or reach the basic level of technology needed to start applying a land use information system. Education and training at all the levels should be an integral part of the strategy. Amount and type of information needed depends in part on the level of technology needed. Training of hands-on users should however be accompanied by education of managers about concepts so they can make wise decisions on its use.

2.9 The Political Economy of Land in Kenya

The value of land to the Kenyan social economic and political life is best described by In his book *Back to Land*, he argues that;

> Our greatest asset lies in our land. In land lies our salvation and survival. It is in this knowledge that we fought for the freedom of our country. Whatever our plans for the future, they must spring from a

resolve to put maximum production of our land *however small the acreage we may possess* (Kenyatta, 1964).

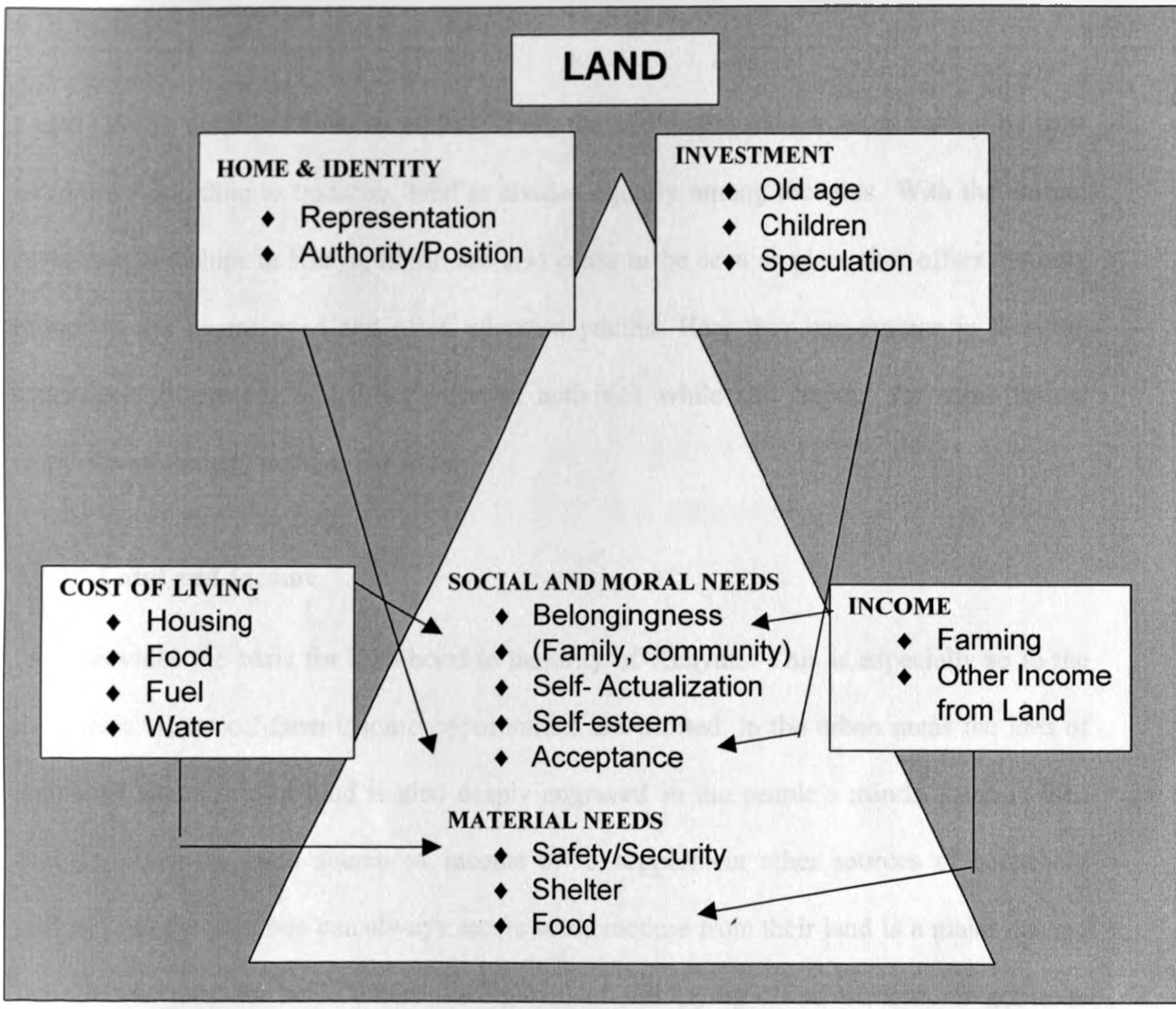
Mbithi (1980) observes that land has been a matter of crucial importance in Kenya *not only for economic considerations but also – and more so, in regard to culture, existence and ontology.* Kenyatta (1978) says this had been so in the pre-colonial era, when land ownership was the foundation rock of the tribal economies. During the colonial era, there was establishment of scheduled areas and African reserves. This led to increase in land problems and the importance of land in the eyes of the African was increased even more. The post colonial period was then characterised by a scramble for land which was seen as a dwindling resource. Land is then currently the most sought asset, be it in the rural or urban areas of Kenya (Mbithi 1980).

Kohler (1987) identifies four functions that land fulfils to the African. These are as a home, contributor to income, reduction in the cost of living and as a form of investment. Figure 2.1 below demonstrates these relationships. The crucial point, he notes is that through the acquisition of land, not only the material needs like food or shelter are met but also social and moral needs which in contrast to the material ones do not respond to physiological deficiency but to the desire for self-actualisation.

2.9.1 Land as Home and Identity

Muriuki, (1984), notes that to the Kenyan, the term home has several meanings. To many, it is a place that provides identity. Land also acts as a representation of the people, where representation here goes beyond the living to include the dead and the unborn. This attitude is deeply entrenched even in the most *sophisticated strata* of the Kenyan community. To many, to be buried in a cemetery is unpropitious. They have to be buried on their land so that they can *always be remembered.* Many people then buy land as a place to *die and rest.*

Figure 2.1: The Functions of Land



Source: Modified by Author from Kohler (1987)

Home is also a concept that improves or enhances the position of the household head and even the spouse. Since the land is theirs, it is the place where they are free in decision making and are their own masters. In this connection, land ownership provides identity. Home is also a place that offers security, especially due to the formal security of land ownership, symbolised by land registration and the issue of title deeds. This is seen as '*Land*

that no one can take away from the legal owner'. This concept is a result of the colonial land policy and the feeling that land as a resource is dwindling. (Kohler, 1987).

Dutto (1975), describes *home* as a place where the aged retire and are taken care-of by their children. According to tradition, land is divided equally among the sons. With the current economic hardships in Kenya, home has also come to be seen as place that offers the only refuge to the unemployed and often educated youths. Here they can engage in farming, small-scale businesses and other informal activities while still hoping for some formal employment, mostly in the urban areas.

2.9.2 Land and Income

Land provides the basis for livelihood to majority of Kenyans. This is especially so in the rural areas where off-farm income opportunities are limited. In the urban areas the idea of individual ownership of land is also deeply engraved in the people's minds. Land is then used as either the main source of income or to supplement other sources of household income. The fact that one can always secure some income from their land is a major driving force in the quest for land. Where unemployment and laying off of workers are common phenomena, the initial goals of many Kenyans is to buy land as soon as they save enough from either business or employment or even agricultural sources (Kohler, 1987).

2.9.3 Land and the Cost of Living

To most Kenyans both in rural and urban areas, land ownership is a sure way of reducing the cost of living. In the urban areas, one would significantly reduce their expenditure by buying a plot and building a home than by renting a house. In the rural areas land ownership is not only a cheap way of getting a home but is also far much cheaper than living in rented land. A

common practice is where men buy land in the rural areas and leave their spouses and children to live and work there while they engage in wage employment in the urban areas. According to the World Bank (1982) the difference between the cost of living in the urban and rural areas differed by almost 70%. Many people therefore prefer to own land and stay in the rural areas as a way of reducing the cost of living.

2.9.4 Land as Investment

With an economy that is prone to high inflation rates, land is considered by far the best form of investment. In the former scheduled areas like Nakuru, land prices generally increased at a higher rate than inflation in the first two decades of independence. This influenced people's conception of land as a way of safeguarding wealth against inflation and as a means of speculation. In many parts of the country, the rich buy large tracts of land then wait and subdivide for sale several years later, thereby making good returns on the initial investment (Kohler, 1987, Dutto, 1975,).

2.10 Conceptual Framework

Based on the above review, the conceptual framework of the study is given below. This starts by recognising land as the basis of all human activity. As the natural resource base, it includes soils, mineral, water, plant and animal species to which man assigns some utility in order to meet his needs. The interaction between man and his environment is governed by the prevailing social, economic and political conditions. Urbanisation and demographic factors are especially important in determining people's interaction with the land resources. The interaction lead to land use change, which cause negative environmental effects. Among these are soil degradation, deforestation, loss in biological diversity, pollution of terrestrial and aquatic environments and loss in landscape beauty.

These effects on environment are then the essence of land use survey, including monitoring and analysis of the changes in land use. In undertaking such surveys, various methodologies are used to acquire the necessary categories of information. Aerial photographs and satellite Remote Sensing provides information on land cover from which land use can be inferred. This is supplemented with field methods like questionnaires, Rapid Rural Appraisal and Participatory Rural Appraisal. After data has been gathered, GIS provides the data management and analysis facility. By monitoring land use change, trends in land use and the consequent environmental effects would be revealed and therefore take mitigating measures. The analysis should then lead to land use planning and policy guidelines, as an intervention to ensure a more sustainable use of land resources. This is effected by agencies of the society including households, Local authorities, Central Government agencies, NGOs and CBOs. These relationships are illustrated by figure, 2.2 below.

2.11 Definition of Operational Terms

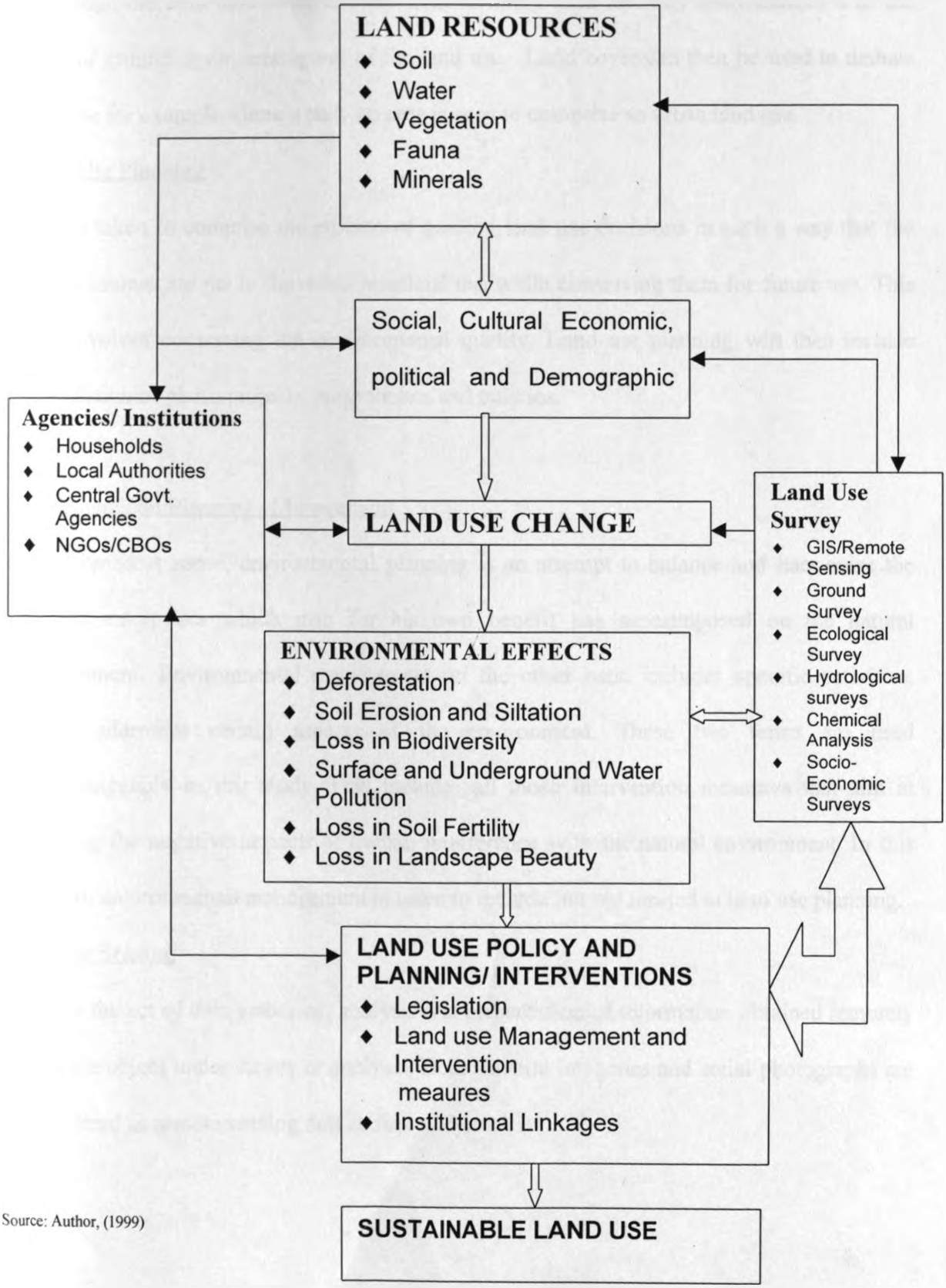
Land

The study adopts a broad definition of land to include the earth's soils surface and the biophysical environmental. In this way land is taken to be synonymous to land resources.

Land Use

This study takes Heilig's definition of land use as the accommodation in spatial terms, of all man's activities on land and the way in which the land surface is adapted, or could be adapted to serve human needs. In this context the decision to leave the natural environment undisturbed will also constitute land use as conservation areas.

Figure 2.2: Conceptual Framework



Source: Author, (1999)

Land Cover

Although the term land cover is often used to imply land use, this study defines it as the form of ground cover, arising out of the land use. Land cover can then be used to deduce land use for example where a built-up area is seen to comprise an urban land use.

Land Use Planning

This is taken to comprise the process of guiding land use decisions in such a way that the land resources are put to the most beneficial use while conserving them for future use. This also involves conserving the environmental quality. Land use planning will then include formulation of plans, projects, programmes and policies.

Environmental Planning / Management

In its broadest sense, environmental planning is an attempt to balance and harmonise the various enterprises which man for his own benefit has superimposed on the natural environment. Environmental management on the other hand includes specific activities, which addresses certain aspects of the environment. These two terms are used interchangeably in this study. This includes all those intervention measures that aim at reducing the negative impacts of human interference with the natural environment. In this context, environmental management is taken to include but not limited to land use planning.

Remote Sensing

This is the act of data gathering, analysis and presentation of information obtained remotely from the object under survey or analysis. Both satellite imageries and aerial photographs are considered as remote sensing data in this study.

Geographic Information System (GIS)

This is taken to be a system for collecting, inputting, processing, integrating, analysing, modelling and reporting information related to the earth surface. Although this could be a manual information system, the study puts more emphasis on computer based systems.

Ground Truthing

This is a process of validating the accuracy of image interpretation by visiting sites of the study area and checking whether the interpretation coincides with the ground condition.

Data/Information

Data is taken to imply a set of facts or figures, which have been collected in a systematic manner and from which conclusions may be drawn. Information on the other hand comprises data that have been processed in order to have meaning. In this context, what constitutes information for a certain purpose may be merely data for another type of operation.

Biophysical Environment

This includes all the biological and physical characteristics of an area.

Catchment, Basin and Watershed,

Essentially, drainage basins and watersheds are the same thing, (catchment areas), In this study the terms are used interchangeably as implying the same thing.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This study aims at analysing land use changes within Lake Nakuru catchment in three epochs. Land use surveys are then undertaken for the years 1973, 1987 and 1999. Land use change within the study area is perceived as a consequence of demand for land for urban development, agricultural and recreational purposes. The study seeks to establish trends in land use and identifying what changes are occurring and where they do occur. The study also seeks to relate the changes to physical, biological and human settlement factors in order to increase understanding on the land use change process and its implication to environmental conservation. By classifying land use activities, the study provides a framework for future land use change monitoring, forecasting and analysis using Remote Sensing and Geographic Information Systems (GIS) techniques. The methodology adopted to achieve the study objectives is discussed in this chapter.

3.1 Data Types and Sources

Various data types were required for the study. Some of these were already available from various sources and were accessed as secondary data. Others data types were not readily available and had to be got from the field as primary data. The various data types and their sources are given below.

3.1.1 Land Use Data

This study is based on the use of Satellite Remote Sensing data in a multi-temporal land use study. Remote Sensing and ground truthing were then incorporated in a land use survey

exercise. A base map of the catchment was prepared by selecting parts of five Survey of Kenya 1:50,000 Topographic Map sheets, areas that are incorporated within the Lake Nakuru Catchment. For ease of handling as one map sheet, the scale of the five map sheets was reduced to 1:100,000 using a Large Format Frame Camera. Transparent positive prints were then made of the various sheets and these were joined to make one base map.

In order to map land use, it is necessary to first classify the various categories of use within the area of interest. Land use classification is a hierarchical process where a certain class can be desegregated to classes of a higher order. Although the classification scheme used in this study obeys this general rule, only the first level of classification was used in the analysis. Land use categories used are then general, but with capability of being desegregated to more specific categories. Built up areas were for example jointly classified under urban land use, but this could be broken up to industrial, commercial, residential, etc, and yet each of these uses can be further broken down. Large-scale farms can also be categorised as to whether they are crop or dairy farms and the crop farms could be further classified as to the specific type of crop. Each of this land use would have significantly different environmental impacts. Different crop types for instance protect the soil against erosion to different degrees. The breaking down of these land uses can aid in detailed environmental impact analysis of the land use. Due to the general land use classification used in this study, the environmental impacts are also dealt with in a general manner.

For current land use, a Landsat Thematic Mapper (TM) Satellite imagery of 1995 was interpreted visually for land use class types. This was supplemented by 1993 aerial photographs at a scale of 1:12,500 which were available for some parts of the catchment. The exercise started with design of a land use classification system. This was facilitated by

personal knowledge of the study area and a prior field visit to appreciate the existing land use class types. The classification scheme was then used in interpretation of the satellite imagery. Seven broad categories of land use were identified in the area as shown in table 3.1 below.

As a way of confirming the interpretation various sites representing all the identified land use categories were visited in the field. A total of 100 sites were randomly picked from the map by overlaying it with a grid and taking each grid square as a point. The chosen points were then visited to compare the actual land use to the interpretation. This field survey also helped in identifying areas where land use had changed since 1995 and therefore served as a way of updating the 1995 imagery to the current ground situation. In the field, the prevailing land use conditions were observed and captured using photography. Reference was also made to published maps, previous study reports and other secondary data types in the preparation of the land use map.

Historical land use maps were prepared for the years 1973 and 1987. For 1973, a Landsat Multi-Spectral Scanner (MSS) imagery was used. For 1987, a Landsat Thematic Mapper (TM) imagery was used. The imageries were initially in the form of transparent positives. These were scanned using a high-resolution drum scanner and then printed at a scale equal to that of the base map. Land use categories were then delineated by visual interpretation on the imagery to give the respective year's land use pattern map. Just as in the current land use survey, reference was also made to published maps, previous study reports and other secondary data types. Each of the imageries with delineated land use pattern was overlaid on the transparent base map and using common features, as good an overlay as was possible

was made. Each of the land use patterns was then digitized into an Arc/Info Geographic Information System (GIS) database.

Table 3.1: Land Use Classification Scheme for Lake Nakuru Catchment

LAND USE CATEGORY	SYMBOL
Urban Land	I
Small Scale Farmland	II
Large Scale Farmland	III
Forestland	IV
Menengai Crater	V
Lake Nakuru National Park	VI
Rangeland	VII

3.1.2 Household Data

A field survey was conducted to acquire socio-economic data. A household questionnaire was administered in selected sample areas to assess some socio-economic information relevant to land use and its change. This included farm holding sizes, family structures (sizes, composition, educational levels, occupations and incomes), farming methods, other land use activities, land tenure and the attitude or intentions of the land owners on their land. Other field instruments included scheduled interviews with officials of central government departments, the Nakuru Municipal Council, Nakuru County Council, and Members of the District Development Committee, Members of the Land Control boards and Non-governmental organisations, (NGOs). Central Government departmental heads interviewed included the District Physical Planner, the District Lands Officer, the District Forestry

officer, and the District Agricultural officer. Discussions were also held with the Nakuru Municipality Physical Planning Officer the Provincial Physical Planner, the Provincial Forestry Officer, the Kenya Wildlife service and World Wide Fund for Nature (WWF) personnel.

3.1.3 Socio-Economic Data

Central Bureau of Statistics (CBS) census reports for 1969, 1979 and 1989 were used for demographic information. A household questionnaire for the sampled areas also provided some demographic characteristics. The relevant demographic features included population size, family sizes and structures, occupation types and income levels, places of employment and land ownership patterns and generally, people's views and intentions on land. The farm holding sizes, farming methods employed and the environmental awareness of landowners were also assessed.

3.1.4 Physical and Climatic Information

Survey of Kenya 1:50,000 map series provided the topographic information. This also provided the base map on which all other information was superimposed for spatial analysis. The exploratory soil map of Kenya (Sombroek *et. al*, 1982) provided the general soil information including characteristics, landforms, slope/gradient and geology of the area. This was supported by the numerous past studies conducted in the area on geology and soils. The study also borrowed from the numerous hydrological studies undertaken within the study area and its surrounding. The Agricultural Handbook of Kenya (Jaetzold and Schmidt, 1983), provided information on climate and agro-ecological zones.

3.2 Sample Frame

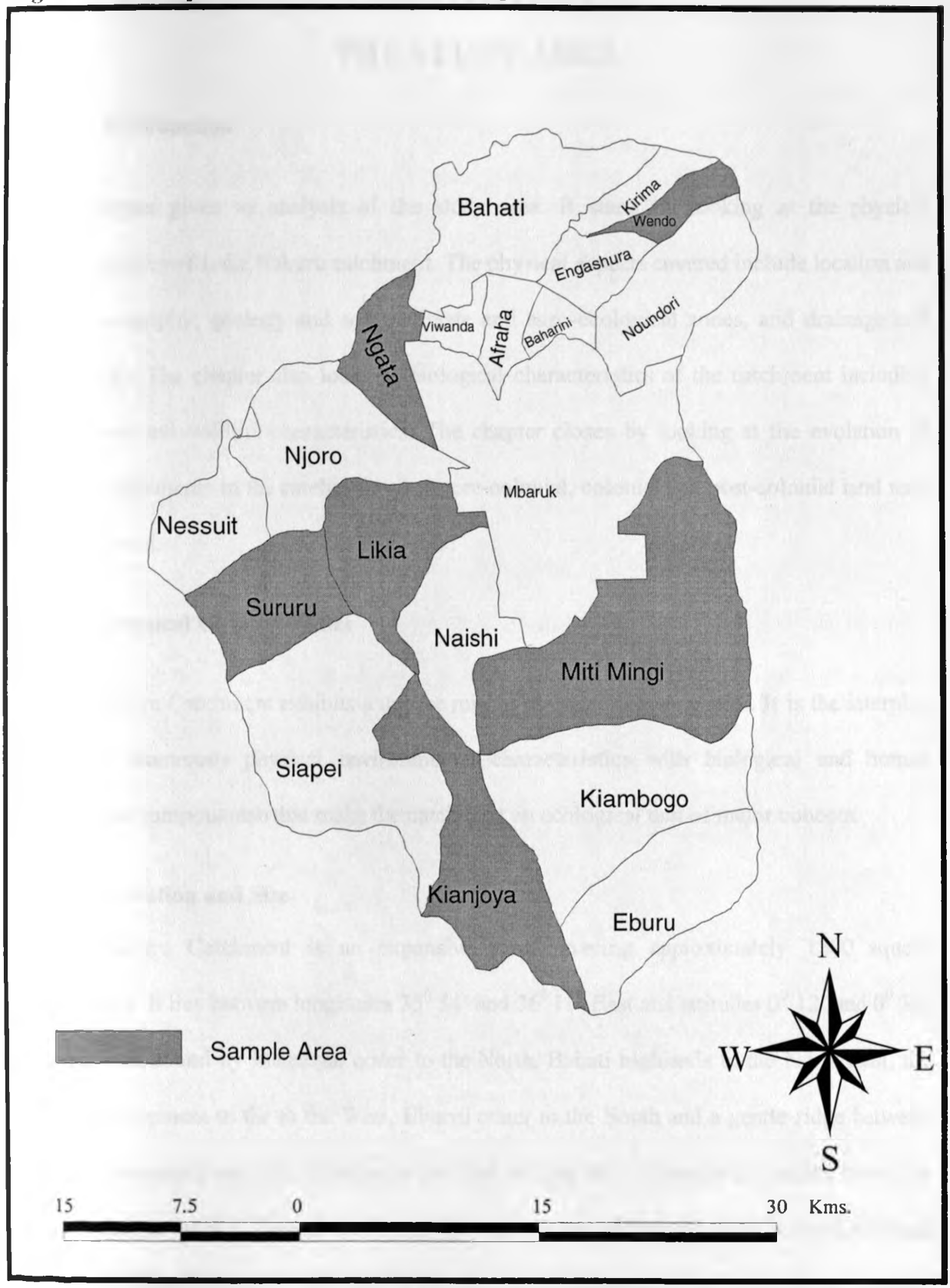
Land use was mapped for the entire catchment for the three epochs (1973, 1987 and 1999). To ascertain the accuracy of land use mapping, field checking was undertaken. One hundred sample points were chosen randomly by placing a one centimetre grid on the area map and numbering the various squares. Taking the centre of the square as the sample point, the points were visited on the ground and the existing land use compared with the classification on the map. This also helped to resolve doubtful and unclassified areas.

Household questionnaires were undertaken in selected sample areas. There are a total of seventeen sub-locations that fall within the Lake Nakuru Catchment. Six of these were chosen randomly as representatives and household questionnaires administered in each. The sample sub-locations are shown in figure 3.1 below. In total forty-two questionnaires were administered giving an average of six questionnaires per sub-location. In choosing respondent institutions and organisation the most relevant and all encompassing organisations were chosen as the ones that would provide the maximum amount of data

3.3 Data Analysis and Presentation

This study relied on the use of Remote Sensing techniques for the acquisition of land use information. Field survey was used in the acquisition of socio-economic information. The Pc Arc/Info software was used to integrate and analyze land use changes. While Remote Sensing served as a data capture method, GIS provided the analysis tool. The two techniques then offered a synergy that is quite useful in environmental assessment applications. Various analyses were then undertaken to display the trends in land use over the study period. This included calculation of absolute changes in the area under various land use categories, representation of these as percentages and time series analysis. The results of the analysis are represented as maps charts and tables.

Figure 3.1: Sample Areas For Household Questionnaire



Source: Adopted From Survey of Kenya Administrative Areas Map

CHAPTER FOUR

THE STUDY AREA

4.0 Introduction

This chapter gives an analysis of the study area. It starts by looking at the physical characteristics of Lake Nakuru catchment. The physical aspects covered include location and size, topography, geology and soils, climate and agro-ecological zones, and drainage and hydrology. The chapter also looks at biological characteristics of the catchment including vegetation and wildlife characteristics. The chapter closes by looking at the evolution of human settlements in the catchment where pre-colonial, colonial and post-colonial land uses are reviewed.

4.1 Physical Characteristics

Lake Nakuru Catchment exhibits a unique mix of physical characteristics. It is the interplay of these numerous physical environmental characteristics with biological and human settlement componentsb that make the catchment an ecological unit of major concern.

4.1.1 Location and Size

Lake Nakuru Catchment is an expansive area covering approximately 1800 square kilometres. It lies between longitudes 35^0 54' and 36^0 11' East and latitudes 0^0 12' and 0^0 36' South. It is bound by Menengai crater to the North, Bahati highlands to the North East, the Mau- Escarpment to the to the West, Eburru crater to the South and a gentle ridge between Lake Elementaita and Lake Nakuru to the East. Within the Catchment is Nakuru town, the fourth largest town in Kenya, 180 Km to the North West of Nairobi, Lake Nakuru National Park and Menengai crater. The Lake is situated sixty Kilometres to the South of the Equator.

It lies two miles south of the centre of Nakuru town with the Southern suburbs of the town coming to the park's boundary and to within one mile of the lake's shores. Railway and road links from Mombasa to Uganda, Southern Sudan, North Eastern Zaire and Rwanda pass through Nakuru town. Figure 4.1 below shows the location of the catchment in the national context, while Figure 4.2 shows its location within Nakuru District.

4.1.2 Topography

Menengai Crater at an altitude of 2240 meters forms the Northern rim of the catchment. To the West and Southwest of the Lake, rolling hills run up to the Mau Escarpment reaching an altitude of 30348 meters to give the highest point within the catchment. The Plains to the East and South rise slowly to the ridge above Lake Nakuru which is the lowest point within the catchment at an altitude of 1758 meters. The plains to the East and south rise slowly to the ridge above Lake Elementaita and to the Eburru mountains, a spur of the Mau Escarpment at an altitude of 2750 meters. Plate 4.1. below captures a panoramic view of the Catchment, taken from the Southern end.

The terrain of the catchment could be classified as hilly, rolling, undulating, gently undulating and flat terrain zones. The hilly zone with a slope of between 16 and 30 percent is the steepest and includes the areas around Eburu Crater. This is followed by the Rolling terrain zone having a slope of between 10 and 66 percent and mostly in the Ndundori forest, Mau Ranges, Menengai forest and the Lion Hill, A large section of the catchment falls under the undulating zone extending right from the Mau Ranges to Njoro. This zone has a slope of between 5 and 10 percent and merges with the gently undulating terrain zone with a slope of between 2 and 5 percent. The last zone is the flat land with a slope of less than 2 percent and

Figure 4.1 Location of The Study Area in Kenya

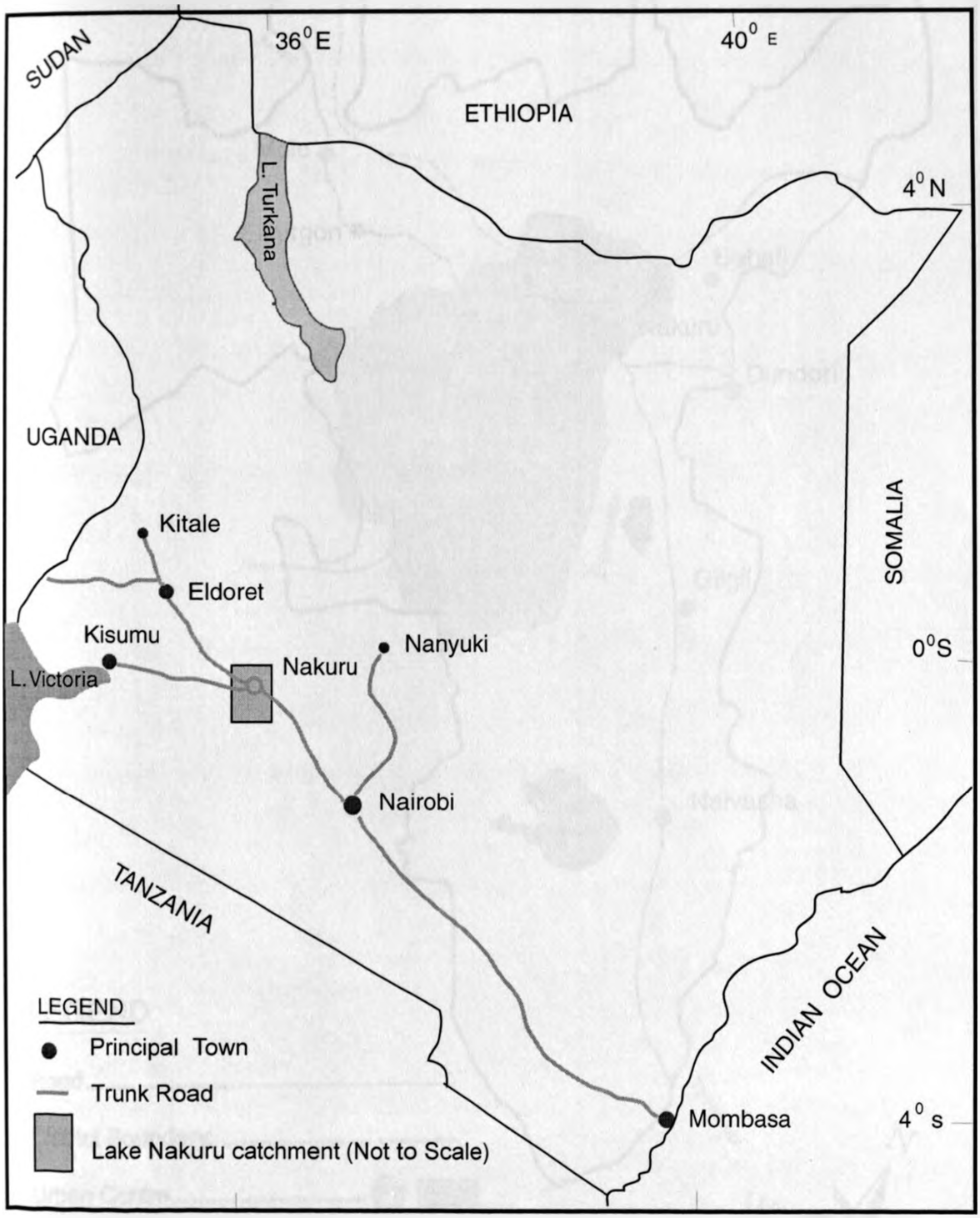
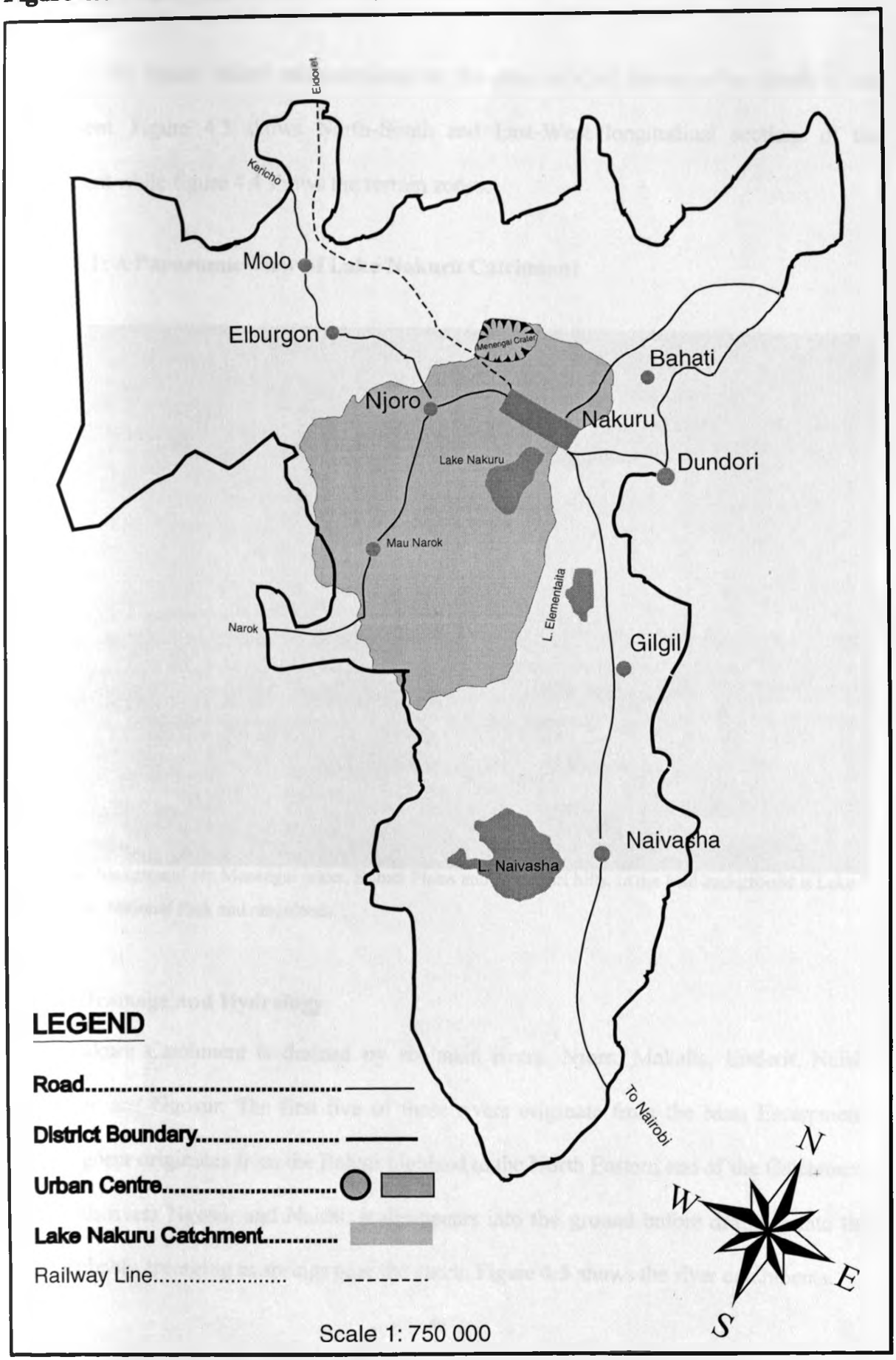
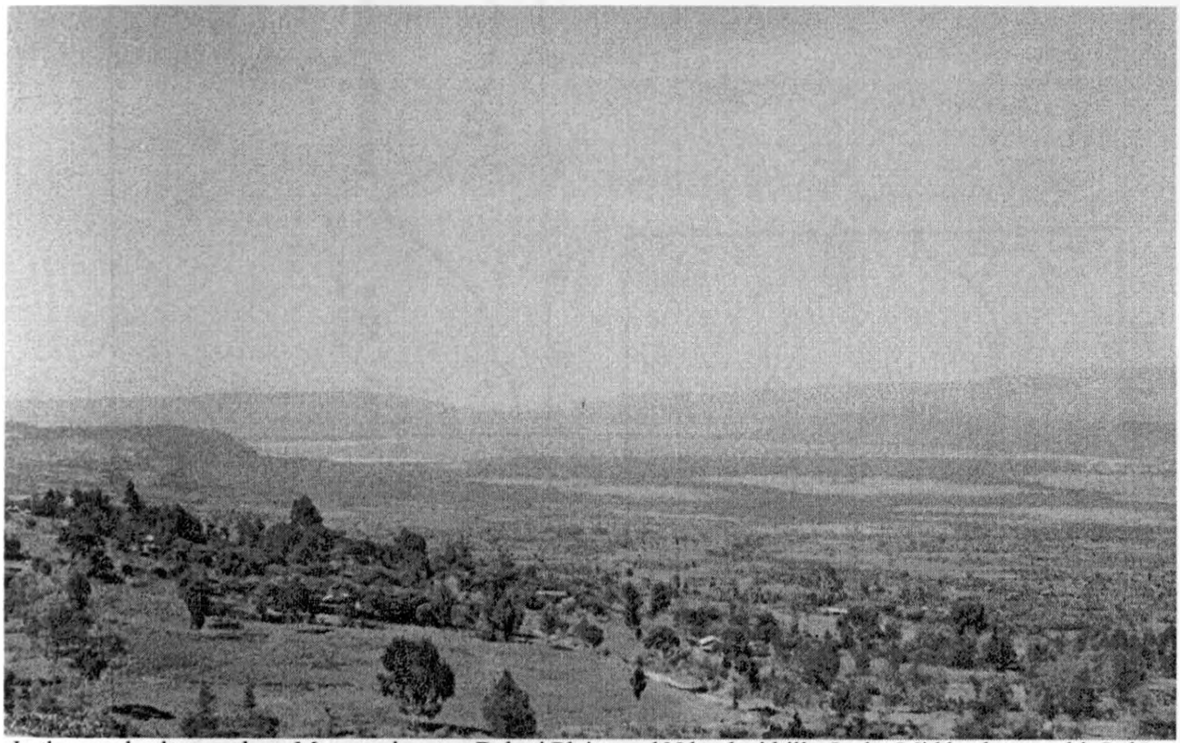


Figure 4.2 : Location of The Study Area In Nakuru District



covering the Bahati plains and extending all the way to Kiwi plains to the South of the catchment. Figure 4.3 shows North-South and East-West longitudinal sections of the catchment while figure 4.4 shows the terrain zones.

Plate 4.1: A Panoramic View of Lake Nakuru Catchment

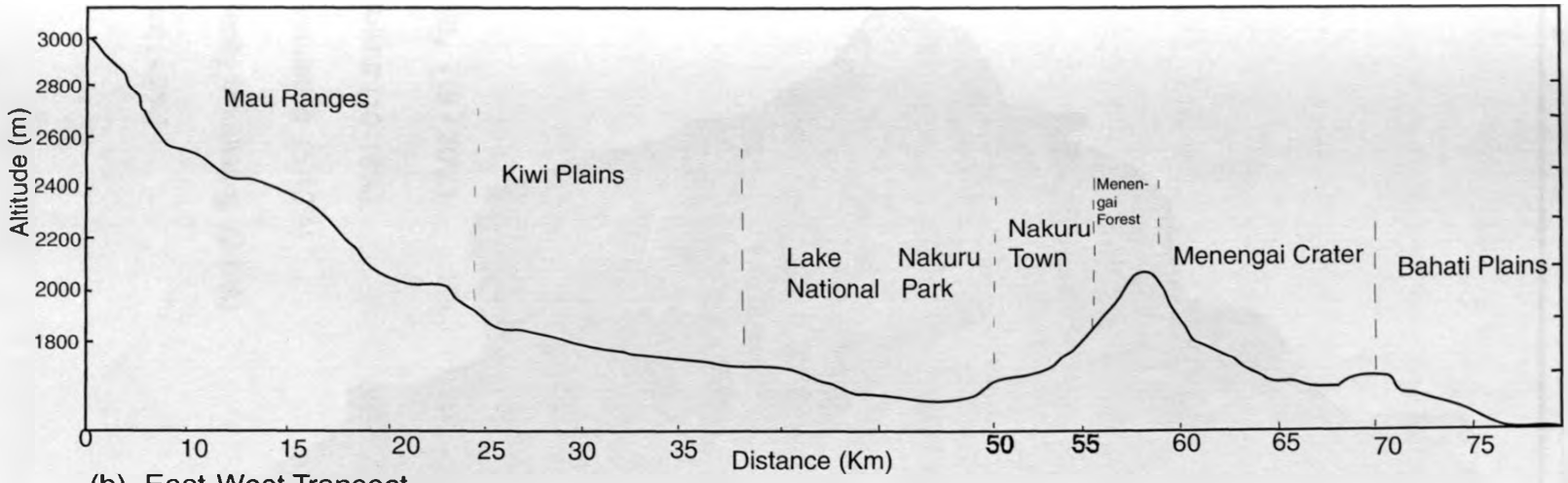


In the rear background are Menengai crater, Bahati Plains and Ndundori hills. In the Mid background is Lake Nakuru, the National Park and rangelands.

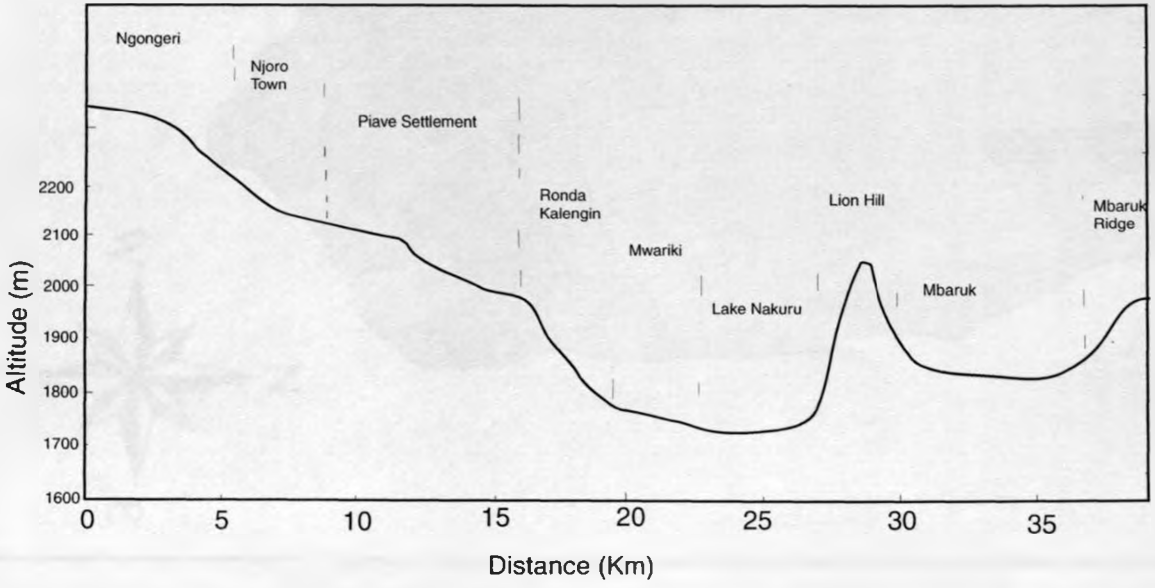
4.1.3 Drainage and Hydrology

Lake Nakuru Catchment is drained by six main rivers, Njoro, Makalia, Enderit, Naishi Lamudiac and Ngosur. The first five of these rivers originate from the Mau Escarpment. River Ngosur originates from the Bahati highland to the North Eastern end of the Catchment. Like both rivers Ngosur and Naishi, it disappears into the ground before draining into the lake, probably emerging as springs near the shore. Figure 4.5 shows the river catchments.

(a) North-South Transect

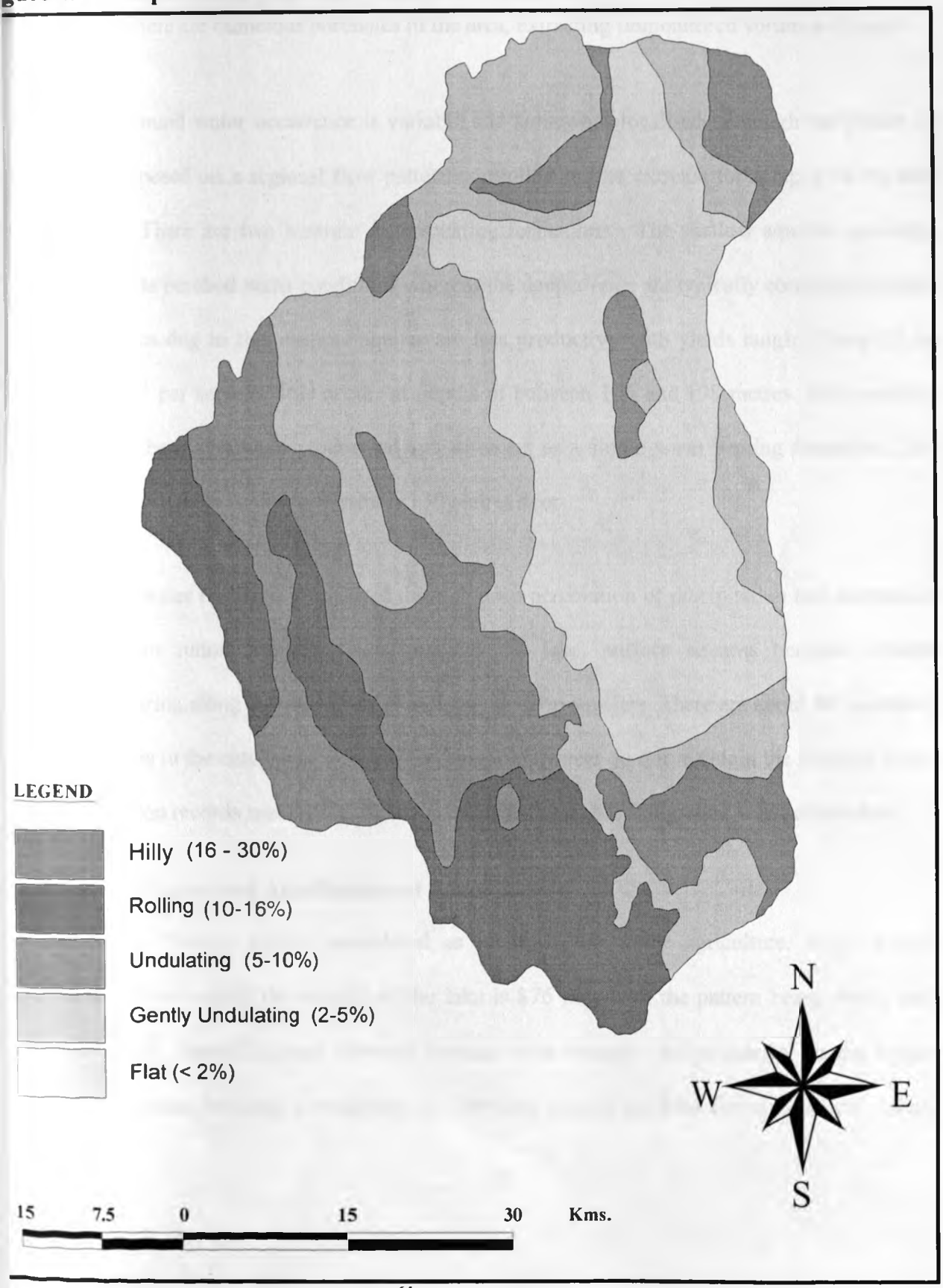


(b) East-West Transect



Source: Survey of Kenya 1:50,000 Map Series

gure 4.4 Slope Zones In Lake Nakuru Catchment



The water level of the lake has been monitored since 1930, where marked fluctuations have been observed. The current mean depth is 2.3 metres. From a level of 1.3 metres, in 1973, it rose to 4.0 metres in 1980. Since 1930, the lake has dried out three times in 1945, 1961 and 1987. There are numerous boreholes in the area, extracting unmonitored volumes of water.

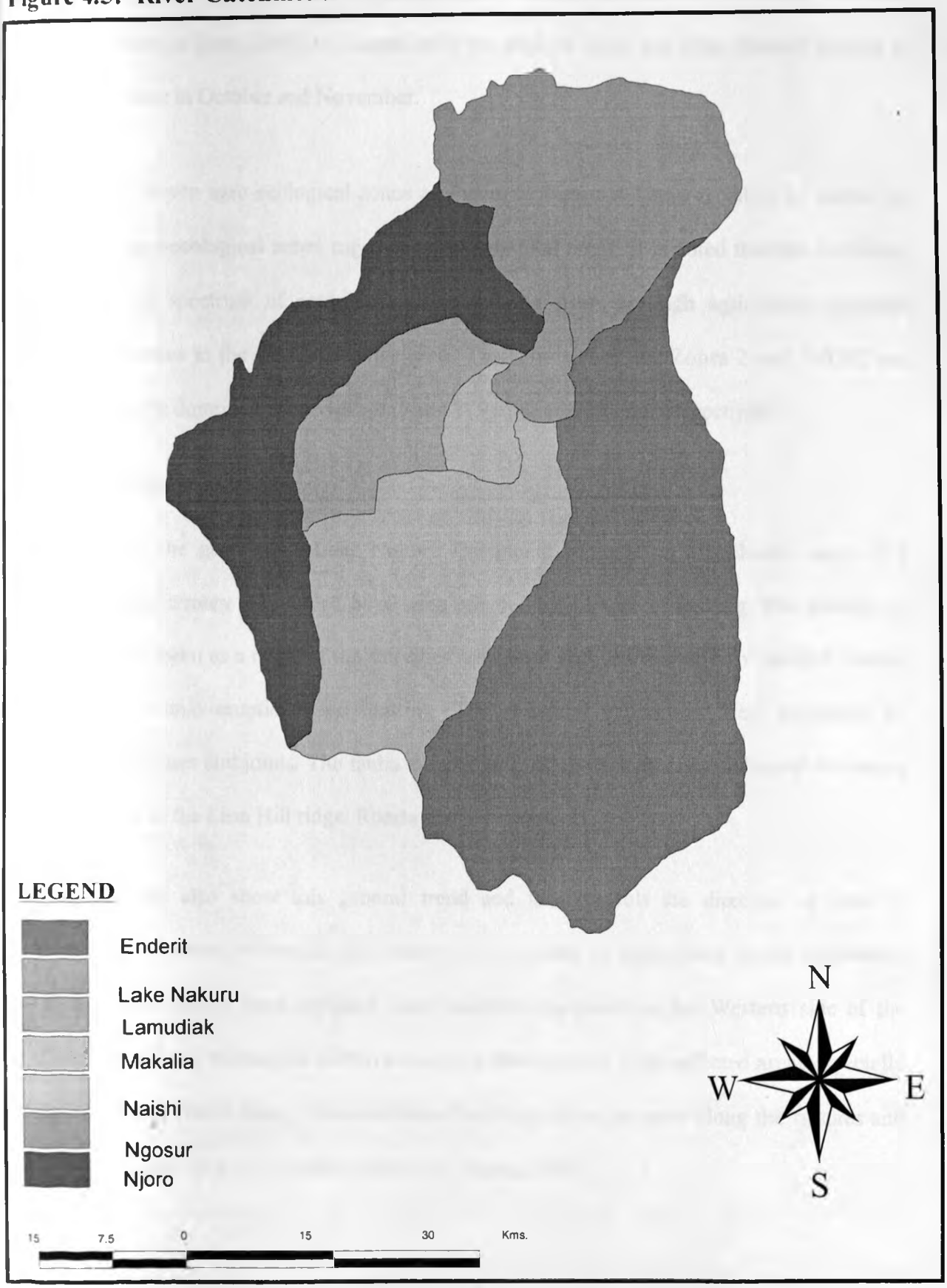
Underground water occurrence is variable and somewhat localised, although the pattern is superimposed on a regional flow pattern controlled by the extreme topography of the Rift Valley. There are two separate water-bearing formations. The shallow aquifers generally represents perched water conditions whereas the deeper ones are typically confined aquifers. Boreholes dug to this shallow aquifer are less productive with yields ranging from 0.5 to 0.833 m^3 per second. This occurs at depths of between 106 and 198 metres. Both aquifers seem to be hydraulically connected and often act as a single water bearing formation. The average borehole in the catchment is 130 metres deep.

Ground water recharge is achieved through deep percolation of precipitation and infiltration of stream runoff through faults. Around the lake, surface streams become influent disappearing along the fault lines as recharge to deep aquifers. There are about 80 registered boreholes in the catchment. Most of the borehole owners do not maintain the required water abstraction records making it difficult to estimate the amount of ground water abstraction.

4.1.4 Climate and Agro-Ecological Zones

Much of Nakuru area is considered as marginal for arable agriculture. Mean annual precipitation within the vicinity of the lake is 876 mm with the pattern being erratic and unreliable. Rainfall figures however increase with intensity and reliability in the higher altitude zones reaching a maximum of 1300 mm around the Mau Escarpment and Bahati

Figure 4.5: River Catchments Within Lake Nakuru Basin



Source: Kimani et al. (1992)

highlands. Figure 4.6 below shows the main rainfall zones within the catchment. The main rainy season is from March to August with the peak at April and May. Shorter periods of rainfall occur in October and November.

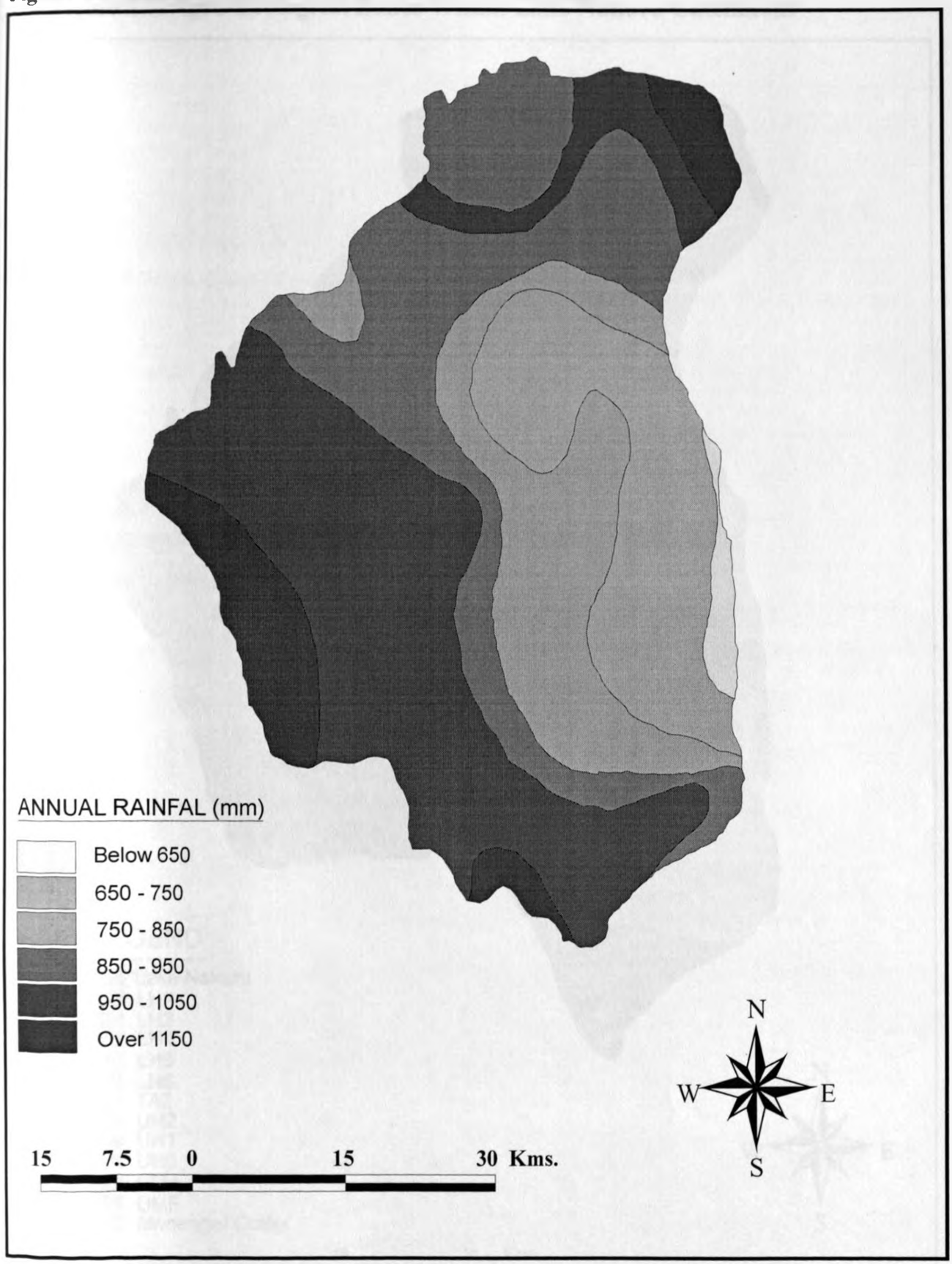
There are eleven agro-ecological zones as shown by Figure 4.7 below. Table 4.1 shows the various agro-ecological zones together with their total areas. It is noted that the catchment has a wide spectrum of ecological zones ranging from the high agricultural potential highland zones to the semi-arid rangelands. The Lower Highland Zones 2 and 3 (LH2 and LH3), are the dominant zones with 202 and 375 square kilometres respectively

4.1.5 Geology and Soils

In general, the geology of Lake Nakuru Catchment is made up of volcanic rocks of a Tertiary-quarternary age, which have been affected by a series of faulting. The geology of the area has been as a result of the activities associated with the formation of the Rift Valley, namely volcanic eruptions and faulting. The structural geology is then dominated by faulting, fissures and joints. The faults are well defined in such areas as cliffs and deforming rocks such as the Lion Hill ridge, Ronda and Western Cliff.

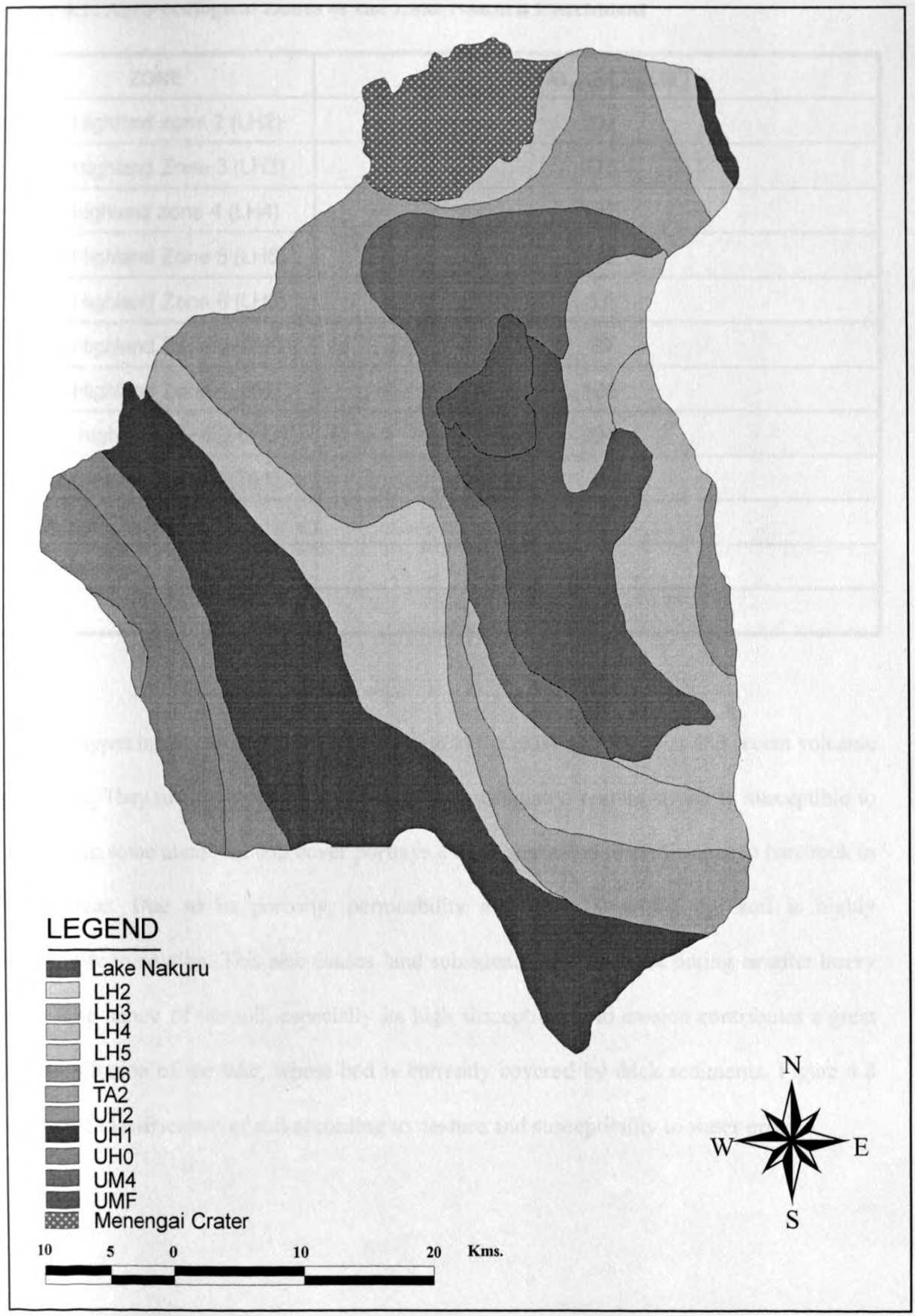
The Fissures also show this general trend and this controls the direction of flow of underground water. Although the faults are not visible in some parts of the catchment, geophysical surveys have revealed their existence especially in the Western side of the Catchment. Land subsidence is then a common phenomenon in the affected areas especially in Ronda and Baruti areas. The subsidence has been shown to occur along the fissures and faults and actually have a North-South trend (Murei, 1995).

Figure 4.6: Rainfall Zones in Lake Nakuru Catchment



Source: Jaetzold and Schmidt (1983)

Figure 4.7: Agro-Ecological Zones Within Lake Nakuru Catchment



Source: Jaetzold and Schimidt (1983)

Table 4.1: Agro-ecological Zones of the Lake Nakuru Catchment

ZONE	TOTAL AREA (KM^2)
Lower Highland zone 2 (LH2)	202
Lower Highland Zone 3 (LH3)	375
Lower highland zone 4 (LH4)	137
Lower Highland Zone 5 (LH5)	112
Lower Highland Zone 6 (LH6)	17
Upper Highland Zone 0 (UH0)	79
Upper Highland Zone 1 (UH1)	136
Upper highland Zone 2 UH2)	323
Tropical Alpine Zone 1 (TA1)	6
Menengai Crater	82
Lake Nakuru	33
TOTAL	**1837**

The soil types in the catchment owe their origin to the existing rock units and recent volcanic eruptions. They are highly porous and with unconsolidated texture which is susceptible to erosion. In some areas, the soil cover portrays a thick strata and then thins out to bare rock in some areas. Due to its porosity, permeability and loose structure, the soil is highly susceptible to erosion. This also causes land subsidence and fractures during or after heavy rains. The nature of the soil, especially its high susceptibility to erosion contributes a great deal to siltation of the lake, whose bed is currently covered by thick sediments. Figure 4.8 shows the classification of soil according to texture and susceptibility to water erosion.

4.2 Biological Characteristics of Lake Nakuru Catchment

Lake Nakuru catchment has some unique mix of biological characteristics that makes it a conservation unit of international significance. The catchment is endowed with both natural animal and plant resources. However there has been human interference with this natural environment making the current biological environment more complex than the original one.

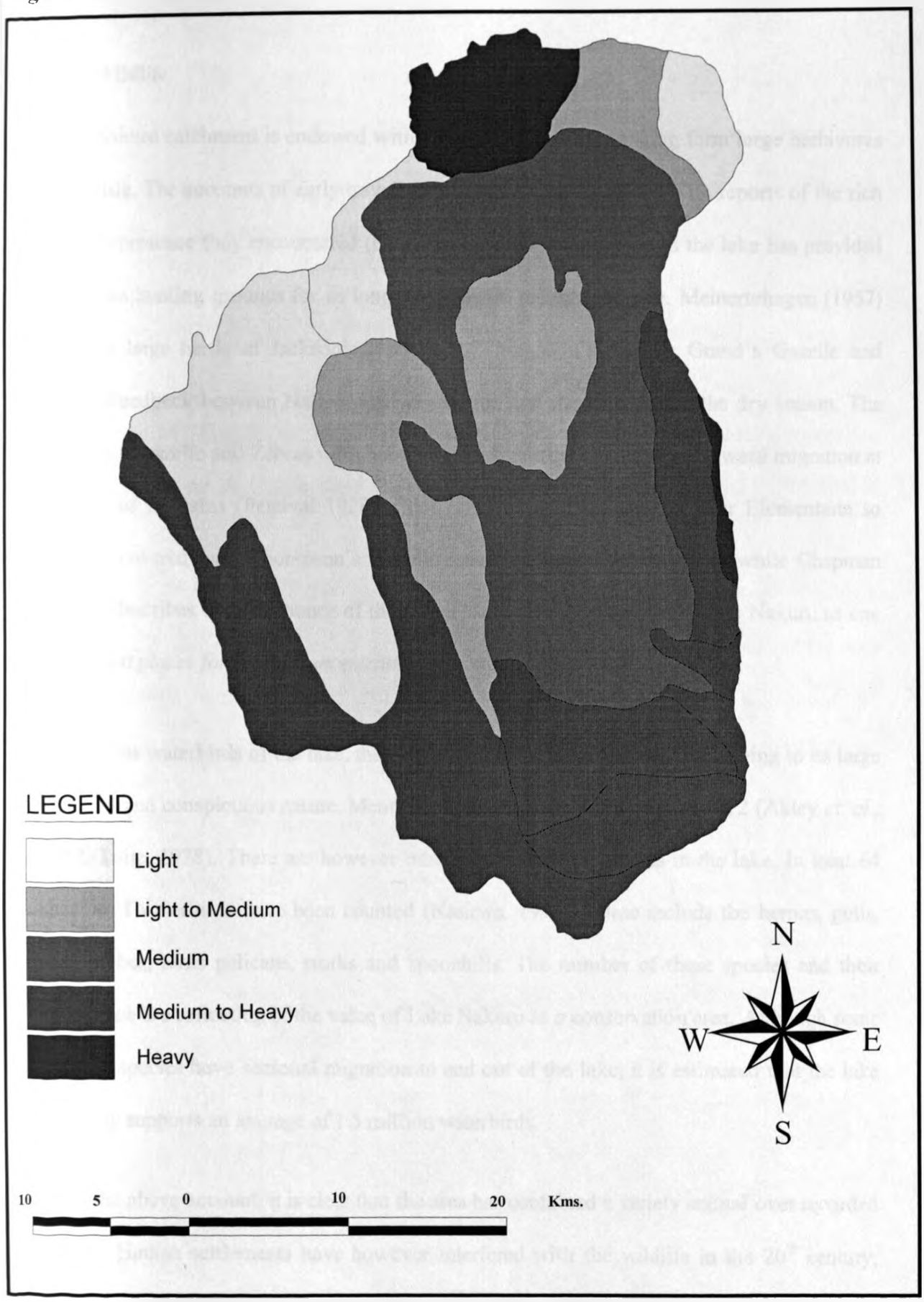
4.2.1 Vegetation

Prior to European settlement, the natural vegetation of the highland zone of Lake Nakuru Basin was Montane forest dominated by three main species; Juniper (*Juniperus procera*), Podo (*Podocarpus latifolius*) and African Olive (*Olea africana*). European settlement however opened up these hitherto virgin forests for timber exploitation and by 1990, the Montane forests only remained in the uppermost reaches of the catchment where they are still protected to a certain limit within the forest reserves.

At the lower altitudes, the Montane forest merged into a woodland dominated by Olive and acacia species, interspersed with patches of open grassland. Outside the National Park, this woodland has been entirely replaced by farmland. Surrounding the shore of the lake, the woodland is dominated by fever trees (*Acacia xanthophloea*). The hills running down the Eastern side of the lake are covered by a forest of Euphobia.

The Parts to the East and South of the Park are still covered by grassland and scattered trees. The area to the North of the lake was formerly a grassy plain. Most of this area is now covered by Nakuru town although part of it is conserved in the Northern sector of the park. Open grassland occurs in the southern sector of the park (Rono, 1996).

Figure 4.8: Soil Texture and Erodability



Source: Sanbroek et al. (1982)

4.2.2 Wildlife

Lake Nakuru catchment is endowed with a wealth of wildlife ranging form large herbivores to birdlife. The accounts of early travellers through the area is filled with reports of the rich wildlife presence they encountered (Mwangi, 1993). The area around the lake has provided important hunting grounds for as long as available records indicate. Meinertzhagen (1957) reported large herds of Jackson's Hartebeest, Thompson's gazelle, Grand's Gazelle and Bohor Reedbuck between Nakuru Railway station and the lake during the dry season. The Thompson gazelle and Zebras were becoming most numerous during southward migration at the end of the rains (Percival 1928). Eliot (1)904, found the country near Elementaita so literally covered with Thompson's Gazelle that *it appeared sandy yellow* while Chapman (1908), describes the confluence of the rivers Nderit and Makalia with Lake Nakuru as *one of the best places for seeing concentration of game.*

Among the waterbirds of the lake, the Lesser flamingo is the most known owing to its large numbers and conspicuous nature. Mention of the flamingo dates back to 1912 (Akley *et. al.*, 1912, Tuite, 1978). There are however other numerous bird species in the lake. In total 64 species of waterbirds have been counted (Nasirwa, 1995). These include the herons, gulls, Ibis, grebes, terns pelicans, storks and spoonbills. The number of these species and their abundance is a reflection of the value of Lake Nakuru as a conservation area. Although some of these species have seasonal migration to and out of the lake, it is estimated that the lake regularly supports an average of 1.5 million waterbirds.

From the above account, it is clear that the area has contained a variety animal over recorded history. Human settlements have however interfered with the wildlife in the 20th century,

greatly altering the wildlife situation. From 1992, very low water levels have been recorded in the lake and this has had negative impacts on the birdlife. Migration patterns to other wetlands have been seen to deviate from those previously recorded. This has raised major concerns among conservationists about the sustainability of the ecosystem and especially the effect of the lake's pollution to the birdlife.

Among the large herbivores, the African elephant is reported among the species that frequented the area but is altogether absent today. The black rhinoceros had become exceedingly rare, with its population only starting to rise because of translation from other areas. Although much of the wildlife is naturally resident in the park, there has of late been introduced some exotic animal species. Among them are the Rothschild giraffe and the White rhino. The introduction of these rare and endangered species has then necessitated the fencing of the park with a perimeter electric fence. Although this fences has dramatically reduced *human-wildlife conflicts* in the areas adjacent to the park, it has also isolated the animals and this will definitely affect their breeding and evolution.

4.3 Evolution of Human Settlements in Lake Nakuru Catchment

Human occupation in the Lake Nakuru catchment goes a long way into the past. Archaeological exploitations have shown evidence of occupation dating back 10,000 to 30,000 years ago by a hunter-gatherer community called the Eburran. At about 1000 years ago, a Kalenjin group settled in the area, some of who practised agriculture. More recently, the Maasai lived in the area, grazing their herds over the open bush land and grassland between the forested areas. Their occupation of the area continued until early 20th century when it was interrupted by the European settlement (Ramesh, 1995).

4.3.1 Land Use in the Colonial Period

The first European to reach Lake Nakuru was Joseph Thompson in 1883. Subsequently, more explorers stopped in the Lake at Baharini springs to replenish their water supply. The arrival of the Kenya-Ugandan railway in 1889 opened the catchment to European settlement. Nakuru was established as a junction on the railway line and it quickly grew into a small town. Increased access led to rapid settlement by European farmers who set up ranches and large mixed farms around the Lake, Njoro, Rongai, Eburru, Dundori and Bahati highlands. Nakuru then became the District capital and the agricultural capital of the White Highlands (Raini, 1987).

During the colonial period, forest reserves were established in the area covering the highlands, Mau- Escarpment, Bahati and Menengai. The Lake Nakuru forest on the South-Western boundary of the present day Lake Nakuru National Park was also gazetted. The colonial period land use was then one dominated by large scale mixed farms, ranches and forested areas. At the same time, the urbanisation process began in the catchment with the growing importance of Nakuru town as an agricultural town

Table 4.2: Settler Farms in Njoro Division (1960/61)

FARM SIZE (ACRES)	NUMBER OF FARMS	PERCENTAGE
<200	12	17.9
201-500	13	19.4
501-800	8	11.9
801-1100	15	22.4
1101-1400	4	6.0
1401-2100	5	7.5
Over 2100	10	14.9
Total	**67**	**100**

Source: MacArthur *et. Al.* (1961)

4.3.2 Land Use in the Post Colonial period

The question of African land rights was one of the main reasons for discontent and the social and political unrest among Africans in the colonial time resulted from land ownership problems. Reclamation of alienated land, the most prominent of which were the *scheduled areas* or *white highlands*, was therefore a key issue and one of the most important claims of the African political activity. The realisation of this claim came with independence in 1963, when the government initiated a series of settlement Scheme programmes.

The first and most widely known of these programmes was the "One Million Acre Scheme", in the course of which about one million acres of land from the White Highlands was to be bought and subdivided into small scale farms for the Africans. Nationally, the total area purchased accounted for approximately 20 percent of the former scheduled areas. The programme which had actually started shortly before independence in 1961 came to a close by the end of the 1970s (Ogendo, 1981). This programme brought to the catchment the first wave of small-scale farmers, starting with Bahati in 1967 and the highlands in 1968.

As the Settlement schemes were being established, it became evident that the government programmes alone would not be large enough to accommodate all those in need of land. Although the One Million Acre Scheme settled about 35,000 families, it still needed to be stepped up by other programmes. By the mid-1960s, it was already accepted that the government programmes were too expensive as a solution to the problem of landlessness and land hunger. There was also a growing reluctance by the main creditors of the programmes to support further programmes financially (Leys, 1975, Kohler, 1987).

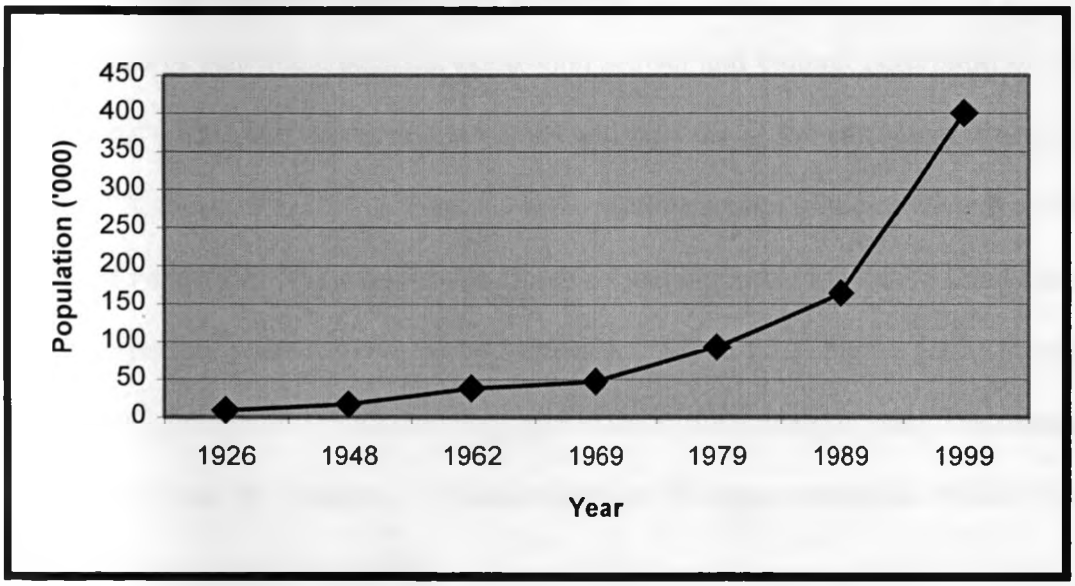
The political leadership then responded by calling on people to resort to the self-help. The concept of self-help or *Harambee* as it came to be known, embraced such ideas as mutual assistance, responsibility and community self-reliance (Mbithi and Rasmussen, 1977). As far as land purchasing was concerned, self-help worked through groups, which were formed by those in need of land in order to pool enough money to buy it. Land buying companies and co-operatives were formed to buy the large Settler farms and then subdividing among individual members. Nationally, it was estimated that by 1970, land buying companies and co-operatives had acquired about 20 percent of the former White Highlands or as much as the government settlement programmes had managed. There were also numerous squatter settlements encroaching into forest reserves. The settlement thrust continued for about two decades until early 1980s when land scarcity and lack of government funds for settlement halted it. The 1983 KANU[5] manifesto stated that in respect of land purchase, the re-settlement programme in the former White highlands was *virtually completed* (Leys, 1975).

While agricultural settlement was occurring, urban expansion was also taking place. Nakuru was declared a township in 1904 with an area of 26 Km^2 and elevated to Municipality status in 1929. In 1934, the municipal boundary was extended to 32 Km^2. Further extension occurred in 1969 to 76 Km^2 and in 1986 to 95 Km^2. Currently it covers some 290 Km^2, which includes the Lake Nakuru National Park. The urban population of Nakuru Township in 1926 was 896 people. In 1948 when the first national census was conducted, the population of the Municipality was 17,000 people. By 1962, the population had reached 38,200. This further increased to 47,151 people in 1969, 92, 851 in 1979 and 163,900 people in 1989. Currently it is estimated to be about 360,000 people (MCN, 1999). Figure 4.9 reveals that the population growth rate has continued to rise with time. This has been as a

[5] Kenya African National Union (KANU), has been the ruling party in Kenya since independence

result of in-migration of people from the rural hinterland and also other parts of the town looking for employment in the town's well-established commercial and industrial sectors. Industrialisation of Nakuru town began in the early 1970s. Currently, there are about one hundred registered industrial establishments with agro-industries dominating the sector. This high rate of industrial development has led to a high immigration rate to the town. It is notable from figure 4.9 that not only has the town's population kept on growing but also that the growth late has continued to rise with time. The graph then has the highest gradient for the period 1989-1999.

Figure 4.9: The High Population Growth of Nakuru Town



Source: Municipal Council of Nakuru (1999)

CHAPTER FIVE

ANALYSIS OF LAND USE CHANGE

5.0 Introduction

This chapter represents the analysis part of the study. The chapter starts by analysing the changes in land use as revealed by both Remote Sensing data and field observation. These changes are then compared and related to the other information regarding the biophysical environment and the socio-econmic data. The chapter then analyses the existing institutional and legal framework for land use and environmental management in the catchment.

5.1 General Changes in Land Use Patterns

The impacts of settlement policies, population growth and cultural perception of land have come to have their full effects on land cover and land use in the catchment towards the end of the 20th Century. Plate 5.1, 5.2 and 5.3 show satellite scenes of the catchment for the years 1973, 1987 and 1999. These have been classified and interpreted to derive Land use patterns for the respective years represented by Figures 5.1, 5.2 and 5.3. Figure 5.2(a)-(c) shows the proportions of the various land use categories in the various analysis years The revelations of these patterns and the biophysical characteristics of the area revealed in chapter four forms the main analysis part of this study.

5.1.1 Trends in Forest Land

Before European occupation, the land use picture in the catchment was one of virtually untouched wilderness of forests and grasslands. Although European settlement resulted in the clearing of significant proportions of natural forests, the settlers also gazetted significant portions of the catchment as forest reserves.

Plate 5.1: 1973 Landsat MSS Imagery

Plate 5.2: 1987 Landsat TM Scene

Plate 5.3: 1995 Landsat Thematic Mapper Imagery

Figure 5.1: **Land Use Pattern in 1973**

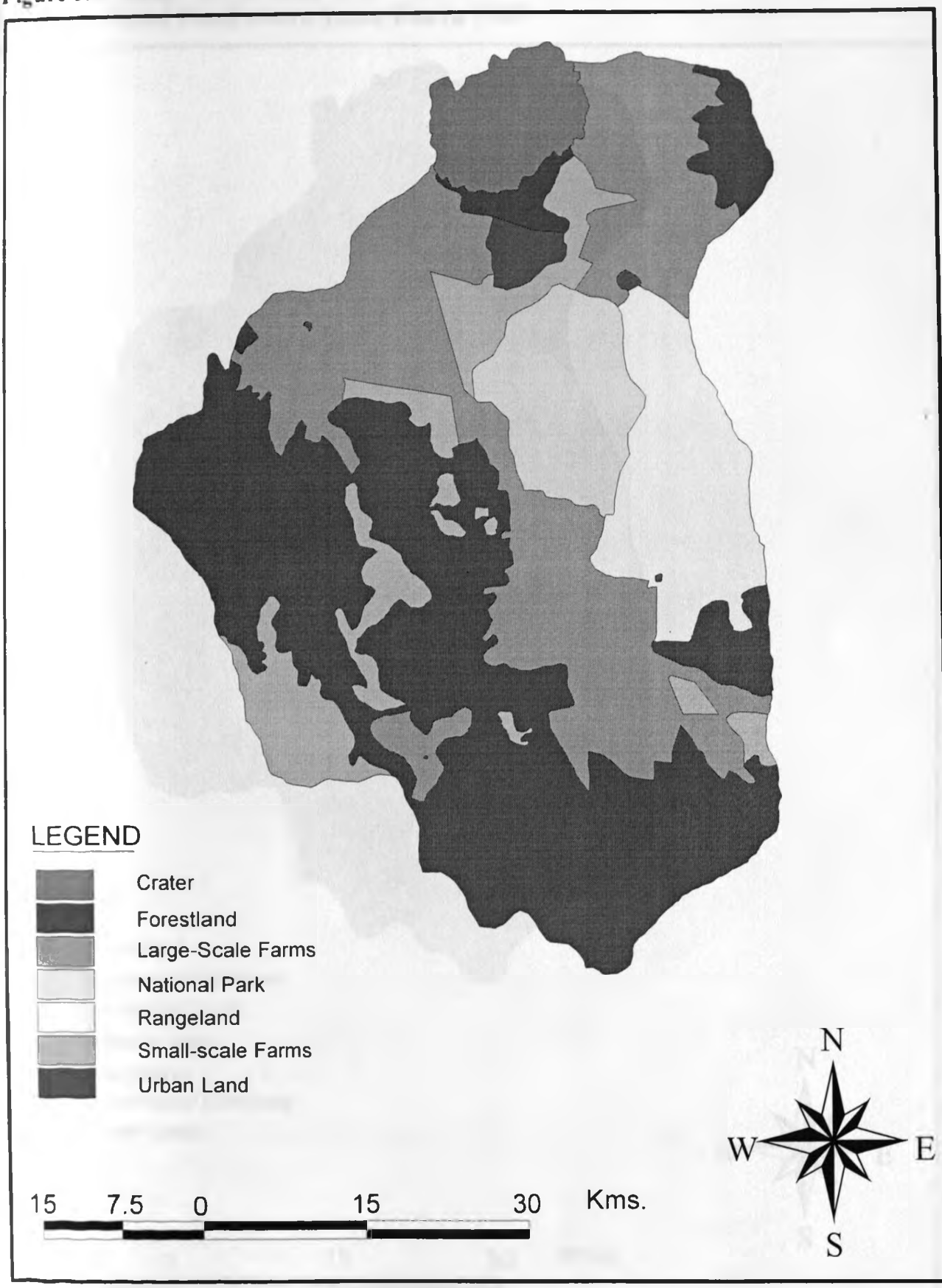
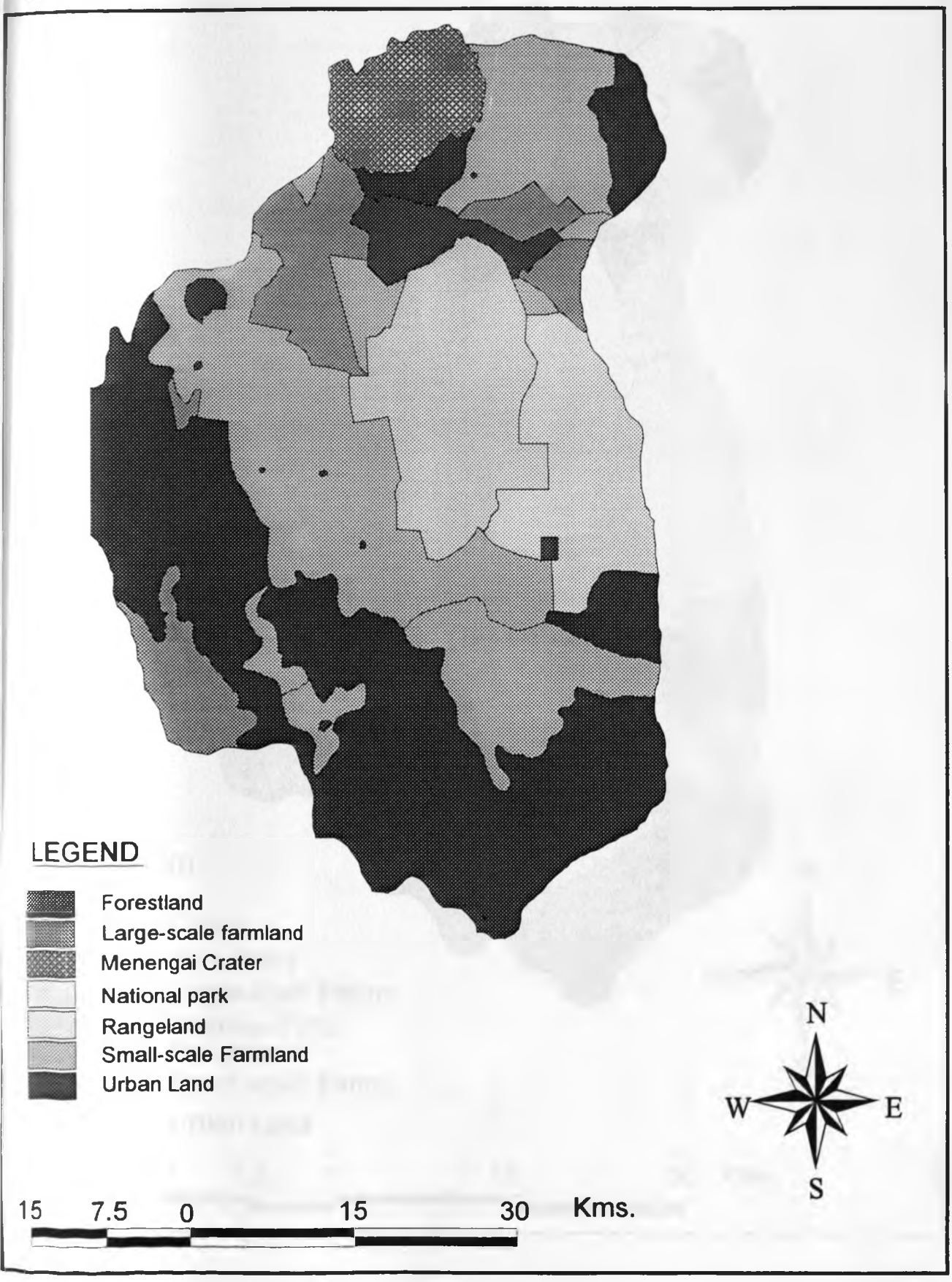


Figure 5.2: **Land Use Pattern Land Use in 1987**



ıre 5.3: Land Use Pattern in 1999

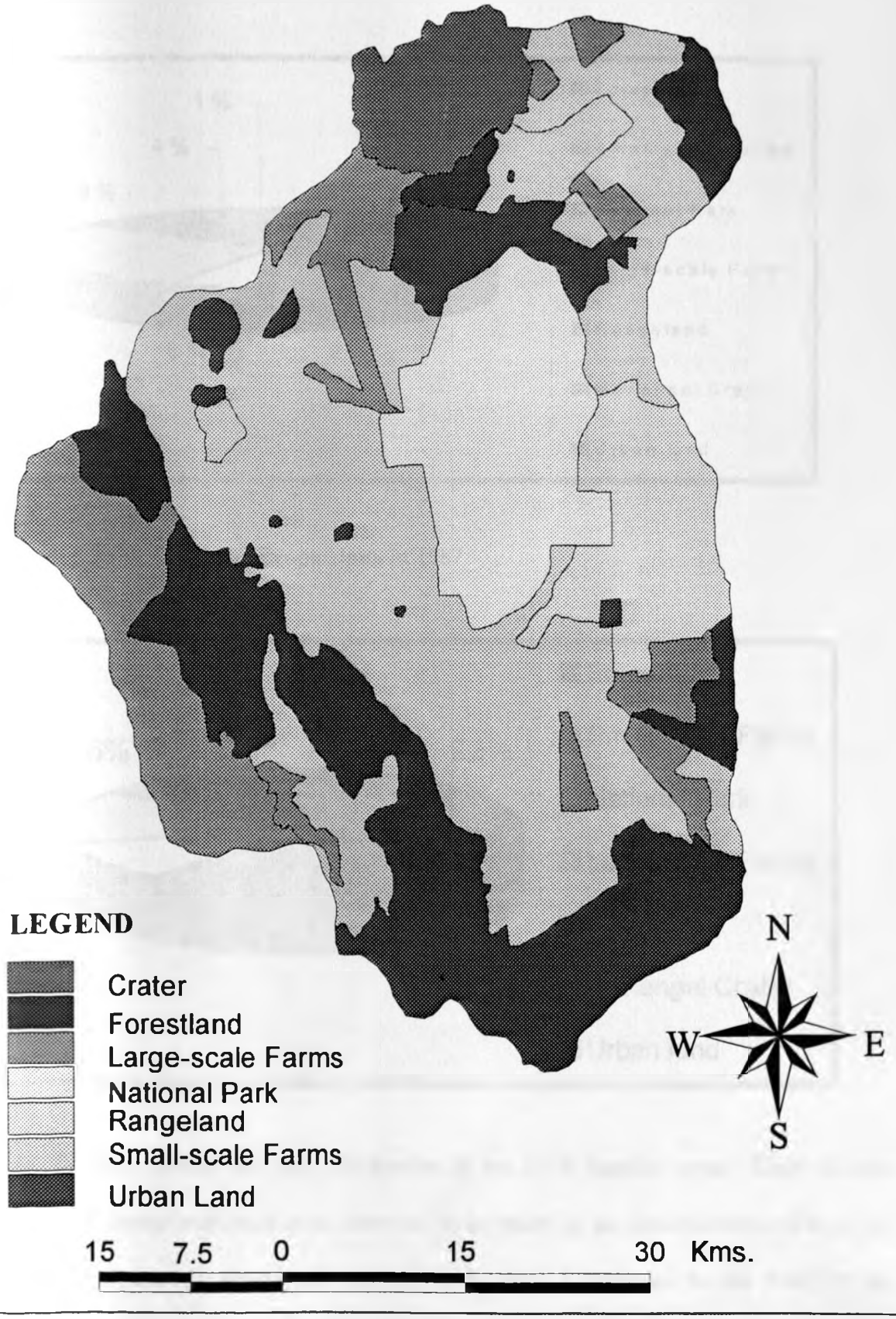


Figure 5.4 (a): Land Use Proportions in 1973

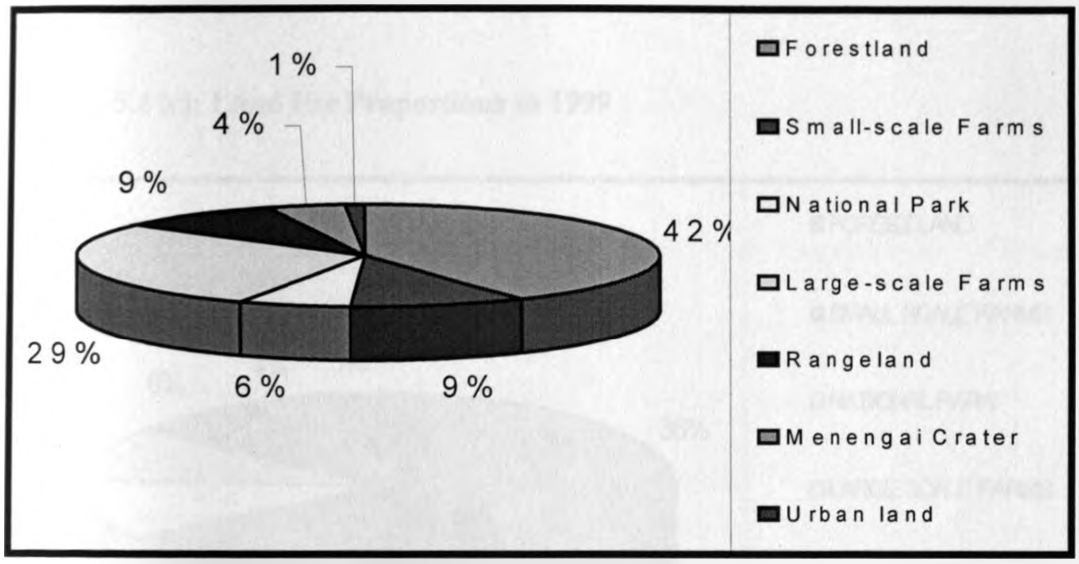
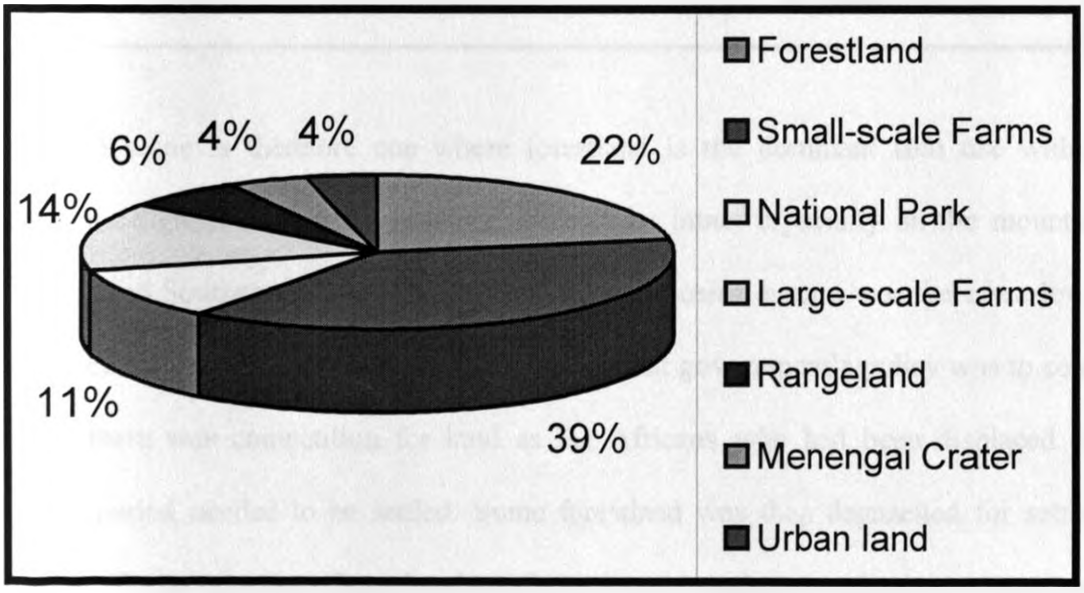


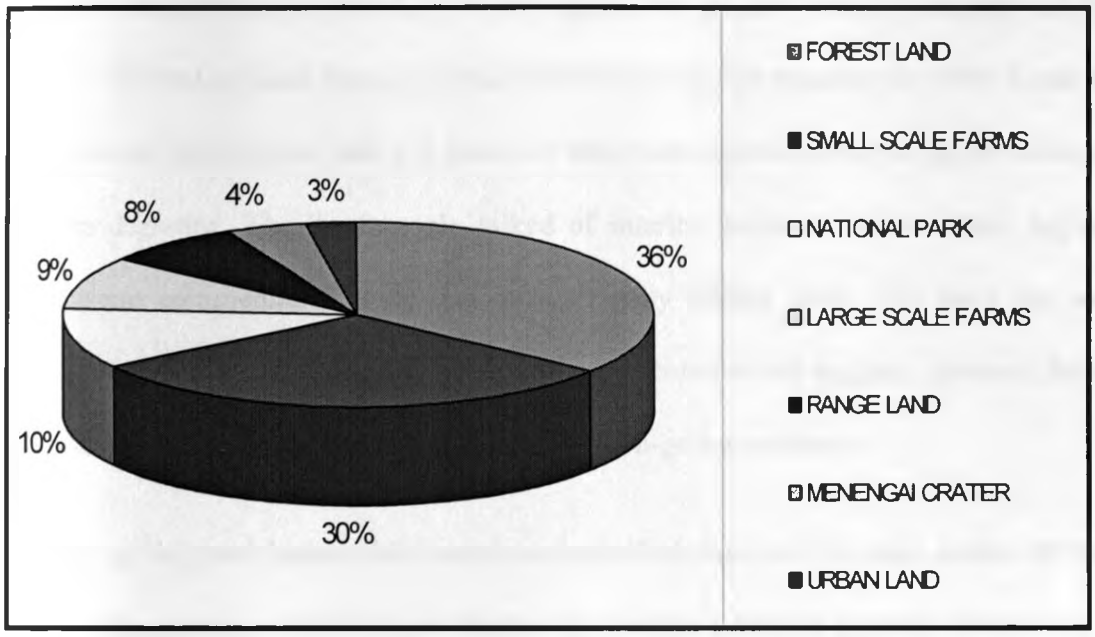
Figure 5.4 (b): Land Use Proportions in 1987



Some of these forests are quite observable in the 1973 Satellite scene. These include indigenous forests and woodlands observed to be intact in the South-western side of the catchment. Plantation forests also existed in the Mau Escarpment to the south of the

catchment where they were protected as forest reserves. In total, forested areas accounted for 758 square kilometres or 42 percent of the total catchment area by 1973.

Figure 5.4 (c): Land Use Proportions in 1999



The 1973 scene is therefore one where forestland is the dominant land use within the catchment. Significant forested areas are seen to be intact especially on the mountainous Northern and Southern areas of the catchment. Soil erosion hazard was therefore low with such extensive forest cover. Although the independent government's policy was to conserve forests, there was competition for land as the Africans who had been displaced during colonial period needed to be settled. Some forestland was then degazetted for settlement purposes. These were then cleared and subdivided under settlement schemes programmes.

The 1987 scene then reveals a significant reduction in forestland. By this time forestland accounted for 656 square kilometres or 36 percent of the total catchment area. The deforestation constituted both natural and plantation forests, which had been cleared for

commercial purposes and also to create land for settlement and farming. From the leading land use, forestland had now taken a second position.

The 1999 scene reveals even more depletion of forestland. By this time, only 406.5 square kilometres of forestland is intact. It is also significant to note that the imagery used was taken in 1995 but updated through ground observation to the situation in 1999. Some areas were however inaccessible and it is believed that more forestland in the inaccessible areas has been degraded. The local people talked of interior depletion of forestland beginning 1997, where commercial logging has been illegally taking place. The land use survey revealed significant degradation of forests through commercial logging, charcoal burning, firewood collection, grazing of livestock and even on-going settlement.

Majority of the rural households interviewed use fuel wood as the main source of energy and the main source of wood is the forests. The people's attitude towards forests was also seen to have changed significantly in the past few years. The previously taught value of forestland has been undermined by recent de-gazetting and settlement of people in forest that the local people had come to revere and respect as conservation areas.

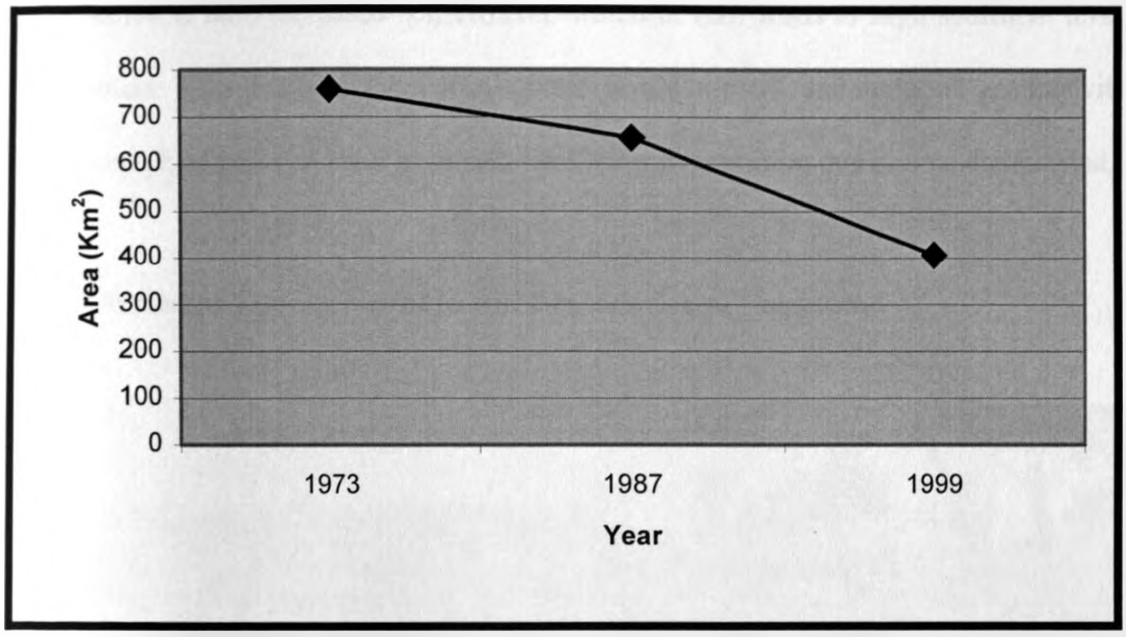
Currently, forestland constitutes 22 percent of the catchment area, and according to the district forest officer, this is being lost at a high rate mostly as a result of allocation of plantation forests for commercial exploitation. Between 1987 and 1999, 3,265 hectares of forestland in the Mau East side were degazetted for settlement of small scale farmers. Most of these farmers are by now settled. Since the degazettement is on the high altitude sections of the catchment, this poses a great threat to the water catchment and to soil erosion.

The natural forests are especially under threat of extinction. Indigenous tree species grow quite slowly compared to exotic species. While plantation forests can regenerate within a matter of several decades, it takes centuries for natural forests to regenerate. The capability of natural forests to conserve environmental resources and biological diversity is however higher than that of plantation forests, which usually consist of a single tree species. Foliage cover is also thicker in natural forest which is particularly effective in prevention of soil erosion and water catchment protection.

Natural forest products are highly preferred and valued for their high quality in building, curving, charcoal and firewood. Their depletion has therefore been more marked than that of plantation forests. Although it was not possible to distinguish between natural and plantation forests from the imageries, field investigation revealed that natural forests currently only exist only around Eburu.

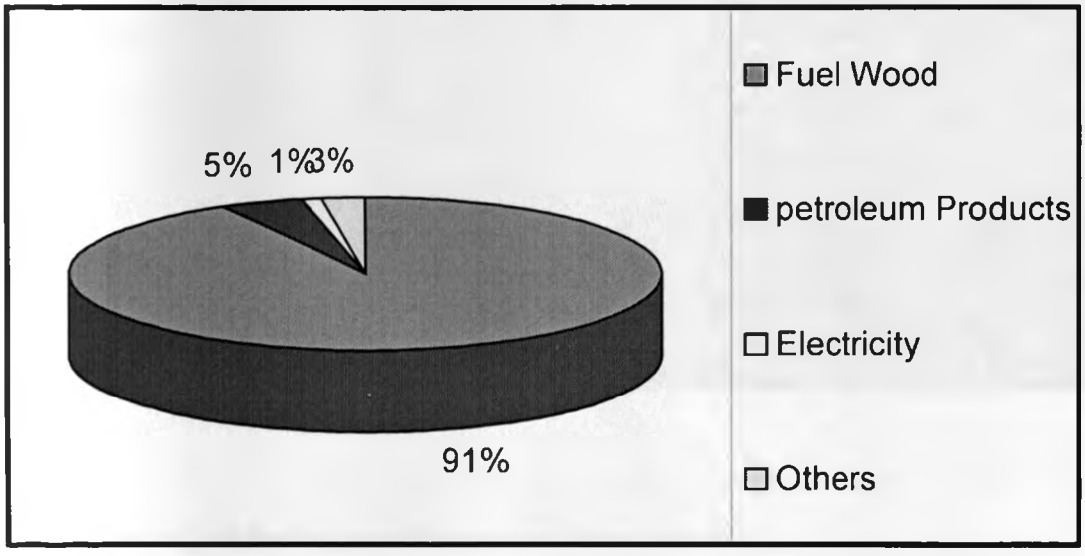
Forests currently exist in Eastern Mau areas of Sururu, Teret, Nessuit, and and Bahati/Ndunduri forest to the northern boundary of the Nakuru district. In 1995, approximately 69 million cubic metres of timber were harvested from these forests. In 1996, Nakuru district earned Kshs. 21 million from the sale of logs and a further 4.4 Million from the sale of miscellaneous forest products such as fuel wood and seedlings, most of which was from forest within the catchment. Wood fuel is an important product of forests as over 90% of the rural households were found to be using it for domestic energy needs. Other forest products include fencing and building poles and saw dust. In many areas however, not much use is made of the saw dust and it is actually seen as a nuisance.

Figure 5.5: The Downward Trend in Forestland



The rate of forestland depletion is seen to be higher for the 1987-99 period as compared to the 1973-87 period

Figure 5.6: The Dominance of Fuelwood in Rural Household Energy sources

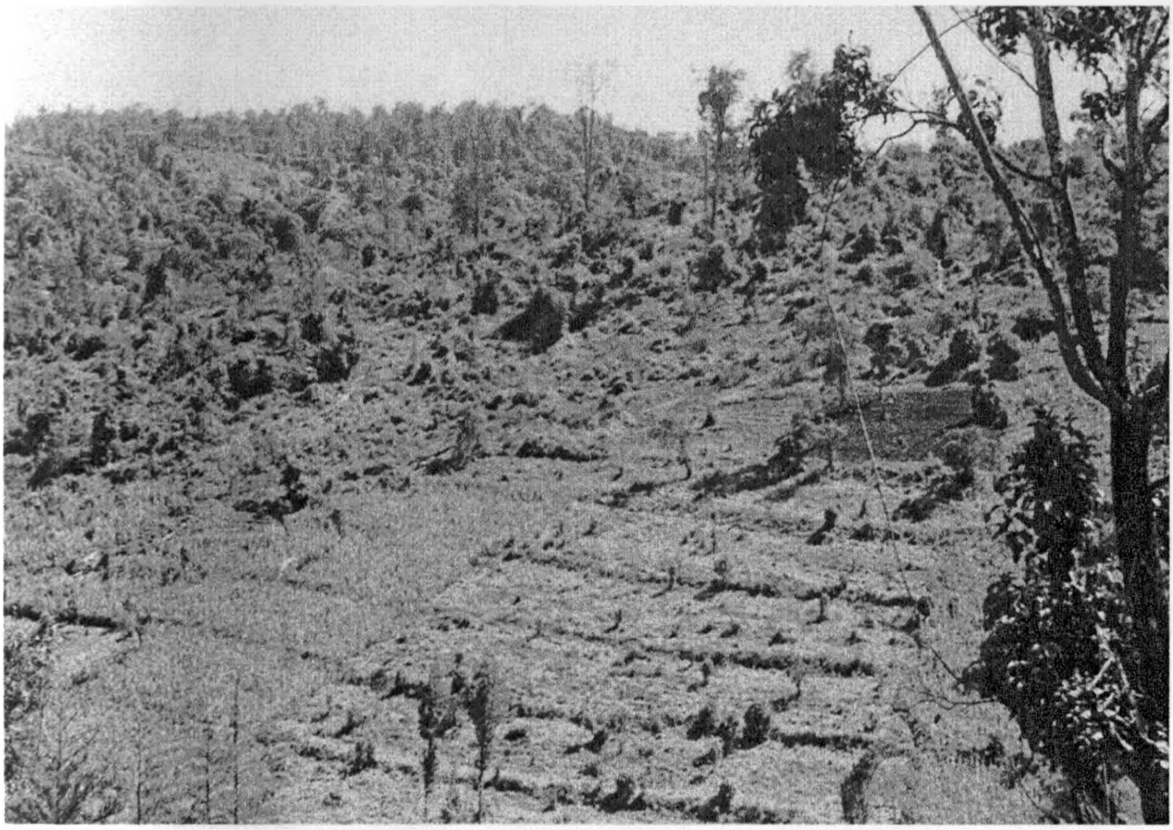


5.1.1.2 Environmental Implications of Trends in Forest Land

It evident that areas with high erosion hazard has been cleared of forest cover. This poses high risk of increased soil erosion in such area. The deforestation is mostly on the higher

parts of the catchment where most of the rivers originate. The most obvious effect of deforestation is then increased soil erosion, which in turn leads to high sediment levels in river waters. This leads to high loss of the fertile topsoil and reduced productivity of farmlands. There has also been increased lake water evaporation due to unchecked wind.

Plate 5.4: Recent Encroachment to and Degradation of Forestland



5.1.2 Ecological Setting and Dynamics of Rangelands

Rangelands are located in the agro-ecological Zones LH5 and UM5 towards the southeastern side of the Catchment. Ecological zone LH5 or Lower Highland Ranching Zone covers an area of 112 square kilometers within the catchment. This zone is not suited for rainfed agriculture. The land carrying capacity is about 3 and 2 hectares per livestock unit on natural

and artificial pasture respectively and about 1.2 hectares per livestock unit with supplementary irrigation. Agro-ecological zone UM5 or Upper Midlands Ranching Zone covers an area of 163 square kilometers. Rainfed agriculture is uneconomical in this zone,

Plate 5.5: Saw Milling;

Illegal and unchecked commercial logging has caused much deforestation in the Southern Part of the Catchment.

but has good potential for vegetable farming under irrigation. The land carrying capacity is about 3.5 hectares per livestock unit on natural pasture. Ranching as a land use currently covers an area of 118 square kilometers as compared to 168 square kilometers in 1973 and 138 square kilometers in 1987. These acreages constitute 6, 9 and 8 percent of the catchment area respectively. These areas constitute cattle ranches owned entirely by Delamere Estate.

5.1.2.1 Implications of Trends in Rangelands to the Environment

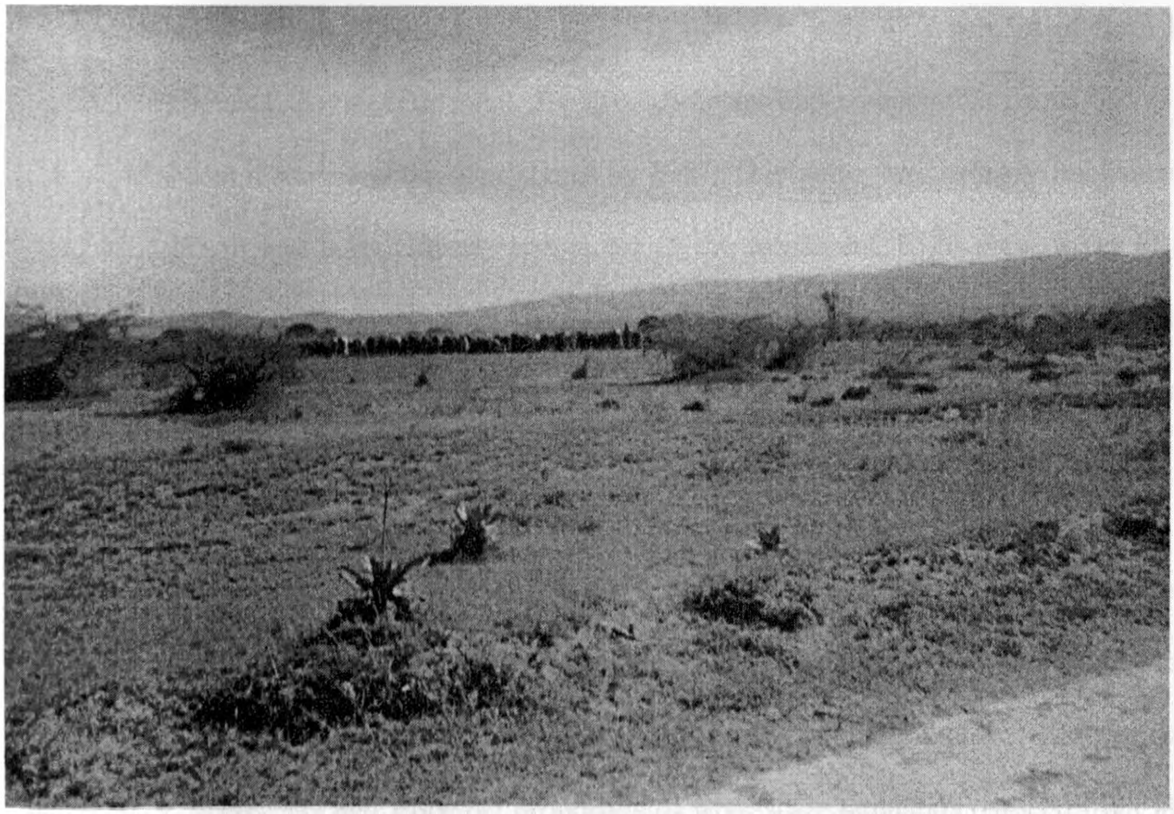
From a conservation point of view, the rangelands with their low carrying capacity are best left to their current use and management. Currently, the ranches are fenced and rotational grazing is practiced. The cattle density is also deliberately kept low to avoid overstocking. Erosion hazard in the rangelands is therefore currently low although soil wash is common along the numerous tracks that criss-cross the ranches. There is little effort to introduce tree planting in the ranches. Virtually no forested area can be found within this zone.

Plate 5.6: Rangeland in Lake Nakuru Catchment

The ranches are a major user of acaricides for control of tick borne diseases. Although there are no rivers flowing from this zone to the lake it is possible that acaricide contamination of

ground water occurs and this eventually finds its way into the lake. The zone also depends on borehole water thus the threat of water poisoning. The use of more environmentally friendly tick control methods is therefore an area requiring attention of the ranch management and the entire community within the catchment. Small-scale holder encroachment to this zone is apparent along the major transport routes. The expansion of Elementaita town is also bound to occur leading to change of land use in the long run. The changes will lead to high-density settlement in an area of low carrying capacity thus posing major threats of environmental degradation, which should be closely monitored.

Plate 5.7: Ranching in Rangeland Areas



5.1.3 Trends in Large-scale Farmlands

In 1973, large-scale farms constituted 518 square kilometers or 29 percent of the entire catchment, which made it second to forestry in terms of spatial extent. The main activities within these farms were wheat, barley and dairy farming. Although European farmers owned

most of these farms, the pace of acquisition by Africans was high. The settlement scheme programmes were started in the area in 1967. Large-scale farms were also being bought by co-operative societies, companies, partnerships and individuals.

By 1987, the proportion of large-scale farmland had reduced to 19 percent of the entire catchment, or 349 square kilometers. The settlement scheme program had by then been completed while most of those who had bought shares in the land buying companies had settled in the area. Field investigation revealed that 54.2 percent of the rural land owners acquired land between 1974 and 1979. By 1979 however, only 47.2 percent of them had settled in the area. By a presidential directive company and co-operative farms had to be subdivided and members given their shares by 1987. This policy was quickly implemented and by 1987, it had been virtually completed in the catchment. Even then, many of the shareholders in company and co-operative lands had many shares and even after subdivision, still remained with substantially big portions of land. Although smaller than the settler farms, these farms were still large by modern day sizes in the area.

It is apparent that subdivision of large-scale farms has continued beyond the settlement schemes and company and co-operative farms. While 7.6 percent of the rural landowners acquired land between 1989 and 1999, 19.5 percent settled in the catchment within the same period. Between 1987 and 1999, the proportion of large-scale farmlands reduced from 19 to 14 percent or from 349 to 263 square kilometers. The hunger for land and the general decline in productivity of large-scale farming are the reason leading to the subdivision. Currently, people own large-scale farmlands have other sources of income and who do not stay in the area. To these absentee landowners, farming is perceived as a commercial activity. Others are speculators holding the land either as a way of preserving or saving their wealth or to

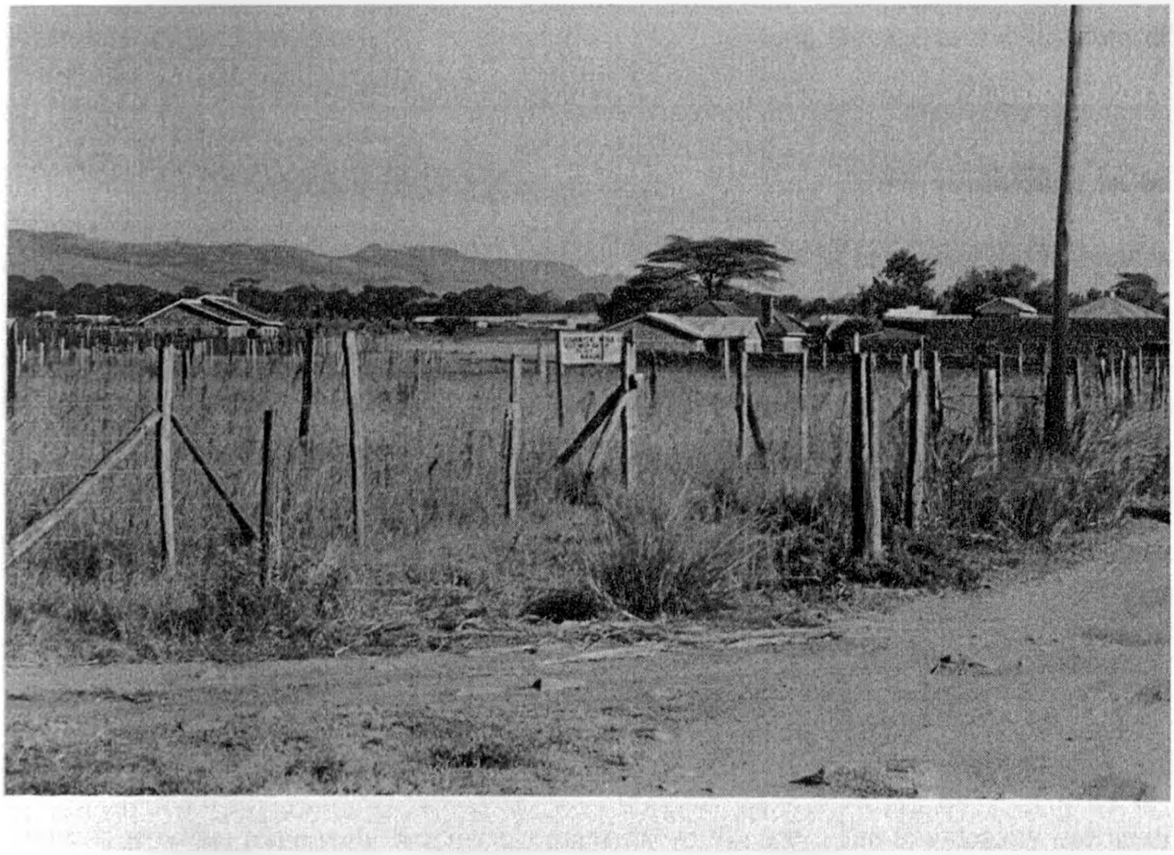
sell it later at higher prices. Most of these farmlands are used for wheat, barley and dairy farming. Most of the large-scale farmers interviewed expressed intention to subdivide their land and sell it as small parcels citing non-profitability of large-scale farming. In the northern side of the catchment, a sizable amount of large-scale farmland has been incorporated within the Nakuru Municipality. The owners of these lands are already subdividing them to very high densities for either commercial or residential uses as can be seen in plate 5.9 below

Plate 5.8: Large Scale Dairy Farming

The demand for such land is quite high. The local people's perception of land and the insistence on owning a piece of land h*owever small,* is an indicator that large-scale farming is a *dying* land use in the catchment. As population increases, the demand for land is bound

to rise and with low incomes, the people will demand smaller and smaller parcels. The fate of large-scale farms in the catchment has already been sealed. The demand for urban land and small-scale farms for subsistence, residential or even speculative purposes is bound to have virtually all large scale farms subdivided within the area in the not so distant future.

Plate 5.9: Subdivision of Large Scale Farmlands



5.1.3.1 Conservation Implications of Trends in Large-scale Farms

The farming practices of large-scale farmers in the catchment are markedly different from those of the small-scale farmlers. All the large-scale farms visited were found to use herbicides, fungicides, fertilizers and pesticides on different crops and at different times. Large-scale farms are therefore major contributors to chemical pollution of water resources. However, most of them were also found to have established soil conservation methods

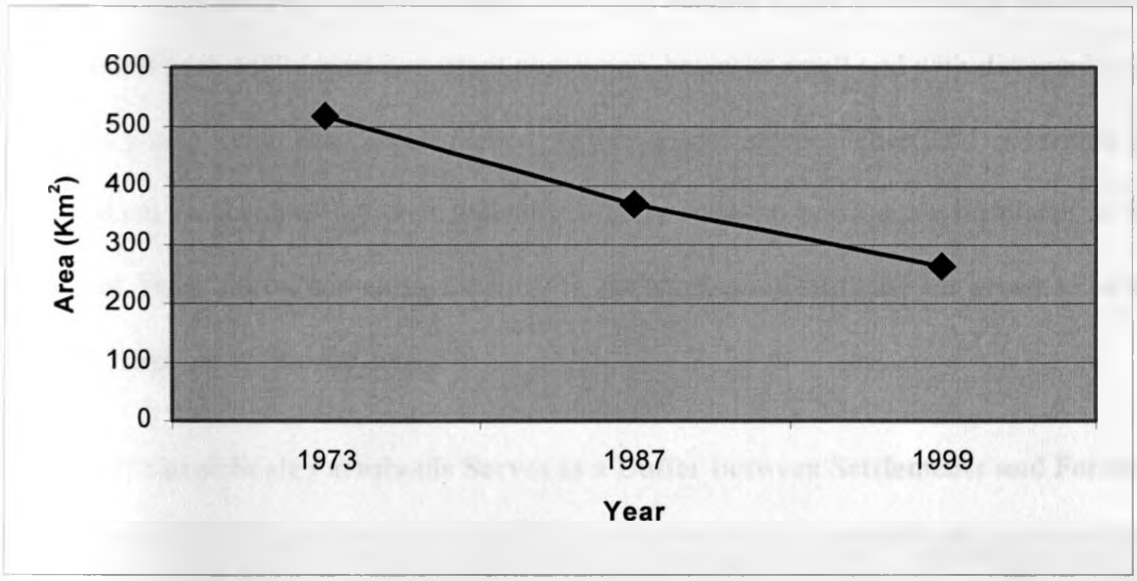
ranging from planting of trees along farm boundaries and planting of woodlots and plantations. Contour bands, contour grass strips and contour ploughing are also common in the large-scale farmlands. Agro-forestry is however not common among the large scale farmers.

All the large-scale farms are common users of farm mechanization like tractors for ploughing and heavy vehicles for transportation. The long-term damage to the structure of the soil and increase in soil erosion due to such practices are high. Large-scale farmlands also contribute to reduction in biological diversity. All these farms were found to be practicing monocropping which when combined with wide use of pesticides and herbicides which kill living organisms indiscriminately, leads to depletion of plant and animal species. Pollution to both underground and surface water and ultimately the lake due to use of agro-chemicals is also eminent. Due to mono-cropping, there are periods when the soil is left bare causing higher soil erosion hazard and river and lake siltation.

Large-scale farming has been found to act as a buffer between forest and other conservation areas and densely used lands such as urban centers or small-scale farms. Because of the nature of practice, large-scale farming is compatible to forestry. The low-density operation implies less demand for forestry products. Consequently, areas with higher proportions of large-scale farms were found to have experienced less deforestation. In the southwestern side of the catchment, it was found that forest edges neighbouring large-scale farms were less encroached than those neighbouring small-scale farmlands. Plates 5.10 and 5.11 show the buffer effect of large-scale farms to forests. The demise of large-scale farmlands should

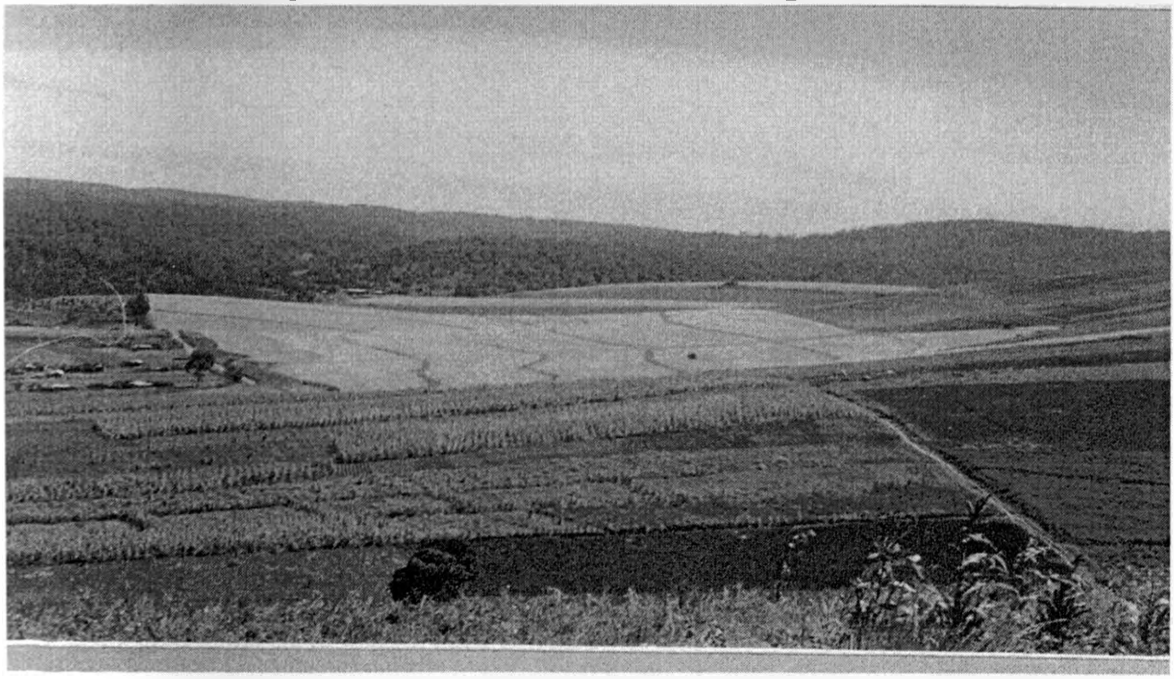
however not be seen just a conservation catastrophe, but as the beginning of new challenges in farming and environmental management initiatives.

Figure 5.7: The Gradual Decline in Large-scale Farmlands



Although the rate of decrease for 1987-99 period is lower than for 1973-87, it is still high at 1325 ha per annum

Plate 5.10: Grass Strips as a Protection to the Soil in a Large-scale Wheat Farms



5.1.4. Trends in Small-Scale Farmlands

For the purposes of this study, small-scale farmlands in this study are considered to be farm holdings of size less than 8 Hectares. The emergence of small-scale farmlands is a result of independent Government settlement policies and the attitude of the independent day Kenyan where land is seen as the most important possession, however small and with disregard to its economic productivity. Small-scale farming is then a post-independence land use within the Lake Nakuru catchment. Before Independence there were no small-scale farmlands in the catchment. From almost non-existence in 1973, the small-scale farmland has grown to be the dominant land use within the area.

Plate 5.11: Large Scale Farmlands Serves as a Buffer between Settlements and Forests

The Left Hand Side of the forest neighboring a large scale wheat farm is seen to be less degraded than the Right hand side neighboring small scale farms

Settlement schemes and land buying companies were the major vehicles in which small Scale farmlands arrived in the catchment. The 1973 land use pattern reveals that by then only 174 square kilometers or 9 percent of the entire catchment constituted small-scale farmland. From the household questionnaire, it was revealed that 29% of the landowners acquired their land before 1973, 58 percent between 1973 and 1987 and 13 percent after 1987. However after acquisition of land, 5 percent of the households settled in the area before 1973, 56 percent between 1973 and 1987 and 39 percent between 1987 and 1999 as shown in table 5.1 below.

Table 5.1: Years of Land Acquisition and Settlement in Lake Nakuru Catchment

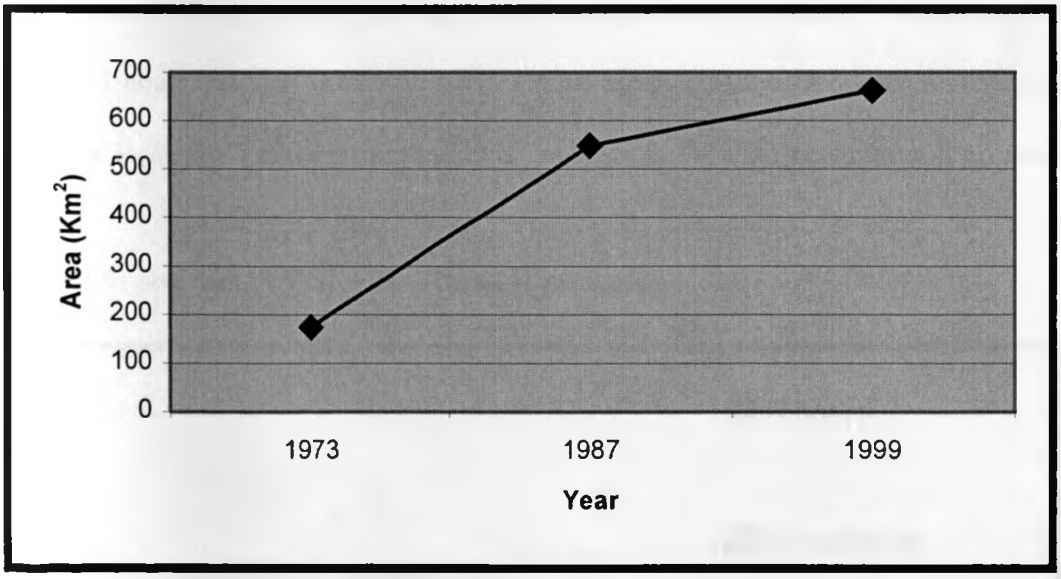
PERIOD	PERCENTAGE OF HOUSEHOLDS	
	Acquired Land	Settled In Catchment
Before 1973	28.6	5.5
1973-87	58.3	55.8
1987-99	13.1	38.7
Total	**100**	**100**

Subsequent subdivision of the initially large-scale farmlands acquired from settler farmers and degazetted forest reserves have aided in the rapid increase of small scale farmlands since the end of the government settlement programmes. Small-scale farmlands have then grown to 36 percent of the entire catchment area from 30 percent in 1987 and 9 percent in 1973, an increase of over 300 percent in 26 years. This has made it the dominant land use within the catchment being as much as one and a half times forest land and three times as large-scale farmlands.

5.1.4.1 Small-Scale Farmlands, Hydrology and Pollution of Water Resources

The average small-scale farmland is 2.4 hectares with an annual income of Ksh. 12,000. Since the average household size is 4.6, this gives an average per capita annual income of Ksh. 2609. For the families to derive their subsistence from such farmlands there is intensive cultivation of the rapidly reducing farm sizes. This involves use of agro-chemicals and hybrid seeds in crop production. From the field survey it was revealed that 97 percent of the farmers use agro-chemicals in both crop and animal husbandry. Such farmers also favoured rise in the use of agro-chemicals in order to raise productivity

Figure. 5.8: The High Rate of Increase in Small-Scale Farmlands



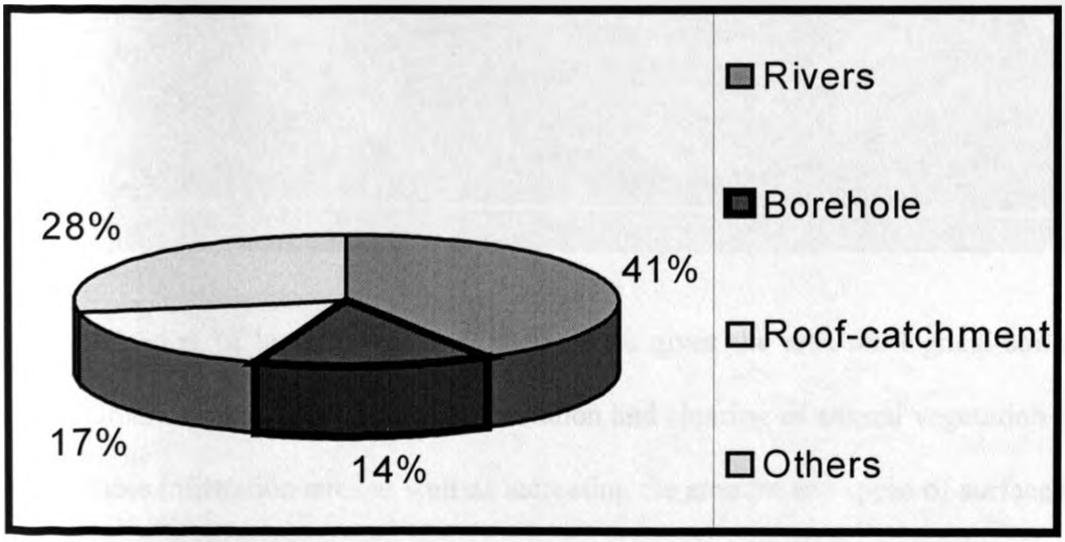
Although the investigation of agro-chemical use per area was beyond the scope of this study, it was evident that it is higher for the small-scale farmlands than for large-scale farmlands. It is also bound to increase with future reduction of farmland sizes. Much of the chemical residuals find their way to the underground water reserves and in the rivers where they

ultimately flow into the lake. More than 50 percent of the rural people in the catchment rely on either borehole or river water as shown in figure 5.10 below. The water pollution threat is then very real in such situations especially considering that high stream densities exists in most of the areas currently under small-scale farming.

5.1.4.2 Small-scale Farmslands, Soils Erosion and Siltation

The small-scale farmlands pose a major threat of soil erosion and siltation. Increased demand of cultivation land has led to clearing of forests and bushes thus exposing soil to erosion hazard. Due to the high population growth rate and pressure for land, intensive farming has also come to be practised in areas of very steep gradients such as that shown in plate 5.12, below. Encroachment on riversides is also evident on both the high and the lower zones of the catchment. Besides crop farming, small-scale farmers also keep livestock such as cattle sheep and goats. In the Njoro and Mau Narok areas, donkeys are kept for transportation. Livestock is usually grazed communally on wasteland. This increases the soil erosion.

Figure 5.9: Sources of Water for Rural Households



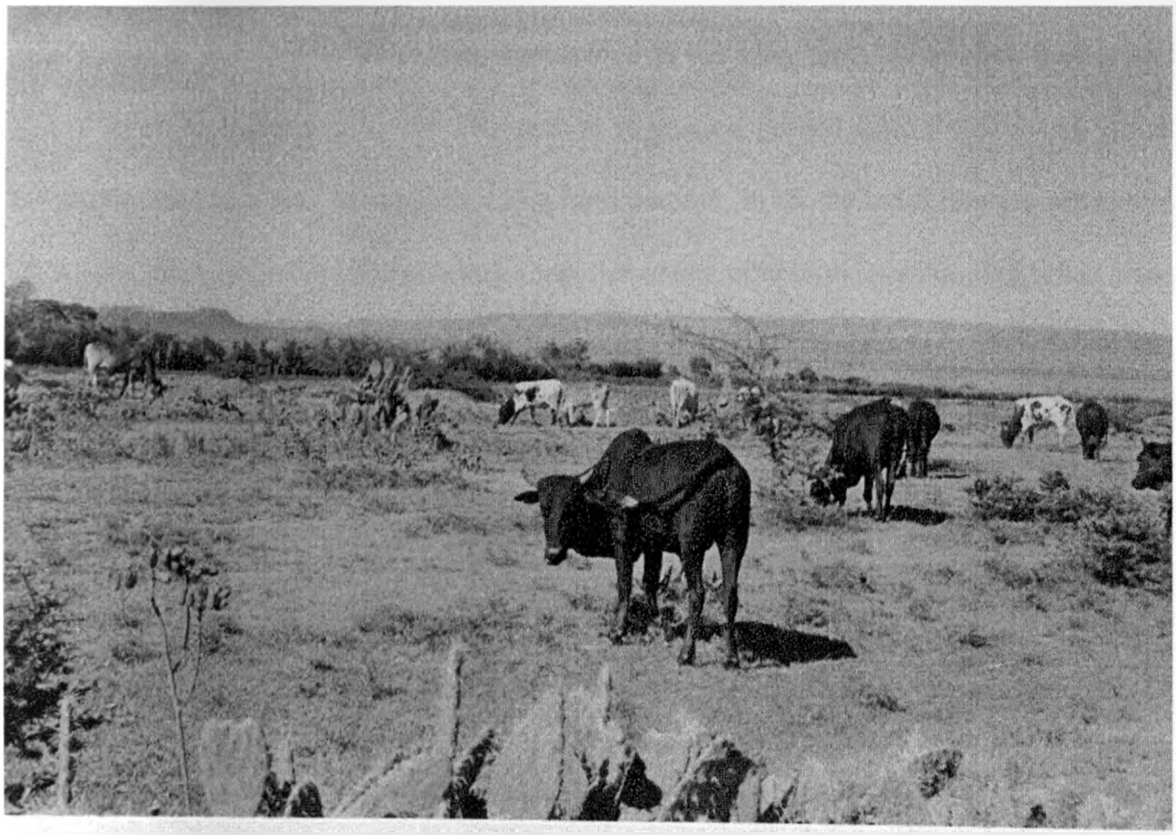
With the recent settlement of more small-scale farmers in the mountainous areas of the catchment, the soil erosion hazard has been increased even more. The southern part of the catchment has the most rugged terrain. It is also the source of the main rivers that feed Lake Nakuru. Because of its higher altitudes, the area receives the highest amount of rainfall, which combines with generally fertile soils to give it the highest potential.

Plate 5.12: Cultivation on Steep Slopes is a Major Cause of Soil Erosion

The combination of high rainfall and steep slopes gives the area the highest soil erosion hazard. Ground treatment in terms of cultivation and clearing of natural vegetation in these areas reduces infiltration rates as well as increasing the amount and speed of surface run off. This decreases the ground water recharge and also raises the rate of soil erosion, and

siltation. According to the KWS, the lake's water level used to take several weeks before it could be observed to rise after heavy rains. Currently, the lake level is observed to rise immediately after heavy rains. The run off gets no time to deposit its solid and chemical impurities before entering the lake.

Plate 5.13: Open Grazing Fields boosts to Soil Degradation



Previously, when there was enough vegetation, rain water would take time to percolate into the ground then to small streams and the main rivers and then into the lake. Currently, with the little natural vegetation cover left, rain water flows directly into rivers and then into the lake. The sudden flow has caused extensive soil wash, slumping, slippage, rill and gully erosion.

5.1.4.3 Small-scale Farmlands and Deforestation

A common practice of the small holders especially in the southern side of the catchment is charcoal burning. The young and unemployed members of the community engage in charcoal burning to supplement incomes from farms. Charcoal burning is then extensively practiced around the forest areas of Kianjoya, Mahiga and Mau Narok. Often, wood for charcoal burning is sourced from gazetted forests. Charcoal burning has almost a historic significance to the people. When they first settled in the area, they had to clear bushes and natural forest to build or cultivate. The natural vegetation proved good for charcoal, which the people used as a way of supplementing farm income. In the Period following settlement in the area, the catchment became a large supplier of charcoal to the surrounding urban areas of Nakuru, Naivasha and even Nairobi. When they exhausted bushes from their farms, the people started burning charcoal in the forest reserves. Currently, although charcoal burning is outlawed in the country, it is still common to find lorries full of charcoal coming out of the remaining natural forests in the area.

5.1.4.4 Environmental Conservation Practices in Small-scale Farmlands

The peasant economy of the small holders is such that farming is not seen as a business venture but merely a means of survival. To most of the small holders, land is a source of security and a home, whether it is commercially productive or not. Subdivision of the small holder farms into even smaller parcels is therefore common. By tradition, sons, and currently even daughters are entitled to a share of the family land. Where the family land constitutes of such small farmlands, the result of such a tradition is sub-economic parcellation of the small-scale farmlands.

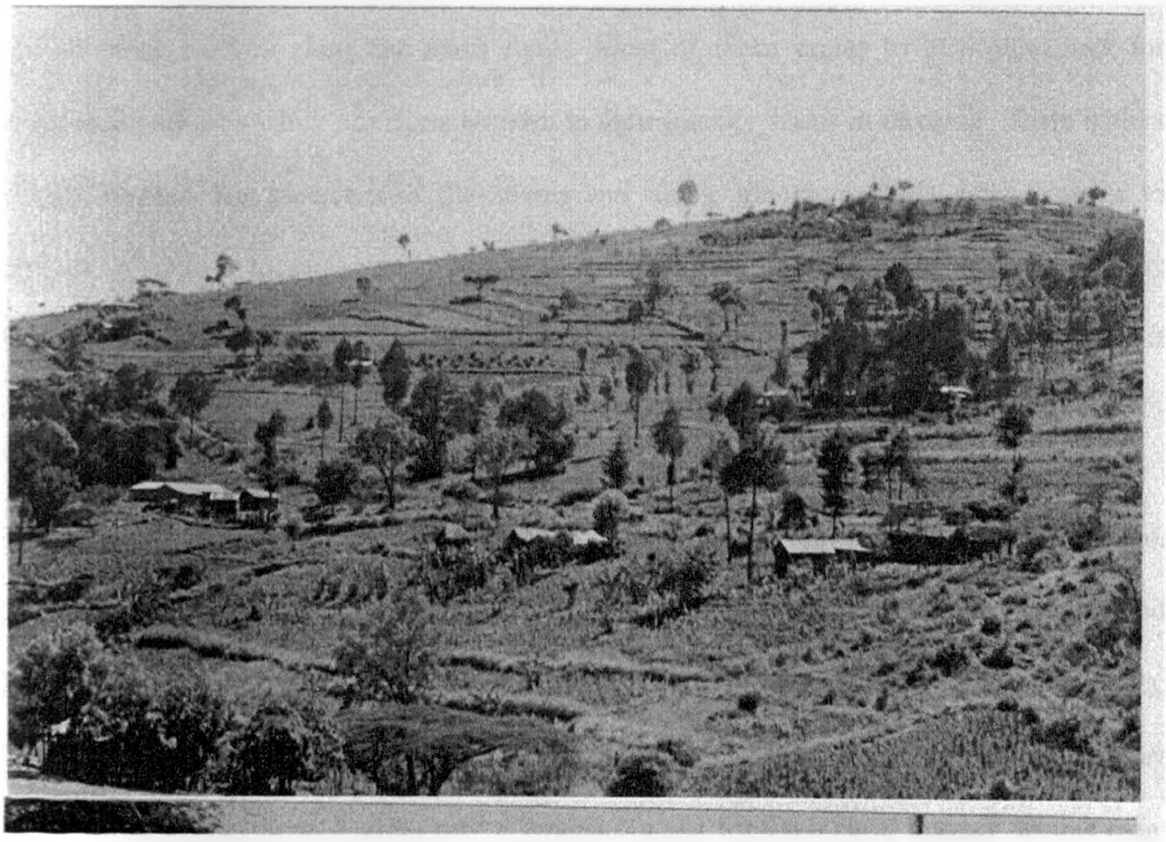
Like most other Kenyan small holders, those in the Lake Nakuru Catchment are a hard working and enterprising lot. They work hard to get their subsistence from the small farmlands and whose soil nutrient level gets depleted every season. The farmers have then to use increasing amounts of fertilizer and enlarge their farms to areas that ordinarily should not be under cultivation. Such areas include sloppy land and river banks. Due to the reliance on small farm sizes for subsistence, the land is never left furrow and is under cultivation throughout the year This depletes the little nutrients left in the soil which leads to poor vegetation cover exposing soil to agents of erosion.

Currently, efforts to curb environmental degradation due to small-scale-farming activities are undertaken by the Ministry of Agriculture, the Catholic Diocese of Nakuru, KWS and WWF/LNCDP. There are also a good number of Non-governmental Organizations (NGOs) and community based organizations (CBOs) promoting soil conservation especially tree planting and sustainable crop and animal husbandry among the small-scale farmers. The Miti Mingi project is one successful case where an NGO has managed to promote tree planting in the southern part of the catchment. Due to the efforts of these agencies, there is currently a high level of awareness of the fragility of the environment and the need for conservation among the small-scale farm owners. Over 68 percent of the farmers visited in the southern region were seen to have undertaken soil conservation measures in their farms. This reveals a high acceptance and adoption of extension teachings by the farmers.

Many respondents attributed the current poor weather conditions in the area to the recent clearing of forestland. They see re-planting of trees as the only hope for the restoration of the area's productivity. Asked what they would expect to be the area's condition as a result of changing land use, many said that the area could as well become a *desert* if no intervention

measures were undertaken. Most such respondents are the ones who settled in the area in the early 1970s and have witnessed three decades of land use change constituting a transformation from a '*Jungle*' into a densely populated area. To them, this is a paradise lost. Although climatic patterns are generally controlled more by large scale atmospheric systems and modified by meso-scale systems like topography and large water bodies rather than a small catchment area like Lake Nakuru Catchment. the response serves to show the local people's awareness and concern on environmental issues.

Plate 5.14: Soil Conservation Measures in Small-scale Farmlands



There is also increased ecological awareness of the functioning of the watershed. Mainly because of the efforts of the LNCDP, many people are now aware of the relationship and effects of activities in one area to the rest of the Catchment. Ecological awareness among the peasants is then a positive score for environmental conservation in the catchment. The

paradox however comes in that in spite of such awareness, many of these small holders still have intentions of subdividing their farms into smaller plots either for sale or to bequeath to their children.

Subdivision for sale is especially common in the Northern side of the catchment where Nakuru town is expanding towards and also around the Njoro town where both the town's expansion and Egerton University are influencing the demand for residential and commercial land. Recent land clashes in the South-Western side of the catchment are also contributing to land subdivision. Those displaced from the interior regions came to rent houses in the towns and shopping centers along the main roads. Most of them prefer to buy plots here for residential purposes while travelling to farm in their interior farms in daytime. There is then a high demand for plots nearer the towns and along the main roads from Nakuru to Nyahururu, Njoro to Mau-Narok, and even in some interior centres like Kianjoya. Many farmers in such areas are responding to this demand by subdividing their land and selling it as small residential and commercial plots.

The issue of land subdivision is therefore a combination of several factors, cultural, economic and even political. About 57 percent of the land owners interviewed had intentions of changing the use of the their land most of which is to involve subdivision. Many of those who hinted subdivision to bequeath to their children also hinted that if they could afford it, they would rather buy a separate parcel for each child instead. In this case, poverty could be said to be leading to land fragmentation. The landowners who subdivide for sale are however reacting to a different stimulus. Mostly being near roads and with the high population growth rate, urbanization is quickly establishing itself in the area. Many shopping

areas are then mushrooming along the main roads of the catchment from Nakuru to Nyahururu, Nakuru to Mau Narok via Njoro and Nakuru to Elementaita via Lanet.

For those who have had to react to the land clashes, this is a case of history repeating itself. Early settlement in the catchment was politically driven just as the land clashes. The political atmosphere at certain periods is then seen to influence land use and this force is till very potent in the Lake Nakuru catchment.

5.1.5 Trends in Urban Growth

Urbanisation in Lake Nakuru Catchment started with the establishment and growth of Nakuru Town. The development of Nakuru town is itself synonymous with the construction of the Kenya-Ugandan railway at around the year 1900. Both Nakuru and Njoro were then established as railway stations and these have continued to be the main urban centres in the catchment. In 1973, Nakuru town constituted the only significant urban land use within the Catchment. The built up area as observed from the imagery constituted 20 square kilometers or 1 percent of the catchment. Njoro was by then a mere shopping centre. By 1987, the scenario was quite different where urban land constituted some 53 square kilometers or 3 percent of the catchment. Apart from Nakuru, other urban centres had started establishing themselves. These included Naishi, Elementaita, and Mau-Narok. There were also numerous shopping centers such as Maili sita and Kianjoya all of which were showing signs of being future urban centres. By 1999, the situation had quite changed from the 1973 scene with urban land covering some 73 square kilometres or about 4 percent of the entire catchment. This gives urban land a 265 percent increase in 26 years, a rate that is only rivalled by small-scale farmland.

Nakuru town is quickly expanding along the Nakuru Nairobi road and the Nakuru-Nyahururu road. The other smaller towns have continued to expand. Njoro township has grown to be an urban centre of significant size. The town's 1979 population stood at 9,026 people. This increased to 22,023 people in 1989. Currently, Njoro's population is estimated at 44,000 people. The areas around this town and Egerton University are quickly acquiring an urban character. Around the university, landowners have reacted to demand of residential houses by constructing rental houses in their farms. Those with a main road frontage engage in commercial activities within their farms. Because of the good road and other services including electricity supply to the farms around this area, demand of plots by university workers is high. Figure 5.11, below shows the dynamics of the urban land use within the Catchment.

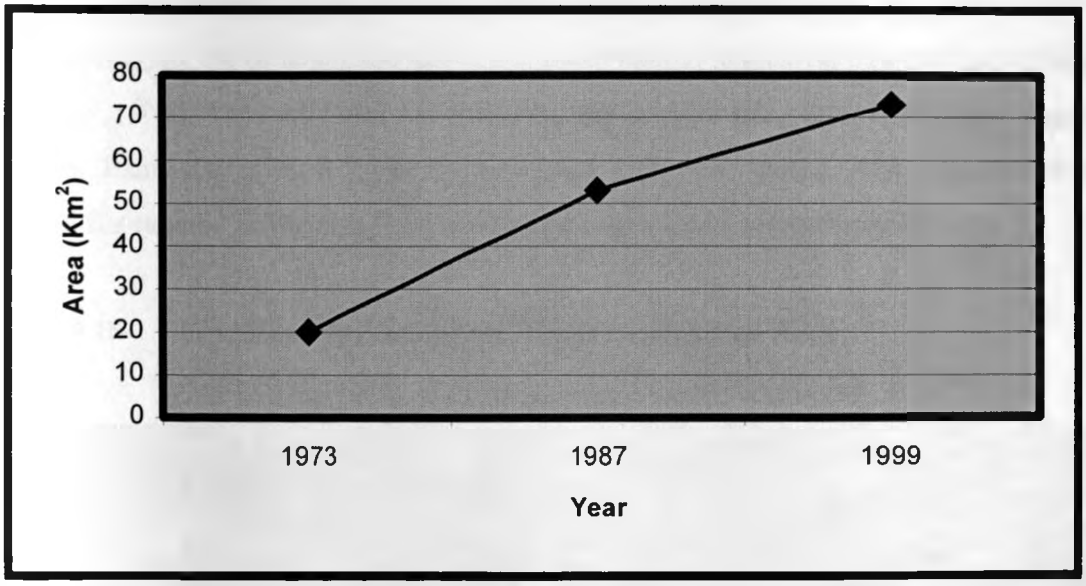
5.1.5.1 Urbanization as a Force in Land Use Change

Within the Lake Nakuru Catchment, urban land could be termed as the ultimate land use, not only influencing other land uses but also gaining quantitatively at the expense of the other land uses. Most of the farmers interviewed sell their produce in Nakuru and the other smaller urban centers. As the market for agricultural produce, urban areas then determine the production activities of the farmers in the rural and sub-urban areas. What is demanded in the towns is what the farmers end up producing.

The small scale-farmers are then currently using intensive farming methods that involves widespread use of fertilizers and other agro-chemicals to be able to meet the demands of the urban areas. More than three quarters of the small-scale farmers interviewed use chemical fertilizers and other agro-chemicals in their farmlands. These farm inputs are bought from

the urban centres, mostly Nakuru town. Agricultural land use therefore ends up having a symbiosis with urban land use. Urban centres also facilitate activities and operations of the large-scale farmers. They not only serve as market areas for agricultural produce, but also serve as processing and value adding points. Farm inputs and implements including machinery are also sourced from the urban centres.

Figure 5.10: Gradual Increase in Urban Land Use in Lake Nakuru Catchment



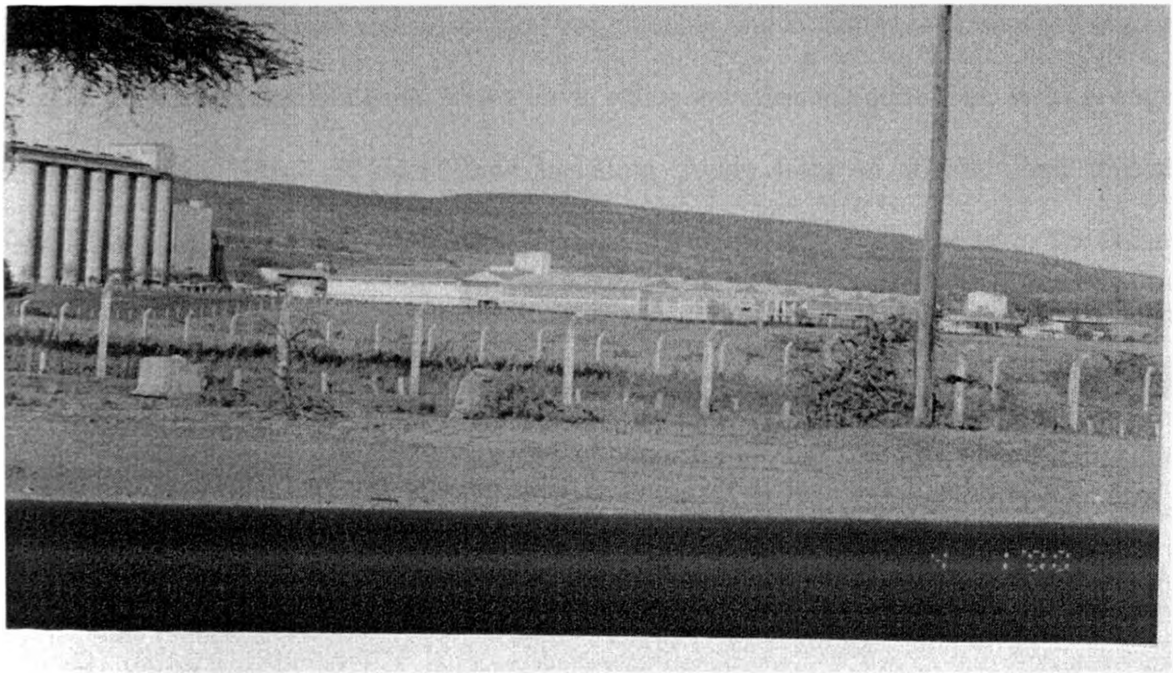
Within the catchment, Nakuru is a primate town. The town is also ranked fourth in the country. The town's population has expanded rapidly from 47,000 people in 1969 to 163,900 people in 1989. Currently, it is projected to be about 400,000 people. The town has also grown to be a significant industrial center with over 100 registered industries. The industries range from soap making, battery manufacturing, steel fabrication, paint production, milk processing and blanket making. The town is also an important commercial center with several banks, hotels retail and wholesale shops. The residential area is quite large and

ranges from well planned and serviced, high and middle income areas to virtually unplanned urban settlements or slums.

5.1.5.2 Implications of Trends in Urban Land Use to the Environment

It is evident that the urban phenomenon has reached significant proportions within the catchment. Urban expansion poses a major threat to environmental sustainability. Among these threats are pollution of underground and surface water by effluent and runoff from the urban area. It also causes land use conversion from other uses like agriculture and conservation to urban use. In Nakuru town for example, the bulk of the water supply comes from ground reserves through some 13 boreholes. Increased town population will imply more boreholes, 20 of which are already planned behind Menengai Crater (Daily Nation, 26th October 1999). This may end up lowering the water table. Increased water supply also implies increased effluent from the sewerage treatment works. Although the sewage is treated for organic pollutants, it definitely contains a lot of inorganic pollutants.

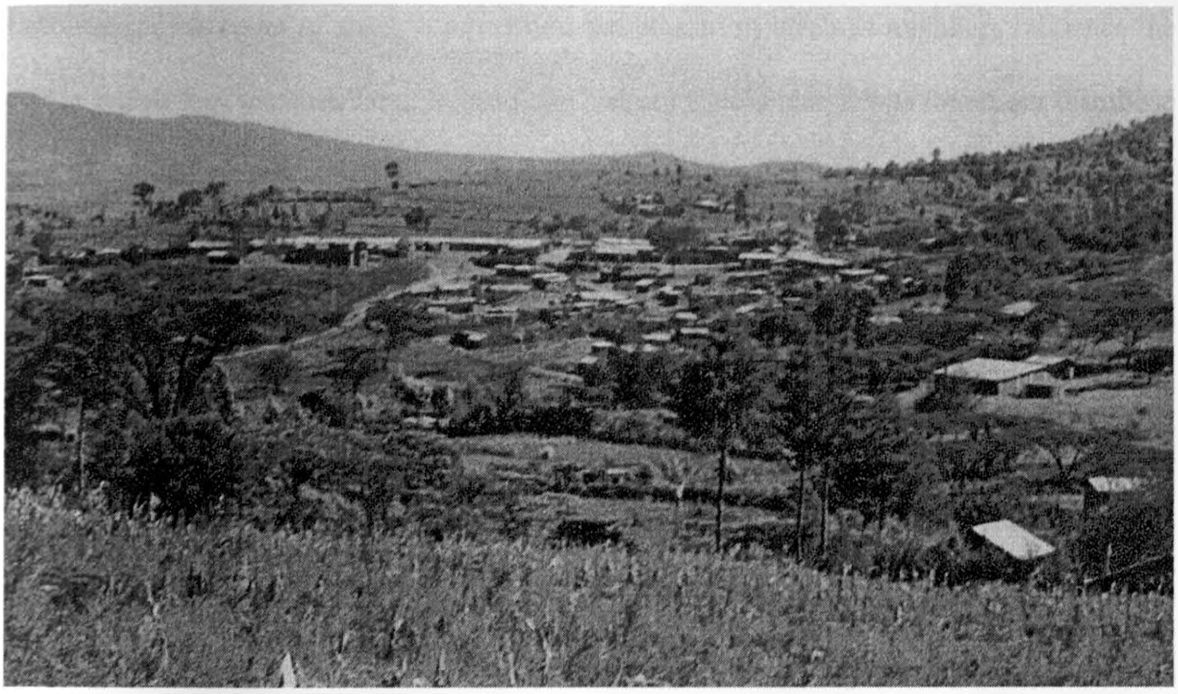
Plate 5.15 The Rapidly Expanding Nakuru Industrial Area



The town is also a major encouragement to deforestation. Its high demand for timber charcoal and even firewood results to more felling of trees from forestlands. Some industries in the town use charcoal and firewood as a source of energy. The urban phenomenon is therefore one of the main factors influencing decrease in forestland. It has also encroached on rural farmlands thereby reducing the area under agriculture, forestland and even geologically unstable land. An analysis of the land use pattern maps reveal that while urban growth has taken land from all other land uses, it has not lost land to any other uses itself. It can then be concluded that the catchment is slowly evolving into one large urban center where urban land may be viewed as the ultimate land use.

The environmental effects of the expansion of Nakuru town especially to the National Park's ecology are well documented in the Nakuru Strategic Structure Plan. For effective environmental management within the catchment, it is imperative that the effects of upcoming towns be studied and urban land use planning and environmental management be done at the earliest possible time. Njoro town, which is expanding quite first, lacks sewage treatment works. Much of its effluent including sludge from an abboitor and several industries enters river Njoro while still untreated and finds its way into the lake. The Other smaller centres are also quickly gaining an urban character. Plate 5.13 shows one such upcoming urban center. Such settlements needs to have their growth planned and controlled at the earliest moment possible or else the quality of their development will have major environmental impcats.

Plate 5.16: **Kianjoya as an Upcoming Urban Centre in a High Potential Agricultural Area**



5.2 Institutional Responsibilities in Land Use Control and Environmental Management

Within the study area, a wealth of institutions concerned with land, its use and environmental conservation operate. As units of society charged with the responsibility of governing the allocation and use of resources, these institutions are important in determining the quality of the environment within the catchment. This section analyses the institutions, their mandates, roles, collaboration, weaknesses and strengths in undertaking land use and environmental management activities.

5.2.1 The Household Institution

The extent of privatization of land in Kenya makes the household a center for land use decision making. Households hold proprietary rights in land and in most rural areas, they have freehold titles. The implication of this is that there is very little control by either central

government or local authorities on how these households use their land. Household characteristics in terms of sizes, composition and education levels of members influence the way in which they use their land. In the Lake Nakuru Catchment, it was found out that those with many sons intend to subdivide among the sons while those with higher education were found to generally intend to introduce some commercial activities in their farms. Where family members were adequately educated, most tended to work outside their farms, this having a limitation on excessive subdivision.

As an institution, the household is then the first body that conservation efforts should be directly concerned with. This is the unit of society that shapes and decides the land use pattern. They own resources in terms of land, labour and capital that ought to be harnessed in the promotion of sustainable land use within the Lake Nakuru Catchment.

5.2.2 The Local authorities

Lake Nakuru Catchment falls within the jurisdictions of two local authorities, the Municipal Council of Nakuru (MCN), and the County Council of Nakuru (CCN). While the municipal council's jurisdiction is in Nakuru municipality, the County Council is in charge of all areas in the district other than towns and the Municipal area. A small portion of the catchment towards the Mau Ranges is however in Narok district and is under the County Council of Narok. Under the Local Government Act and even in the Physical Planning Act, local authorities are identified as important players in land use and development control control issues. Under the Physical Planning Act for example, any development must be approved by the local authority on whose area of jurisdiction the proposed development is to take place.

The two local authorities in the catchment are then institutions of critical importance in as far as controlling and guiding of future land use is concerned.

5.2.2.1 Municipal Council of Nakuru

The Municipal council of Nakuru is in charge of some 290 square kilometres or about 16 percent of total catchment area. The crucial role of this area emanates from the high concentration of people and land use in Nakuru town. The town is the main point source of pollution to Lake Nakuru. As the main urban centre containing more than a half of total catchment population, the town is arguably the most influential land use within the catchment both in terms of pollution threat and also in influencing other land uses.

It is because of these crucial effects of the town that the municipal council is a centre stage institution in the planning and control of land use within the catchment. It has been identified as the main implementing agency in the Nakuru Strategic Structure Plan (NSSP), which aims at experimenting on localising Agenda 21 in a Third World African City. The plan recognises institutional collaboration and community participation as main strategies towards achievement of the plan objectives. Since the results and lessons learned from the NSSP will be used in duplicating the LA21 to other towns in similar settings, the council faces a major challenge on how to fit in this role.

5.2.2.2 The County Council of Nakuru

In Kenya, a county council covers the administrative area of the district. The jurisdiction of the county council however excludes those areas under Municipal and town councils. The county Council of Nakuru is therefore the authority having the bigger share of the catchment under its jurisdiction. It is in charge of all the small and medium sized urban centres. The

potential role of the County Council in managing land use and environmental issues in the catchment can not therfore be overemphasised.

5.2.2.3 Weaknesses of the Local Authorities

Like most other local authorities in Kenya, the current capacity of the councils to undertake land use change monitoring and control is very limited. There are operational restrictions imposed by the Central Government making the councils unable to hire or even consult technical experts who my be required to undertake the tasks involved in land use studies. The councils are then made to rely on the services of the district and provincial central government officers for data and information and even advise regarding land use change and control in their area of jurisdiction. Such officers are however answerable to their respective ministries and often do not serve the councils requests adequately. For the same reason, the role of the local authorities tends to be eclipsed by that of the District Development Committee, which comprises of the District Departmental Heads.

The local authorities, being responsible for licensing of all commercial activities within their areas of jurisdiction have important databases on changes in land use. The rate at which rural shops are being established is an indication of changes in the general area where catchment population concentration must have risen to warrant an establishment of a rural shop. The management of the information is however very poor. Old filing systems are in use and there is no attempt at computerisation of the data. The staff is also not trained in modern data management methods. This poor information management system results in wastage of time in accessing information and definitely limits the utility of the information. It also limits the scope of collaboration with other stakeholders who may require the information. With the current requirement by the Physical Planning Act that all development applications be

submitted to local authorities, the need for technical expertise among council employees and the establishment of a land use and environmental information system is even more urgent.

5.2.3 The Kenya Wildlife Services

The importance of Kenya Wildlife Services (KWS), in the environmental management of the Lake Nakuru Catchment stems from the centrality of Lake Nakuru in the National park. KWS is the body mandated to manage and be custodian of all the wildlife in Kenya. This role automatically makes it the manager of all national parks and game reserves within the country. KWS is therefore a centre stage institution in the management of land use and environment within the catchment. Initially, KWS was not concerned with activities outside the park and concentrated within the park boundaries. The current park management however recognises the fact that most of the problems facing the park emanate from land use outside the park and that the park cannot be planned and managed in isolation.

The depletion of water volume in Lake Nakuru, its siltation and the increased chemical pollution of the lake waters have been some of the reasons prompting KWS to develop an interest in land use outside the National Park. KWS has been keeping records of water flows for all main rivers entering the lake including their chemical content. It has also collaborated with researchers especially from Egerton University and WWF in undertaking environmental studies within the catchment. KWS therefore joins the two local authorities as one of the major institutions that should pool their resources towards the development of a land use monitoring and environmental conservation programme in the catchment. These institutions already have massive data and information which is currently unavailable to the other institutions, either through deliberate restriction or due to the shear effort required in

retrieving any meaningful information from the data due to the storage and management methods.

Although in terms of personnel training KWS staff have better appreciation for environmental management and information systems than those in the local authorities, there was still identified some need for prioritisation of information collection and management programmes. The staff members also need to be further trained and be provided with modern information technology equipment.

5.2.4 The Physical Planning Department

The Mission of the Physical Planning Department is stated as

> to ensure that human settlements are planned providing an appropriate spatial framework within which environment and socio-economic development activities of the country can harmoniously take place through the preparation of National, Regional and Local land use development plans (GOK, 1968).

This mission statement gives the department a leading role in the determination of land use policies and plans. The PPA also gives the Director of Physical Planning the role of preparing Regional and Local Physical Development Plans that local authorities are then supposed to use in guiding development within their areas of jurisdiction. Since these plans will directly influence the future land use pattern in their respective areas, the department is then a main player in the development of a land use monitoring and control system.

Through the District and Provincial Physical Planning offices, there is a scope for collaboration on issues concerning land use and environmental planning. The department has of late been able to spearhead the preparation of both the Nakuru Strategic Structure Plan and a Nakuru Regional (District) Physical Development Plan. The Department however

suffers from many limitations. Like many other Central Government departments, it is beleaguered with a bureaucracy that often makes collaboration difficult. It is also ill equipped, understaffed and the staff members are quite unexposed to modern office operations especially in modern planning data and information management systems.

The strength of the department lies in formulation and advice on land use planning policies to the local authorities and also assisting in monitoring of their implementation. Since the department's operations cover the entire catchment and even beyond, it is the best forum to bring the County council, the Municipal council and the KWS together in the management of their land resources, as all these other institutions are only mandated to manage specific areas of the catchment.

5.2.5 Department of Lands

The Kenyan, constitution vests all land in the state. The president as the head of state is the trustee for the national land resource. He however appoints a Commissioner of Lands who heads the Lands Department within the Ministry of Lands and settlement. The commissioner administers all national land on behalf of the president. The commissioner has powers to give grants to individuals and institutions of government land under the Government Lands Act. Before the enactment of the Physical Planning Act, the commissioner had to approve all development proposals including Part Development Plans (PDPs), made by the director of Physical Planning. The lands department is then an influential department in as far as deciding and future land use is concerned.

5.2.6 Other Central Government Departments

Most Central government departments are represented in the District Development Committee, (DDC). The DDC could then be regarded as a multi-disciplinary institution concerned with all aspects of development within the district. There are several departments whose interests touch on issues related to land use and whose operations may generate important land use information. Such departments could also benefit from an integrated land use information system within the catchment. Although such departments normally operate at the administrative unit level such as the district, it is also true that they often deal with issues at a project basis. For those projects that are based in Lake Nakuru catchment, a scope of collaboration exists with other institutions

The departments/ministries include that of Agriculture, water, industrial development, environment/forestry and natural resources, among many others. The Ministry of Agriculture's extension officers were for instance found to be very effective in disseminating soil conservation methods among the farmers. Such a network is then very useful in land use data collection and the dissemination of conservation information regarding peoples use of their land. The Ministry of Water development keeps hydrological records including volumes and quality of water. Variations in this statistics could be correlated with those in land use in an attempt to model land use-environment relationships. The department of Resource Surveys and Remote Sensing in the Ministry of environment is yet another relevant central government organ that deals with land use information gathering. The department makes regular aerials surveys of crop vigour, forest resources and stocking levels of wildlife and rangeland areas. Formally, the department has undertaken vegetation mapping of the Lake Nakuru National Park. The capacity of the department to work with

other institutions in general and in undertaking specialised resource surveys using aerial surveys and satellite remote sensing techniques is quite high.

The Survey of Kenya as the government department responsible for surveying and mapping the national wealth also has a crucial role in the management of the environment. The department makes accurate maps, which are useful in various types of studies. The department also engages in aerial photography and remote sensing data analysis. The Director of Surveys is also custodians of massive data on proprietary units of land and topographical maps at various scales. Bureaucratic requirements that one acquire clearance from the Department of Defence however discourage people from requesting for the maps. The data held by this department ends up not being fully utilised by the same public that pays for its compilation and storage. The department also suffers from lack of proper equipment and personnel and is unable to update the maps in a continuous basis.

5.2.7 NGOs and CBOs

Non-Governmental Organisations (NGOs) and Community-Based Organisations(CBOs) have played an important role in the development and also in the environmental conservation of the Lake Nakuru Catchment. Church groups have especially been undertaking development projects including water and educational projects. The WWF through its LNCDP has been the main agency undertaking conservation studies and education within the catchment. The Miti Mingi Project has also been active in afforestation measures in most parts of the catchment.

NGOs and CBOs, because of their nature of operation, which unlike in government departments has less bureaucracy, were seen to be the best link between the government

agencies and the local communities. They provide a good network or forum for organising the community into groups, which facilitates their participation in and benefiting from conservation efforts. NGOs also source extra funds from external agents to supplement local resources in conservation efforts.

5.3 The Prevailing Legal Framework for Land Use and Environmental Management

Various legislation have been put in place to give institutional roles and also aid them in the control and regulation of land use and formulation of environmental management programmes. In Kenya, the legislation that governs the use of the nation's land resources is diverse ranging from general laws to resource specific laws. The legislations, their scopes, weaknesses and strengths are reviewed in the remaining part of this chapter.

5.3.1 Forest Act and the Forest Bill

The forest Act, CAP 385 of the Laws of Kenya, came into operation in March 1942. Although the act was meant to facilitate the management and protection of forest resources, recent developments in resource management and conservation paradigms have made it inadequate. The act adopts a Top-Bottom approach, which places the management of forests in the hands of government bureaucrats while ignoring the role of communities in conservation of forest resources. The Act has been unable to protect forests and at times even facilitated their depletion.

There is currently a bill of parliament that proposes to put emphasis on community based forest management as a main strategy for securing the country's forest resources and placing it under cheap and effective management structures. The bill comes out the realisation that at

the current rate of depletion, the country's forests will be decimated by 2050. This could be supported by the findings on forest depletion in Nakuru catchment since 1973. The bill seeks to establish a statutory body to oversee the management of forests in the country. This body, the *Kenya Forest Service* will have powers to protect all forests in the country, prepare management and exploitation plans for all the forests in the country. It shall also include the establishment of state forests on un-alienated government land, purchased government land and compulsorily acquired land

The proposed bill is however not devoid of weaknesses. It does not provide a memorandum of understanding between various stakeholders. Although it seeks to have local communities involved in the management and conservation of forest resources, it does not give the modalities of bringing them to participate, neither does it give the gains that the communities are to derive from such a participation. The bill also fails to give a clear definition of who are to be considered to constitute the community living around the forest. Although the bill proposes a penalty for those found plundering forest resources, the penalty is not harsh enough to serve as a deterrent. The maximum penalty is Ksh. 10,000 or six months imprisonment or both fine and imprisonment. It is unreasonable that following this bill's proposals, someone caught fetching firewood in the forest may be penalised the same way as one found using a power saw for logging in a plantation forest. Like with many other laws the effect of this bill may end being that the *small timer*, who usually has less impact is the one who gets the blunt of the law while the *big-time* plunderer goes scot-free.

5.3.2 The Environmental Management and Co-ordination Act

The Environment Bill was passed by parliament in December 1999 and became the Environmental Management and Co-ordination Act after presidential accent. The Act seeks to establish a Parastatal, the *National Environmental Management Authority* (NEMA) which shall be charged with the responsibility of among other things overseeing the state of the environment as well as its management. Section 68(1) of the act requires the authority to carry out an audit of all those activities that are likely to have significant impacts on the environment. The Act establishes a *Standards and Enforcement Committee* which shall be advising the authority on criteria and procedures in environmental quality assessment.

The Act makes it mandatory for manufacturers to publish an environmental impact assessment report before commencement of any project. It also gives citizens a right to be heard in court (*Locus Standi*), over issues concerning the environment. Another positive aspect of the Act is its recognition of the roles of multiple actors in environmental issues. The National Environmental Council is mandated to co-ordinate the activities of public departments, local authorities, private sector and NGOs engaged in environment conservation. It will also formulate policy and set national goals regarding environmental conservation and also publish annual reports on the state of the environment. The Act will also oversee environmental education and public awareness in environmental conservation. The Act gives a right to the access of environmental information to the public.

The Act however has got some shortcomings. Although it gives to citizens a *locus standi* on environmental issues, it ignores the role of indigenous knowledge in environmental conservation. The Act also sounds utopian in its requirement for water and air quality checks

within an environment of limited quality analysis facilities. Although the bill sets harsh punishment for polluters of the environment including the cost for restoration, the method of valuation of the pollution damage are not clearly stated.

5.3.3 The Land Control Act

The Land Control Act (CAP 302) of 1967 is the most influential legislation when it comes to subdivision and transactions in agricultural land. It lists a number of controlled transactions for which consent has to be obtained by the agricultural landowner before the transaction can have the force of law. The Act defines agricultural land as land; *that is not within a municipality, a township, trading centre or market, or any other land that the Minister may by notice in the gazette declare to be agricultural land.* A hierarchy of land Control boards is then established ranging from the divisional to national level. The boards have representation consisting of the provincial administration, central government officers from relevant ministries, local authorities and community members.

In the context of this study, the Land Control Act is important in as far as regulating of the subdivision and change of user of agricultural land is concerned. Provisions of the Act if properly followed could salvage agricultural land while lack of its enforcement can result to sub-economic agricultural land sizes and even conversion to urban uses.

5.3.4 The Water Act

The Water Act, Cap 372 of 1962 is an act of *parliament to make provision for the conservation, control apportionment and use of Water resources.* Section 3 of the act vests all water over or upon any land in the government. Subject to any rights of user which may be granted to any person. Section 8 empowers the Minister to acquire land for the

conservation, improvement or use of water resources. Section 14 empowers the minister to declare an area a protected catchment. This may include that he order, require, regulate or prohibit the doing by any person in such protected area of any act which he considers necessary for the protection of such an area or for the protection of water supply obtained therefrom. Any person who fails to comply is guilty of an offence and liable to a fine not exceeding ten thousand shillings. Section 20 of the act establishes a Water Resources Authority, whose duty includes investigating the water resources and advising the minister in regard to the improvements, preservation and conservation, utilisation and apportionment of such resources, and to the provision of additional water supply.

In section 22, the authority is empowered to subdivide the country into catchment areas and to amend such catchments from time to time. A board is appointed for each such catchment by the minister, its duty being to advise the water apportionment board of the area. In section 24, Regional Water Committees are appointed by the Minister to advise him on the water conservation and development policies, and also to receive recommendations for water development from local authorities. Section 25 establishes Water Apportionment Boards which subordinates the Water Resources Authority.

In section 158, the penalty for polluting water resources that are used for human consumption is provided. The section however considers water resources in the narrow sense of water for domestic use. Water bodies such as Lake Nakuru, which are not sources for domestic water does not therefore benefit from provisions of the act. The section particularly exempts: -

1. Any lawful method of cultivation of land or the watering of livestock which in the opinion of the Minister does not conflict with the principles of good husbandry,

2. Reasonable use of oil, tar or other substances on any highway or road so long as the authority concerned takes all reasonable measures of preventing any liquid thereof from polluting any source of water.
3. The disposal of effluents or waste. (GOK, 1999).

These exemptions are however seen to be among those posing the greatest risks in the Lake Nakuru Catchment, especially the Non-point sources of pollution. To this extent it is true that the Water Act fails to protect Lake Nakuru as a water body.

5.3.5 The Local Government Act

The Local Government Act, CAP 265 of 1963 is an act of Parliament *to provide for the establishment of authorities for local government, to define their functions and to provide for matters connected therewith and incidental thereto.* Under the act, Local authorities include Municipal, County, Town and Uban Councils. Section 145 (v) of the act requires Local Authorities to establish, maintain and assist information centres and inquiry bureaux. Section 147(d) empowers authorities to control the cutting of timber and destruction of trees and shrubs to prohibit the wasteful destruction of trees and shrubs and to require the planting of trees. In section 155 (f), Local Authorities are given power to establish and maintain forests. Under section 159, county councils have power to prohibit and control shops in the rural areas. All council are given power under section 162(g) to control the subdivision of land within their areas of jurisdiction. Under section 166, every local authority is empowered subject to any written law to prohibit and control the development and use of land and buildings in the interest of proper and orderly development of its area.

The Local Government Act is therefore seen to be a comprehensive legislation in as far as land use and environmental conservation is concerned. In as far as it allows local authorities to make by-laws, the act has a capacity to address unique local situations like those found in

the Lake Nakuru cacthment. The main weakness of the act lies in that it denies Local Authorities the autonomy they need in order to effectively implement the programmes they are mandated to undertake.

5.3.6 The Registered Land Act

There are various legislations giving various forms of land tenure in Kenya. Different land tenure types are then administered using specific statute that specify not only the form of ownership but also the type of use and method of conveyancing. To reduce the multiplicity of legislation on land the government's intention is to have all land registered under the Registered Land Act (Cap 300) of 1963. Land initially registered under the Registration of Titles Act (Cap 281), is then being converted to RLA. The reasoning behind the conversion is for easier administration of land.

From a Planner's point of view, land held under the Registration of Titles Act may seem easier to administer because the law has specific provision for conditions under which owners of land can subdivide, use or develop and transfer their title. The essence of the Registered Land Act is however historic in nature. By the time of independence, the African land problem was top in the agenda. Registration under the Registration of Titles Act required rigorous survey and accurate fixing of land boundaries. This not only meant much delay but was also quite expensive. The Registered Land Act was then enacted in 1963 to facilitate registration of land under general boundaries where less-accurate but quicker and cheaper surveys could be used. Registered Land Act however covers registration of land under both general and fixed boundaries. Private land held under Registered Land Act has no user conditions listed in the title. The prohibitive legal mechanisms in-built in the

Registration of Titles Act are legislated in other separate legislation like the Land Control Act and the Physical Planning Act.

While it is true that the Registered Land Act has made land administration easier, it is observed that this ease has been accompanied by difficulties in land use control and environmental regulation. The act is not explicit in terms of planning provisions and therefore requires much reference to the other more explicit planning legislation.

5.3.7 The Physical Planning Act

The Physical Planning Act (1996) is *an Act of Parliament to provide for the preparation and implementation of physical development plans and for connected purposes*. Passed in 1996 as a law in Kenya, the Act came into commencement in mid 1999. Section 3 of the Act defines development as to include *the making of any material change in the use or density of land or the subdivision of land.* Section 4 of the Act establishes the office of the Director of Physical Planning who is the chief government advisor on all matters relating to physical planning. In section 5 of the act, the Director is empowered to formulate national, regional and local physical development policies, guidelines and strategies and to prepare regional and local physical development plans with reference to any Government land, trust or private land.

A regional physical development plan is taken to be a plan for an area or part thereof of a county council while a local physical development plan will be within the area of a city, municipal town or urban council, a trading or market centre. The Director's duties also include advising the Commissioner of lands and local authorities on the most appropriate use of land including land management such as change of user, extension of user and lease,

subdivision and amalgamation of land. He is also empowered to require local authorities to ensure the proper execution of physical development control and preservation orders.

On the approval of a physical development plan, no development is allowed to take place on any land within the plan area unless it is in conformity with the plan. Each local authority is empowered to prohibit or control the use and development of land in the interest of proper and orderly development of its area. It is also required to control or prohibit the subdivision of land or existing plots into smaller areas and to consider and approve all development applications and grant all development permissions. Section 30 (1) requires anybody intending to carry out development within an area of a local authority to get permission from the authority. Under section 30 (5), no licensing authority can grant a license of commercial or industrial use of land if the respective local authority has not granted development permission. The Local authority on the other hand is required to ensure that the Director has issued the developer with a certificate of compliance before granting development permission.

Where any development application require subdivision or change of user of any agricultural land, the local authority is required to refer the issue to the relevant Land Control Board for advise on whether to approve or reject the application. Where the Local authority feels that a proposed development will have injurious impact on the environment, it may require the applicant to submit together with the application an environmental impact assessment report. Subdivision and land use plans in relation to any private land are to be prepared by registered physical planners and approved by the Director. The act requires that no private

land within the area of a local authority may be subdivided except in accordance with the requirements of a local physical development plan approved in relation to that area.

Section 23(1) empowers the Director to declare an area with unique development potential or problems as a special planning area for the purpose of preparation of a physical development plan irrespective of whether it lies within or outside the area of a local authority. This includes an area cutting across the boundaries of two or more local authorities and which has spatial or physical development problems. Section 42 requires that due regard be taken of the requirements of the relevant physical development plan before subdivision, consolidation lease or renewal of lease of un-alienated government land or trust land under the Government Lands Act and Trust Land Act respectively.

CHAPTER SIX

CONCLUSION AND RECOMMENDATIONS

6.0 Summary of Findings

The study has revealed the general trends in land use over the past twenty-six years and the likely environmental implications of this trend. Table 6.1 is a summary of these changes. The most remarkable changes are the increase in small-scale farmland and urban land at 304 percent and 265 percent respectively. Small-scale farmland has now overtaken forestland as the main land use within the catchment. Urban land, although still the smallest in terms of areal extent has consistently maintained a lead in the rate of growth. Given that the growth in small-scale farms is a step towards urban development, it is true that the region is growing towards becoming one large urban area. While majority of the landowners acquired land in the catchment between 1973 and 1987, settlement is still going on through government allocation of degazetted forestland or through buying of subdivided large-scale farms.

Land use was were also found to have potential negative implications on environmental conservation in the catchment. The upcoming urban centres are largely unplanned and pose major threats as point sources of pollution. The large and small-scale farmlands are non-point sources of pollution while still exposing the soil to major soil erosion hazards. Erosion hazard is especially acute in the southern side of the catchment. This is the area which has higher amount of annual rainfall and yet with steeper slopes. Clearing of forests has aggravated the risk. All these activities are bound to increase the level of pollution of ground and surface water resources and increase siltation of the Lake.

Table 6.1: Summary of Land Use Changes

LAND USE	1979		1987		1999		ABSOLUTE CHANGE (KM^2)	PERCENTAGE CHANGE
	Area (Km^2)	Percentage	Area (Km^2)	Percentage	Area (Km^2)	Percentage		
Small-scale Farmland	784	9	548	30	703	39	528.6	304
Urban Land	20	1	52	3	73	4	53	265
National Park	119	6	192	10	199	11	80	67
Rangeland	168	8.8	138	8	118	6	-50	-30
Large-scale Farmland	518	29	169	9	263	14	-255	-50
Forestland	758	42	565	36	406	22	-352	-46

There are various conservation efforts being undertaken in the catchment. These are however undertaken in a piecemeal fashion and without integration and ends up not having much positive outcomes. Most notable are the WWF/LNCDP in collaboration with the Ministry of agriculture/KARI and the KWS in promoting conservation efforts among the small-scale farmers. The Municipal Council of Nakuru in collaboration with the Ministry of Lands and Settlement/ Physical Planning Department has also prepared a Strategic Structure Plan for Nakuru, the greatest contributor of point source pollution in the catchment. The Provincial Physical planning office has also prepared a Regional Development Plan for Nakuru district, which addresses some of the environmental issues in the catchment. It is such already existing activities that has promoted conservation awareness among the communities living in the catchment. This gives an indication to the way forward where partnerships will have to be a major strategy in land use planning and environmental conservation in the catchment.

A review of the legal and institutional framework for land use planning and environmental management also reveals both hopes and weaknesses. These range from legislation governing the rights in land to those prescribing planning and land use and development control measures. Recent enactment of the Physical Planning Act, Forest bill and the Environment Act and the appointment the Presidential Commission on land matters are developments at the national level that give renewed hope for more positive policy regarding land use and environmental conservation.

There is also revealed a wealth of institutions operating within the catchment from both the public and private sectors. These institutions however lack the necessary capacity in terms of funds and human resources to fully undertake land use and environmental conservation studies and implement the necessary remedial measures. The data collection and

management systems of these institutions are also rudimentary with hardly any updating of their records. This not only makes it difficult for collaboration in research but also makes information acquisition to the public very difficult.

6.1 Towards Sustainable Land Use in the Lake Nakuru Catchment

From the analysis, and guided by the research objectives and questions, the study makes recommendations on the way forward for better land use and environmental management in the Lake Nakuru Catchment. The recommendations touch on the various interventions that need to be made in order to arrest further deterioration of the environment. These range from community sensitization and partnership formation to enhancement and more strict enforcement of legislation concerned with land resources and their utilization.

6.1.1 Changes in Predominance of Land Use

The trends in land use within the catchment since 1973 to the present reveals that the area has seen quite some dynamism in terms of land use. It is evident that land use has changed over the years from predominantly forest and grassland area to large-scale farmlands and currently to small-scale farmlands as the main user of land. The small-scale farmlands have also given in to urban land use, making it reasonable to conclude that urban land is the ultimate land use within the catchment. The observation leading to this is not only the fast expansion of Nakuru town but also the mushrooming of many smaller and medium centres. Land use planning and environmental conservation measures within the catchment will then have to take this into consideration. Immediate measures are required to deal with the negative implications of the predominance of small-scale farmlands and their ultimate

conversion to urban land. The measures in this case will range from direct land use control to incentives for sustainable land use.

6.1.2 Provision of Alternative Economic Opportunities

Most of the small scale farmers in the catchment were found to be peasants, relying on the little produce from their farms for subsistence and many having no alternative sources of income. Most of them have low or no formal education at all. For such farmers who on average have four children, the worry is that if their children do not get better education and other forms of economic empowerment, they will end up having to rely upon the farms as well for subsistence. The solution then lies in provision of off-farm employment opportunities for the youth.

For the Youth to be involved in off-farm employment, education is of prime importance. Fortunately for the younger generation, they are better educated than their parents, 77 percent of those below the age of 25 having at least completed primary education, 43 percent secondary education and 18 percent with post secondary education. It was generally found out that those with post secondary education tended to move out of the rural areas and seek employment in urban areas. Most secondary and primary school leavers however lack vocational training, which could enable them to be self-employed or compete effectively for employment. There is then a need to focus on promotion of vocational training in the area. This will involve the establishment of youth polytechnics within the rural areas. Currently, such institutions only exist in the urban centres thereby putting the youth from the remote parts of the catchment at a disadvantage.

The Ministry of Vocational Training ought to collaborate with the church and other community based organisations in establishing and maintaining such institutions. There is also need for assistance of youth and women groups to undertake non-farm income generation activities. Such measures are bound to reduce the level of reliance on the diminishing farm sizes hence stem land subdivision among children of the current landowners. Retention of current farm sizes will not only avoid deterioration of impacts to the environment but also prevent further reduction in the current level of farm productivity.

6.1.2 Land Use Control Measures

The right and duty of the state to control and regulate use of private land arises out of the negative externalities resulting from the use of private land. Whereas legal stipulations provide for detailed land use control measures in urban areas where leases are given with certain user conditions, the same is not quite true of rural land. Most rural land is held under freehold tenure and the authorities have very little powers to control their use and development other than in cases of formal subdivision, sale or lease. There is evidence that much informal conveyancing has taken place where both the buyer and the seller just exchange land without going through the cumbersome, and expensive bureaucracy of formal conveyancing. This informality in land sales has made it very hard for any concerned authorities to keep track of development in land use and changes in farm holding sizes.

For freehold land that is quickly gaining an urban character, there is need to develop some land use and development control measures. Such measures will include the conversion to leasehold whenever subdivision approval is applied for, the control of the proportions of land being used for specific purposes and even prohibition of certain land uses perceived as being environmentally harmful in certain parts of the catchment. Cultivation in certain parts

of the catchment without terraces could be not just be outlawed but also strictly enforced by a joint effort of the Ministries of agriculture and Environmental conservation. Operation of shops and other commercial activities in non-designated shopping centres could also be discouraged by the County Council.

The issue of rural land use control is a contentious one and may be beyond the scope of this study. The issue may even not be adequately addressed at a local level such as the Lake Nakuru catchment. It ought to be part of a national land policy, whose formulation would necessitate a review of the current land and property laws. The recently appointed presidential commission on land is an excellent forum to discuss the issue. The fact however remains that rural land cannot continue being under the little land use control as it currently enjoys. The fact that non-point sources of pollution have been identified as being a higher contributor of pollution and also that the rural land of today is tomorrow's urban land is a pointer to the necessity for controlling rural land use.

6.1.4 Conservation Training

Even as measures are undertaken to reduce dependency on farm income, it is true that the small-scale farmlands will continue being a major land use within the catchment. Emphasis should then be placed on farmer education on the need for environmentally friendly land use. Although the farmers who have been in the area for same time seem to have appreciated the need for soil conservation, those who are currently settling in the area will take some time to reach the same level of appreciation. The harmful environmental impacts of agro-chemicals are not yet fully appreciated by farmers. Where organic fertilisers and pest control methods are used, this is simply as a cost cutting measure and rarely because of environmental considerations. The need for afforestation and re-afforestation is recognised by most large

and small scale farmers who have been in the area for some time. This is evident in the Miti Mingi area where through afforestation, part of a rangeland is being reclaimed to arable land. To most current settlers, the tree cover may however appear too much and inexhaustible.

Emphasis needs to be given to sensitising the new settlers on the environmental fragility of the catchment and the need for conservation efforts. Older settlers will also have to be encouraged to continue with conservation efforts as well as being taught new methods. Organic farming could for example be promoted so as to reduce chemical pollution of water resources. Agro-forestry as a way of increasing tree cover amidst decreasing land sizes will also need to be promoted. Research on tree species that can coexist with crops and that have a high utility to the farmers, for example as animal feeds, source of wood and also adding soil fertility, ought to be facilitated. The issue of tree nurseries needs to be addressed. Apart from the Miti Mingi project, there are no other major tree nurseries within the catchment. The forest department is required to replant all areas cleared of forest but currently, there seems to be no interest in this direction. Emphasis should however be on establishment of private and community based tree nurseries as a way of promoting agro-forestry and plantation forestry within private farms.

6.1.5 Urban Planning Measures

The transformation of the catchment to a highly urbanised area is quite eminent. Nakuru is already a major urban centre with a high residential population and a substantial industrial base. Several satellite towns have also developed including Njoro, Naishi and Mau Narok and these are bound to expand rapidly. Regional urban planning at the catchment level then needs to be undertaken so as to achieve guided urban growth.

While the growth of Nakuru has been planned under the LA21 programme, the smaller towns have not been given much attention and are bound to cause major land use and environmental problems in the future unless their growth is guided through planning. It was for instance found that Njoro town with a current estimated population of 44,000 has over-grown the capacity of the initial septic tanks that were meant to serve it. Much of the sewerage including sludge from the slaughterhouse finds its way into Njoro River while still raw. The urban centres if well planned will be centres of employment, attracting many youths from the surrounding rural areas. Here, they will engage in non-farm economic activities thus reducing pressure on the diminishing land parcels in the rural areas. This will have positive implications on and use and environmental impacts in the rural areas.

6.1.6 Lake Nakuru Catchment Authority

Most of the conservation problems arising in the Lake Nakuru Catchment are as a result of the absence of a single body to control land use and development within the area. The multiplicity of agencies with only a part of the catchment to manage or only one aspect of environmental management to oversee has led to lack of integration in conservation efforts of government departments and private agencies. The mandate of the KWS is restricted to the National Park while that of the Municipal Council of Nakuru extends only to the Municipal boundary. The county council is responsible for development in not only the other parts of the catchment but also the rest of the district. None of these bodies is able to effectively address conservation issues within the catchment as a region.

For effective conservation of the catchment, there is need to establish an authority to undertake land use planning, control and co-ordination of conservation activities within the catchment. Such a body will have representatives from the Municipal council, the County

Council, KWS, the DDC, NGOs and community interest groups. Such an authority would be best suited to address issues affecting the catchment in a wholistic manner. It could also have the capacity to undertake land use studies and planning at the catchment level and also monitor the changes in land use in a quick and efficient manner so as to provide timely remedial measures. Although member agencies could be required to contribute to its funding, the authority would have the necessary partnerships with NGOs and CBOs to raise funds from donors and international conservation agencies. It would also liase with local and international research institutions in undertaking land use and environmental studies. The authority will then be extending the LA21 principles to the entire catchment.

6.1.7 Community Involvement in Forest Management

The reduction in forest cover within the catchment is one of the most remarkable changes and the environmental effects of this can not be overemphasised. There is then need for more effort to reduce further deforestation. One method that has for long been used in the management of forests in Kenya is that of Non-Resident Cultivators (NRC) or shamba system. In this system, local people are allowed to cultivate forest areas where seedlings have just been planted. The cultivators on their part are to cater for the seedlings by weeding and ensuring their survival.

For the period that it has been in use, NRC has had many advantages. It not only ensured a high seedling survival rate but also contributed significantly to the food requirements of the local communities. In the year 1962-63 for example, NRC contributed about 10 percent of small holder maize production in the country. The system was however banned in 1987 because of cases of invasion of forests by squatters who deliberately destroyed seedlings

through cutting of roots and debarking in order to reduce competition with crops. Seedling survival rates had then dropped to an average of 60-70 percentage from an average of 90 percent in 1984 (World Bank, 1988). The system was then reintroduced in 1994 but with new conditions. A cultivator is currently required to sign a contract with the Forest Department binding him to ensure a seedling survival of over 90 percent. No building of structures is to be undertaken in the forest area and the cultivation period must end in three years. The cultivator is also required to care for the seedlings in non-crop seasons.

Re-introduction of NRC has had some positive impacts on the development of forests in Kenya. Between 1994 and 1996, backlogs in forest plantation reduced dramatically. In 1994 they stood at 176,578 hectare of replanting, 133,886 of thinning, 22,750 pruning and 2175 of copice reduction. By 1996, the backlogs had reduced to 11,000, 85,000, 5000 and 1000 hectares respectively. Due to labour shortage only 20 percent of the clear felled areas were replanted between 1987 and 1994. Lack of weeding also saw seedling survival fall to below 30 percent (Kenya Forest Development Project, 1996).

Despite its acknowledged effectiveness, NRC has not been widely used in the Lake Nakuru Catchment. The politically volatile nature of settlements in the area may be one reason. The conditional titles initially intended to be given to new settlers had this sort of licensing in mind, but one that never worked. Because of lack of legal basis of the intended conditional titles, the settlers have ended up with freehold titles and this has had a dramatic reduction in forestland. Management of the remaining forest areas will then need to incorporate local people through the NRC system. This way, it will offer them an opportunity to own fertile land and ensure food security to the community. Since they will have a sense of ownership to the forestland. Local people will jealously guard against the encroachment of forests by

external agents. The remaining forest areas are however in the high erosion hazard areas. Any cultivation in such areas will need to be supervised by both agricultural and forestry officers to avoid excessive exposure of the soil to erosion.

6.1.9 Environmental Information System For Lake Nakuru Catchment

The institutions operating within the study area were seen to be custodians of various forms of data regarding land use, its change and effects on the environment. Information systems per se were however seen not be emphasised among all the institutions. This is in spite of the recognised importance of accurate, relevant and timely information by all these agencies. There is need for the operations of the institutions to change so as reflect the current need for land use information. Modernisation and streamlining of the council departments so as to make their systems more available and accessible to the public and other collaborating agencies is of particular importance.

There is also need for the undertaking of regular land use surveys. This will not only assist in controlling the changes in land use but also in identifying where variations or adjustments in the council zoning plan are necessary. Urban land use is more intricate as compared to rural land use. This calls for more refined land use survey methods in the urban areas. Large and medium scale aerial photographs (1:10,000-1:25,000), combined with ground data collection will provide much of the needed information in establishing a land use monitoring system or observatory. Such a system will require use of digital techniques in management of the massive data sets that will be generated. The council will in addition be able to efficiently manage information on land transactions and use of buildings within the Municipality.

Some aspects of the relevant urban land use database may be developed and maintained by the council on an incremental basis. The undertaking of certain scientific and technical studies will however require the participation of other public and even private institutions that are well endowed with both human and material resources for these specialised tasks. The Survey of Kenya for instance maintains for the municipality a Topo-Cadastral map at a scale of 1:10,000, showing both property boundaries and the topographical features. The map ought to be extended to cover the extended municipality area. This could also involve enlargement of the mapping scale to 1:5,000 or 1:2,500 so as to be able to map the decreasing plot sizes. This would then be the base map used in establishment of a Municipal Geographic Information System. Each council department would be responsible for establishment of information layers relevant for its functions and relating this to the general functioning of the council. Because of the digital format of this data, updating, and sharing of the information both within the council and by other agencies including the general public will be quite efficient.

The Lake Nakuru Catchment Authority will be the institution in focus when designing an information system for the entire catchment. At this scale, satellite remote sensing coupled with small and medium scale aerial photographs will help in monitoring land use and other environmental changes. The authority will then be the central body under whose custody all the other institutions will be keeping their data. It will also be a conduit for data and information exchange. The municipal councils database will then be a subset of the catchment environmental information system. To be able to implement and maintain such an information system, the authority will need to have the latest state of technology in land use

and environmental information systems. Proper funding and training of the personnel will also have to be provided.

6.2 Conclusion

The study set out to investigate the land use changes that have taken place in the Lake Nakuru Catchment between 1973 and 1999 together with the environmental, implications of these changes. The Catchment emerges as an area that has experienced major changes in land use over the past 26 years with indications that the changes are bound to continue, some at a higher rate than before. These changes have seen small-scale farmlands take the biggest proportion of catchment, a position initially held by forestland. Urban land, although currently having the least area has been seen to have the highest rate of growth. The indication is then that the area is quickly attaining an urban character.

It is important to note that some of the areas classified here as small-scale farmlands are actually areas of mixed use with quite substantial proportions of commercial and residential use. Most of the rural land can then be perceived as land in transition from forest and large-scale farmlands to urban land. The areas along Nakuru-Nyahururu road, Njoro-Mau-Narok road and also the Rhonda- Mwariki area could as well have been classified as mixed use areas to show the transition. Since the changes from forestland and large-scale farmlands to small-scale farmlands is as a result of population pressure, it is right to regard such a change as a move towards urban development. The study then arrives at the conclusion that urban land is the ultimate land use in the catchment.

The lands most vulnerable to urban conversion are the large-scale farmlands and gazetted forest areas. The large-scale farmlands are being subdivided by their owners who are either speculating or selling because of reduced profitability of large-scale farming and also the high prices and demand for land in the area. Forestland has also variously been degazetted to allow settlement of people. Most of these activities are taking place on the more accessible parts of the Catchment especially along the major transport routes.

The trends in land use as revealed by the study have negative implications to environmental sustainability. Intensification of use is causing major environmental threats including higher rates of soil erosion and pollution to water resources. The land use trend in the area then poses a major threat to its environmental sustainability and calls for immediate measures to ensure harmony between development and the environment.

Within this quickly urbanising region, there are impressive conservation efforts and awareness. The Menengai crater and the Lake Nakuru National Park have remained under very little interference from human settlement, with the area of the park increasing by 50 percent. Public and private collaboration has been witnessed in planning and conservation efforts within the catchment. The hope lies on the continued and improved collaboration between all actors concerned with environment and development. This will be in the field of land use studies and environmental planning within the catchment.

Specific areas to be addressed are continued farmer education in soil conservation and afforestation, monitoring and seeking alternatives to the use of agro-chemicals. Organic agriculture should be promoted among the small scale farmers as a way of reduction of chemical pollution The planning of the small and upcoming urban centres is also of

particular importance given that they are to be the biggest point sources of pollution in the near future. These efforts require a collaborative effort of the relevant agencies and also a continuos review of the legal framework controlling land use, land rights and environmental conservation.

The study has also revealed the importance and applicability of rapid land use change information and its management. Satellite Remote Sensing has been identified as an effective method of acquiring such information for expansive areas such as the Lake Nakuru catchment. Since satellite data is being acquired continuously by space borne sensors, it is possible to be undertaking historic land use analysis and relating these to the current land use conditions. This will help in projection of the future land use and its implications thus the appropriate environmental intervention measures.

Once land use information has been acquired, GIS has been identified as an appropriate management and analysis tool. It will not only help information management but will also increase the utility of data by combining information layers to give new information. The lack of use of these modern tools in the environmental management within Lake Nakuru catchment therefore points to the need for sensitisation among managers of the relevant institutions on the crucial roles of GIS and Remote sensing in land use planning and environmental management. This study is a step towards that end.

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APPENDIX I: Household Questionnaire

Declaration : The Information given in this questionnaire will not be used for any other Purpose, besides academic.

Questionnaire Number_____ Date of Interview_____

Name of interviewee_____

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1 Name of local area_____

2 Household Composition

Name	Age	Sex	Marital Status	Education Level	Occup-ation	work Place	Monthly Income

3 Relationship of respondent to household head_____

4 Type of House: 1) Temporary 2) Semi-permanent 3)Permanent

5 For how long have you Lived in this area_____

6 Where did you live before then_____

7 How long have you lived in this particular plot_____

8 What is the size of the plot/farm _____Acres

9 How many households live in this plot/farm

10 What is the main land use in this plot/farm_____

11 What other land uses are undertaken on the plot/farm

i).

ii).

iii).

iv).

12 What is the annual income from the land

Land Use	Annual Income

13 What is the dominant land use in the neighbouring farms_____

14 What other land uses are undertaken in those Farms

i).

ii).

iii).

iv).

15 Nature of land Tenure a) Freehold, __ b). Leasehold ___c) Others, Specify

16 Does the land has a title deed 1)Yes_____ 2) No_____

17 When was the land acquired_____

18 How was the land acquired 1). Inherited 2). Bought 3) Gift 4). Rented

5) Others Specify_____

19 If farming is practised, which of the following modern farming methods are used

I).Fertilisers

ii). Other agro-chemicals

iii). Hybridisation

iv) Farm mechanisation

v). Soil conservation (specify)

20 Where do you buy your farm inputs _____

21 Where do sell your farm produce_____

22 Since you started living here, what land use changes have you introduced in your farm?

Type of change	Year of Change	Reason of Change

23 Do you have any plans to change the land use plot/farm? 1). No 2). Yes If yes, Specify_____

24 What was the land use condition in this area before 1970?

a) Plot sizes_____

b) Dominant Land use types_____

c) Other changes_____

25 What land use condition would you expect in this area in the next 15 years?

_____

26 Is this the land use conditions you would prefer? Yes____2). No_____

27 If No, what land use condition would you prefer and what do you think can be done in order to achieve your vision? _____

_____

28 Are there any conflicts or competition between land uses in this area? Yes 2) No If yes, specify_____

29 How can these conflicts be resolved?_____

_____

30 What is the present market price of an acre of land in this area? Kshs. _____

31 What is your source of water? a). Piped b).borehole c). River d) Roof catchment e). Others (Specify)

32 What is your household's major source of power a) Fuel wood 2)Electricity

3) Petroleum products 4) Others specify

33 What type of road accesses your plot a.) tarmac b) Murram c)Earth/Graded d). Others

34 What is the road condition and transport services your land and Nakuru town.

35 Are there any hardships or constraints in the use of your land caused by its physical or natural characteristics like slope, soil types a).Yes b). No If yes explain_____

_____

_____

36 How far away is your farm from the following facilities

Facility	Distance (Km)	Time taken to reach there
Water point (Permanent)		
Tarmac Road		
Power line		
Primary school		
Secondary school		
Youth Polytechnic		

37 Do you experience land subsidence problems in this area? 1) Yes 2) No. If Yes Explain, Nature _____, When _____ How far was it from your plot/farm? _____Km

38 What other environmental problems do you experience in this area (Soil Erosion, water pollution) _____

39 How can this problems be solved?_____

40 Are there any environmental community based organisations (CBOs) in your area? 1). Yes……. 2). No . What do the groups engage in?

Name of CBO	Activities

41 Are you a Member of any such group? Yes 2) No

42 What other organisations undertake environmental conservation activities in your area

Organisation	Activities

43 In your opinion, what is land and what role does play in the life of the individual?

Thank You

APPENDIX II:INSTITUTIONAL ASSESSMENT SCHEDULE

1 Name of Institution_____

2 Environmental Activities engaged in

i). _____

ii). _____

iii). _____

iv). _____

3 Area of Operation _____

4 Institutions collaborated with.

Institution	Nature of collaboration

5 Type, Current sources and method of collecting, the information used in environmental planning and management .

Information type	Current source(s)	Current collection method(s)

6 For each of the information types listed above give the current status (the quantity and quality of information already gathered

Information Type	Status

7 What other information types would you require but currently lacks ways of acquiring

i) _____

ii) _____

iii) _____

iv) _____

8 Current method of information management (Storage and retrieval).and data analysis. (Tick whichever is applied)

Activity / Method	Information management	Data analysis
Manual		
Automated		

9 Approximate annual budget for data collection and information management Kshs_____

10 Personnel trained in information management

Type of Training	Number of Staff trained

11 What are the three most significant problems facing your institutions in terms of land use information acquisition, management and analysis, and how would you suggest that the same be solved,

Problem	Solution